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draft version

Creativity is at the center of many outlook. In liberal viewpoint, creativity is considered as the core of the economical competitiveness being the real key driver in terms of change rate and economical growth. Moreover, the temptation to redefine the concept to be more in phase with the modern area is sometimes observed ? An interesting highlight is the comparison between the outcomes of two different creativity processes, the researcher and the collaborative approach. Striking difference in terms of timescale, relationship, emotion and final outcomes can also be identified. Probably, a particular care should be taken to prevent imitation and conformity effects resulting of brain and attitude mechanisms linked by the mis-use of modern technologies and connectivity to preserve our cultural heritage. Probably, the natural human and collective based filtering, association, aggregation, classification and coordination of information flux resulting from the society organisation has been completely disrupted by the use of modern technologies with hyper-connected information system. Creativity is probably more fragile, more human and cultural related that it was probably estimated. Environmental factors and creativity pattern plays probably a major role in our civilisation heritage.

Creativity, Civilisation, Perceived creativity, Emotional intelligence, Collective cognition and group process, Modern technology, Creativity crisis

DRAFT

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Krzeminski Christophe

INTRODUCTION

Worldwide intense economic competition has triggered the development of innovation and new methods in design thinking in order to create and renew objects and services^[1]. Creativity is the key driver of liberal economy where the corporate strategy is often resumed by the ability to change^[2]. Thus, a significant part of the high-tech firm budget or laboratory is devoted to develop novelty in the hope to survive in the economic warfare. However, a question sometimes put in the place^[5]: with an increasing amount of money spent to increase the speed of innovation^[7] or for breakthrough^[5], global innovation seems to slow down ? A connex question could also be : why some societies or cultures are more inventive than the others ? Many plausible hypotheses relative to recent contextual or policy reasons can be put forward in order to explain this paradigm : the difficulty to satisfy the need of high-skills profile and the knowledge trap^[9], the increasing division of labor and also probably monetisation policy. Among these different hypotheses, this article suggests another detrimental fundamental reason: the impact of the digital space and modern technology on individual or small group creativity. Creativity, where time matters, is the first brick sustaining innovation. The hypothesis expressed is that the level of global creativity could also be reduced or radically changed by the use of modern digital technologies that maximises spontaneity, connectivity but also imitation effects. This article also suggests a possible fundamental shift from environmental to technological creativity which tends to disrupt the cultural and civilisation aspects. In some way, this article simply remembers the key role of environmental factors in creativity such as human aspects, ethical, time matters and management^[13].

WHAT IS CREATIVITY?

Trying to define the real nature of creativity seems to be quite difficult. Some literature work place the ability to create as a reflect of our civilisation. On the other side, the difficulty to define or sometimes even class creative works often triggers human reactions like fascination^[14] or rejection and negative feedback^[5,7]. This bipolar relationship related linked with creativity is emphasized by the fact that whereas the left hand tends to maximise creativity the other part rejects or fear the consequence of creative ideas^[6,16,17]. This definition is probably evolutive^[19] and tends to reflect significant cultural differences regarding the literature. It ranges from the modern one which tends to reduce it to novelty and utility up to ancient definitions. A modern and pragmatic way to define it as a novel idea or concept that can be easily transform into a commercial product to the market. A computational version of creativity is sometimes foreseen^[18] but do not seems to meet a real adhesion^[20]. It seems that the continuous stimulation by simple novelty is limited in regards of our psychological needs. The fact that creativity is a perceived feeling which could be highly subjective to past experience and crystalline knowledge has been introduced recently^[15]. However, creativity seems to be revealed as a more complex, human and social process^[21].

CREATIVITY, OUTCOMES AND SOCIETY ORGANISATION

Probably, the large difficulty to give a unique definition of creativity due to the share of this concept in the society, each one having his role often defined by cultural aspect trough history in many diverse areas of the society. As a challenge to be creative, I would add a another definition to the previous list^[6] : “creativity is a long mental activity of individual (or a small group) that could be benefit from reasonable interaction and lead to a final outcome judged as pertinent, interesting and original by external parties. The creative process is extremely fragile, environmental and depending on the nature of final expected outcomes. For such purpose, a significant level of knowledge could be necessary”. Creativity is a complexe notion difficult to apprehend without experienced it. Qualifying his outcome seems probably to be even worse as for example innovation and research are often confused. Both discovery, invention, innovation and communication can be distinguished from possible final outcomes of a creative work process. The next figure 1 sketches, in a symbolic way, the interaction between creativity and the results of a creative process. It should be stressed that despite often confused in literature work, these different notions are strongly different:

- **Discovery:** can be defined as the breakthrough of a long term research process which provide a new understanding, knowledge, abstraction of a phenomena or the nature itself.
- **Invention:** is the result of a creative work which leads to the creation of an original product or services.

- **Innovation:** is complex to define but can be viewed as a negotiation process shared by many actors that leads to the adoption of an original but existing idea, process, product, service.
- **Communication:** is a vast notion...Primarily, it corresponds to the creation and the transmission of an emotion, a short message, a knowledge.

A hierarchy could be drawn between these different outcomes in terms of future expected incomes as illustrated in the figure 1. For example, considering as an example, a research institute, an ideal linear research process should consist in the discovery of new knowledge or understanding by a senior researcher which could trigger an invention implemented by an engineer that could be integrated in an innovation process by support services and could leads to, scientific communication, to a specific community. The main issue of the current worldwide information society is first these frontiers in terms of organisation, skills tends to disappear. Secondly, this long process barely coexist with short economic cycles or policymakers expectation. The actual level of interconnection made that a global innovation process is no more linear and organisation defined. Whereas, a global competitive process could be drawn in which creativity could take a central place. However, each outcome is in competition which each other. This competition takes place mostly based on limited shared resources (human, time matter, effort, emotion) and visibility, return on investment. Probably, the fact that digital communication and innovation plays a growing part in the creative process is a side effect of modern technologies.

MENTAL OR INTERACTIVE CREATIVE PROCESS ?

Different types of creative processes have been introduced with the evolution of the field. Two different models of creative processes could be put forward and is discussed in the next section. The first one corresponds to individual creativity and is the basis of many professional works like engineer, scientist or artists. This picture of individual creation on a long period has been magnified and associated to the notion of genius often viewed as the most intelligent and creative one^[1]. A complete opposite model is the collaborative approach often based on highly connected re-configurable team as described just above. These two extreme models of organisational creativity are strongly different in terms of working method, timeline and even in terms of expected final outcome.

The researcher mental process

Description

The creativity and innovation process for a researcher is mostly based on the activity of an individual person that after several years of study investigates a problematic and the field

of knowledge associated. The creative process of classical research^[22] has been formalised in an elegant way by the experience Shapero^[24] based on many years of research. Many researchers will probably afterwards recognize the mental process of their idea emergence. This complex process could be summarized by this figure 1 using four steps. It is a *mental* process mostly linear with a succession of conscious and inscocious phases:

- An optional phase in the creativity process is an orientation step. An open question linked to thematic field that stimulate curiosity which can be put forward to initiate the creative process. Creativity can also be trigger in a different way by the appearance of a problem which generate many research works.
- The first stage of the creativity process is a relative long preparation phase in order to explore the field of study. Mostly, an overview of the literature is being performed in order to clarify their degree of understanding, the progress and the remaining challenges in the research field.
- The next phase of the creativity is related to the incubation step. It is a relatively long period of several months, not really understood, where the brain performed an associative work. During this phase, a different activity is often experienced as beneficial for the maturation of ideas.
- The breakthrough or the discovery is often associated to the illumination phase. During a free conscient state or at an hazardous moment, the new idea or concept emerged. It is often claimed that the mental associative process between the different ideas is maximised during a period of free thought. On the other side, a clear detrimental factor in this phase of mental activity is a continuous exposure to a different information flux. This key moment often depicted as a flash is probably the most intriguing stage being fragile and can be barely stimulated at the individual level. A key environmental factor is to be master of his own time^[43].
- The last stage is a formalisation step where the idea, concept is being evaluated often by pairs. This formalisation can take many forms of deliverables as described in the next table 1.

An interesting complementary viewpoint has been recently put forward is the nature of the feeling associated with the research process. Each phase of the creative process can, in my opinion, reasonably linked with an emotion that strengthen the human nature of the research process. The start is often a problem or an open question that has gained the researcher attention. Curiosity is the mental state that probably characterizes the early stage of the creative process during the preparation phase. Next, interrogation comes often with the sketch of primitive solution which involves to the frustration point put forward in this work^[33]. Probably, the phase describes by a schematic representation with the journey between frustration and interrogation is the core of the creative process that probably

generate unconscious brain process and the conceptualisation of new solutions. Individual satisfaction comes after the illumination phase which clearly inhibits frustration and can be perceived as a reward for the brain. Finally, with the examination phase positive or negative by the pairs comes the completion phase where the main feeling is that the research work is finished and it seems not possible to provide a more creative, original solution. With the communication of the results and the generation of new open questions, initiate the beginning of the creative process but probably for another researcher which would address the problem with probably a complete different viewpoint. A particularity of the old researcher process was the relative isolation, preservation during the creative process that effectively reduce social comparison and interaction. One major drawback of such isolation is that stimulation effects and knowledge flux is reduced. On the other side, the mental preservation is probably beneficial and the limits in terms of psychic energy constrained the number of tasks. A permanent social comparison between researchers of the same field breaks the researcher isolation enhance competitive individual effects or sometimes trigger a consensus for a community but on the other side, also imitation effects.

Mental process and modern technologies

Modern technologies based on highly connected devices such as smartphone can have a detrimental impact on the creativity process by analyzing the possible impact on human emotion or behavior:

- Attention and concentration is clearly limited by the use of these new devices that tends to capture the user attention. Saturation seems to be the counterpart of the mis-use of digital technologies. The access provided by many different applications to a large flux of information non only captures but also saturates and often defogs the human attention. Even one secular ago in the reflection of Wallas^[22], the necessity that “ ‘during important mental process nothing should interfere with the free unconscious or partially conscious processes of the mind’ ” was put forward.
- Connectivity to others by the use of digital social network is amplified with the “death of distance”^[23] but also supprisingly reduced. Social network lower and flattern the barrier an easy connection to others person through the use of digital communication that probably would never existed. On the other side, the predominance of short time digital communication increases the face to face contact barrier for real direct verbal communication often needed in the first stages of the creativity concept.
- Curiosity on a specific topic is reduced by the use of modern technologies as the access to high level, quality information is subject to financierisation and sometimes even constrained for competitive reason. On the other side, the curiosity is often amplified by digital tool on low abstraction level information, individual information.

- Personal frustration, at the core of the individual creative process, is a feeling that in my opinion barely coexists with a connected brain submitted to permanent stimulation. It can be observed that frustration is often deported by an addicted user or even related by a community through publicity on the smartphone itself; short term creativity and communication being used in this case as a protection.

Probably, the partial paradigm shift discussed in the previous section, from cultural to a “computational” creativity is also due to the fact that human brain is in strong harmony with the connected devices. In the physical world, both the filtering of undesired sollicitations in the incubation step or even the search of sollicitations in the preparation was relatively easily. This no more the case as most of the flow of external sollicitations mostly driven by spontaneity and opportunity of the digital network environment provided to device user are mostly short-time based, fragmented, unrelated and non-classified in strong analogy with the information transmitted by packet of the Internet protocol network.

Outcomes

Many deliverables results can be associated from the creative process of a researcher. Experiments and software simulations are often used or developed during the creative process in the preparation phase. The influence of experimental activities in the development of creative ideas enabling a time both in terms of exposition and also in the maturation of ideas is also a point that has been overlooked in the digital era. Simulations can be favorably used in order to clarify, support hypothesis. In this way, computational creativity support human creativity in it most interesting way as sometimes it can provide complex images or results that stimulate or confirm human intuition. Different final outputs are expected like scientific data that can take a physical or digital form. A clear distinction can be done between the different outcomes expected from a long term research work:

There is probably a strong similitude between science and creativity in a sense that the scientific outcomes are often the results of a tension between various human attitudes like divergent and critical thinking and, at the same time, a respect of the domain, field. Scientific creativity is often located somewhere between an independent view and also the tolerance for others works^[34]

Questioning the anthropocentric model

The model of the individual researcher often associated to the occidental culture is clearly questioned^[16]. One major criticism is the cult of the creative “genius” which tends to reinforce hyper-individualism. It is relatively clear that the context and environment around the researcher plays also a major contribution to the researcher creativity^[25] and performance. Some limits have been identified in the creation process for an individual researcher. Probably, the main issue often associated with a long career linked to one or few field’s study.

Thus, copying with the rate of change in the modern area is probably one of the main limit of the individual researcher with the increasing specialization and division of labour. The second one is the cost linked to the career of the researcher since it required to block a financial budget where on the other side most of the economy relies more and more on very short term economic cycle.

Some circumvention schemes can be introduced in order to cope with the limits of the researcher system. The first one is the introduction of research project where the initial objective was to federate the work of several researchers in order to achieve a common objective. The second is the thematic change in terms of research field when the scientific field is being exhausted. The next section tackles the question of group creativity which clearly set a challenge to the individual researcher, professor, expert model^[27]. On the other side, in terms of high-level knowledge neutral assessment and diffusion, no real alternative has emerged up to now.

The collaborative approach

Description

In the hope to keep with the change rate of modern area in terms of activity, semantic, the collaborative or the co-design approach revisited the classical brainstorming approach based on a postponed judgment. The main trigger idea was to enhance the creativity of individuals by creating a global stimulating and creative environment, radically different from the highly organised of research institute :

- **Material environment:** the use of a vast open space with large table for maximising group interaction and verbal exchange. The disposal of large set of small materials (pen, post-it, plastic) and easy fabrication set (printing) and plugable hardware electronic cards facilitate the creation of prototype on a short time.
- **Project environment:** the definition of a various number of projects based on a very short period (a dozen weeks) that maximises the number of creative experiences.
- **Team environment:** the creation of highly re-configurable team with various different actors also maximises the combinatorial aspect. This is the main principle of the co-design approach as many different actors should be placed at the beginning of the creative process working in marketing, design, engineering, business in order to increase the chance of market adoption. In the present case, the originality comes from the presence of students in pre-professional working with professionals, animators, professors. Despite the short time period, The cost associated to the number of participants is a intrinsic limit of the method.
- **Creativity management:** a co-design period has a duration of few hours and is regulated by a protocol defined by the animator. Generally, as described by the next figure 2, three

times of creation are being considered. The first time aims at relaxing the atmosphere and welcoming the participant by informal presentation. Simple creativity games are often done to start the collaborative work and to touch the problem in question. In a second time, the creative techniques helps the participant to exchange in smaller groups about the question and by noting the ideas on post-it or small piece of papers. The term reactive expansion is often put forward in order to describe this phase where ideas are exchanged. In a third time, a restitution phase is often made in order which often leads to categorize the different ideas. Probably, one of the surprising result is that every actors at the individual level go back with his own global feeling or results of the co-design period.

Creative emotion and co-design approach

Looking back at the individual mental process research, the co-design approach is completely different. It differs in the nature of the creative process being mostly an interactive process, thus being totally different from a mental process. The key principle is to maximize the probability that a consensus or a new idea will emerge with the number of different participants. On the emotional point of view, this process is completely different.

- Curiosity about the approach and observation between the different participants is characteristics of the first stage.
- Spontaneity is the emotion which emerge during the “reactive expansion” and the interaction between the different participants. A clear interest of the method is that the interaction with the digital tool is interrupted, the attention being focused on the creative work and the exchange of ideas in the paperboard or post-it.
- Formalisation and transaction among the different actors summarizes probably best this stage. Informal discussion takes place at the individual levels whereas the animator seems to be the most appropriate feeling for the last stage.

It can be observed that this creative process strongly differs from the individual researcher. The spontaneity of the method has some advantage. The participants often appreciate this creative period “out of the box” that breaks their routine job. In this way, the method clearly benefits in the democratisation of creativity. The second positive aspect is that each actors of the creative seance takes his own benefit, feedback also contribute to increase the positive perceived creativity. On the other side, the limits of the collaborative approach are clearly seen. The main limit identified is the preparation phase where acquisition of knowledge does not exist as in the classical researcher process which imply that the verbal exchange are not at the frontier of knowledge and the participant not aware of the state of the art. The second one is that frustration, saturation is mostly observed in the animator group who made a large number of co-design meeting and in his role of animation is more concern with originality. The second limit is the time of the creative work. The co-design approach is a very short

term creative process (a few hours) integrated in a project of a few weeks that can lead to the deliverables summarized in the next table 2.

Limits

Some limits of the co-design approach could probably be identified. The most striking one is in terms of knowledge and reflexion. The method is clearly not able to cope with the transmission and analysis of moderate or complex knowledge which required both an assimilation time for understanding and also written communication. The second one is relative to the group interaction. A criticism often made to the model of the isolated inventor^[12] ¹ is that it will not benefit from different viewpoints and filters provided by a collaborative team that could generate “ a more rigorous selection process” and decreases the probability of a useful invention. The level and the detrimental influence of social interaction and at the same time the need to personalize the creative process, at the hyper-connectivity age, has probably be underestimated re-enforcing imitation effects. However, one of the main limiting factor of the individual researcher model is the knowledge necessary to reach the frontiers of a possible invention, discovery state, factor completely overlooked and difficult to estimate in statistical studies. There is some space between the complete isolated individual process research and highly universal re-configurable team creativity.

Synthesis

The questioning of the individual researcher creative process by modern innovation technical of group brainstorming gives the opportunity to draw a phenomenological return. The first one is that the result of creative process seems to be strongly related with emotional intelligence. The emotion and behavior being strongly different between individual and group creative process. The nature of the creative process is clearly predominant in terms of output expected. Group creativity, mostly characterised by spontaneity and interaction seems to be the most suitable for oral or image outcome like transaction, debate, informal communication. Mental and individual creativity based process on preparation, reflexion seems more to be more adapted for formalised written outcome like scientific communication, intellectual property. For the influence of modern technology, even a phenomenological return is more complex. It is relatively clear that both individual or group brainstorming are influenced by modern technologies. The mental creative process seems probably the most disrupted and even the most critical article on the anthropocentric model recognize the necessity of solitude and isolation in the creative process^[25]. The initial orientation and final examination phase is effectively

¹The fact that a patent or an article has only one author do not necessary reflects the fact that the complete creative process was completely isolated, even in the orientation, preparation or examination phase. For the core part of the creative process, illumination or reflexion it is more plausible. Moreover, symbolic communication aspect relative to an article or a patent also made that all the contributors do not necessary appears and in a different viewpoint also relative the myth of the alone inventor.

strongly environment and contextual dependent. Protecting curiosity is clearly a real challenge as contextual dependent and also fragile against saturation effects at the information age. Isolation is needed after curiosity in the central part of the creative process for understanding, reflexion, introspection. Personal frustration in the creative process should in some way protected and channel to expect an illumination phase. A clear inherent contradiction is that in the creative process, social and collaborative interaction and comparison are highly promoted and at the same time there is a need to personalized the creative process and to attribute the final outcome and the benefit in a symbolic way to a person. This tension between individual and group creativity is probably emphasized by the overhead conflict between crystallized and fluid intelligence, this form of intelligence based on verbal interaction and factual knowledge being maximised by modern technologies^[26].

CREATIVITY : SELF-REGULATION OF EMOTIONAL CONFLICT ?

The main thesis discussed by this article is that global and cultural creativity is fundamentally disrupted by the use of modern technologies and the permanent connexion to the digital space. A Darwinian evolution in terms of creativity could not be excluded^[41]. The questioning of the researcher model and the shift from a mental to an interactive activity illustrates an unexpected effect of modern technology. Several other shift can be identified. The first one is the interaction between the device and the emotional shift in the creative process. The creative process has been displaced from a self-centered human process to a human-device process which by simple observation seems to be characterized by completely different emotional states. The second one is the use of a proactive digital environment in creative seance which do not boost creativity but seems finally to limit divergent thinking. A futurist approach self-centered on individual could be foreseen where the creativity could be totally disactivated by technological tool. The third one is the amplification of imitation effects through the use of modern digital tools which seems to be linked with the core principle of modern communications. An amazing observation is finally the group creativity in terms of recent semantic to qualify recent innovation which is probably more relevant of an emotional internal conflict taking place between the degree of dependence in terms of connectivity to the digital space and the expressed acid servitude to the digital world. An hypothesis that could be formulated is that creativity seems also to play a role in term of self-regulation the emotion conflict of human dependence in modern technologies.

Creativity and emotional, behavior displacement

Most of creative process are strongly linked with emotional states. Modern technology and the relation of human with their smartphone probably disrupt the mental creative process in terms of emotion and also behavior. If we analyze the way that human reacts to a problem or a question, a complete paradigm shift is observed. This behavioral shift can be explained

easily by the fact that self-centered human creative long term process disappear to be replaced by a short term human process in complete interaction with a digital device. Curiosity has been replaced by connectivity and mostly consist to find the person who would be able to solve the problem. Personal reflexion also as been displaced by two phenomena : i) the capture of the human attention by the device and ii) by the amount of uncategorized data available on the Internet. Probably, the most striking difference is the core of the creative process is that the concentration necessary for the introspection and interrogation process has been replaced by activity and spontaneity through displacement, environment captivating and interactivity with the device through digital application framework. Depending on the degree of dependence with the device, the responsibility of this reflexion and introspection phase is often transferred to the device and the digital space which is not able to respond. Modern digital technological system are being mostly based for one to many communications. This is a another striking difference between human and the digital space since most of the human communications are mostly individually based.

Digital proactive environment and divergent thinking

Beyond, the behavior shift in terms of relation between human and device user, history social influence is known to affect creativity. An another aspect is the digital proactive environment generated by digital technologies with for example the number of digital screens. It could be of interest to extrapolate this tendency and the next step from a human in interaction with a device to a completely futurist digital proactive environment. The connectivity to a complete digital space would be immediate with technology based on emotion recognition and the answer by the cloud of application and knowledge providing quasi-instantaneous (voice assistant). Probably, the spontaneous phase of displacement observed today, activation phase observed could disappear to reach a complete immobilization in the future. The transaction with the environment would be permanent by the use of symbolic resources provided by the digital space and human frustration, emotion outside the norm could be software regulated through normative compliance to the system. Creativity in the sense today would probably be completely be inhibited, divergent thinking necessary^[38] for creativity not possible by the digital proactive environment. This futurist vision would leave the place to a complete mechanical creative system probably more in phase with the definition of creativity of novelty^[35].

Digital technology and imitation effects

It has often be observed in the past, that suprisingly duplicate inventions often take place at the same time^[36]. The spread of similar knowledge and the existence of similar constituent cultural elements (the spirit of the age) has been put forward to explain this phenomena. How can re-estimate this effect at the digital era ? A another radical shift associated to digital

technological technology is the explosion of imitation effects detrimental to global creativity. As shown by the figure 5, different mechanisms could be put forward to explain this amplification and breakthrough. First, the use of technology or applications based on broadcasting like e-mail, social network makes that similar orientation to emergent problematic is often generated. Orientation has a key influence at the beginning of the creative process which could explain, the increased number of similar activities. The use of professional social network and the permanent social comparison probably trigger imitation effects and reinforce the small world effects detrimental to creativity. Secondly, mechanism of replication, duplication of information and also the packetizing of information transmitted through network explains the demultiplication of information with relatively low abstraction levels. Finally, digital technologies are mostly based on quantification and numbers that probably amplified quantitative (not qualitative) control and mental projection to numbers without any context consideration. For example in research activities, some limits in terms of similar thematic orientation, imitation effects induced by the use of modern technologies communication could easily be observed. A another point is the predominance of communication as an outcome of creative processes from the creator point of view but more surprisingly also by the external parties like exterminator or regulator.

DIGITAL ERA: TOWARDS AN ORGANISATIONAL CREATIVITY ?

Creativity and society

Creativity takes probably a hidden but central part in the organisation of society. The next figure 5 is a non-exhaustive illustration where creativity and the different outcomes takes a central part both in the economical sector (production, services, teaching) domain but also in cultural or civilisation aspects. It can also be noticed that each outcome is probably tightly binded to a specific domain. Discovery, breakthrough is intimately linked with research, knowledge and finally intelligence. The different invention of new products and services can be related to the production sector or services. Innovation is more tightly related to business and networking and his first aim was to fluidify probably economical market by transaction of the different actors. In some part, his primary sense when very few products, services are in competition on the global market. And finally, communication which probably plays a major role in the influence of cultural, civilisation aspects at the risk to lost a major part of his power due to saturation effects and sometimes even the lack of a message. The digitalisation has disrupt in some part the linear innovation process but some sign of a detrimental influence on the different domain (services, production) due to the confusion between i) the different outcomes of the creative process, ii) the economical resources allocated and finally the function itself for the different sectors. It could be noticed that finally each field (business and innovation) or (communication, creativity) tends to focus on their own shared aspect of creativity^[42]. It someway has probably be discussed but, the expected control of society organisation by digitalisation has not be reached probably by the difficulty to describe the complex human process organisation and the confusion generated by digitalisation of complex function.

Evolution: from interactionist to particular model ?

Many work address the creativity at the individual level without any consideration of the systemic part of creativity. Before the digital revolution, creativity at the organisational level was probably nicely described by the model of Woodman et al.^[37] as reported in the next figure 6. In this model, the global creative outcomes of an organisation is function of his environment and of different group process. Ability is a group characteristics composed of different individuals making his richness and fertility by the different personality, motivation, knowledge, creative behavior and cognitive style. This interactionist model finally summarizes the creative outcome before the introduction of modern technologies.

Modern technology have probably disrupted this model of group communication, exchange and building by addressing directly the individuality. As shown by the next figure 6, the global environmental influence is no more outside the organisation but takes a central part in the creative process with both positive and negative influences. In his relation with the digital space, the user is in permanence solicited through e-mail, social networks access to knowledge and explain probably the shift from mental process to “reactive” creativity.

The next figure sketches a potential description of an interactionist model of creativity through the digital space representing modern technology. The individual has been replaced by a user of a digital ecosystem, intrinsic motivation being replaced by solicitation and personality factors blurred by human-device interaction. In this digital space, the notion of community would probably more qualified to describe the group interaction. The interaction, agglomeration process takes place with the sharing of common values or upon incitation. The building of these community is made by affinity or rejection to a self-organisation . The individual function in a group has been replaced by activities. The digital space triggers a large set of different activities which remains however constrained in a digital ecosystem itself often limited by plastic frontiers. This complete digital ecosystem can be in electrical conflict at the frontiers to the real world or “earth”. An another issue is that the individual crystallised knowledge often acquired during long mental activity has been replaced by human-device interaction. The knowledge transmission path between the user and the community takes place through the digital space.

Looking back at the original feeling of Jones^[9] that the space of innovation or more generally that creativity is slowing despite huge investment. One main conclusion of is that a particular care should be taken more generally in mental activity in terms of sound objectives but also in terms of final outcomes expected both at the individual level or in group organisation taking account the side-back effects of modern technologies and hyper-connectivity. A another striking issue is the conflict and probably the determination of suitable ratio between ambient and crystalline intelligence and creativity, a too large part of ambient intelligence being detrimental to the acquisition of permanent knowledge and leads to superficial, and factual communication. Whereas, it should be recognized, that on the other side, a complete crystalline intelligence inhibits probably all human transmission and creativity. To conclude,

global creativity seems more be a “patchwork”² of many though processes resulting of the society fragmentation and the coexistence of the past and digital era. As shown in the last figure 10, a key factor is the perception and the economical regulation of inherent societal conflict. Probably, the presence of two threshold effects, the first one related to the minimum intelligence and knowledge necessary to solve a problem or divergent thinking, a new frontier being “digital” separating the digital ecosystem (tool, behavior, communication) from the past one. This figure also supports the main thesis put forward in this articles that depending on environment sollicitation, creative minds are hyperconnected in the digital environment^[5] and ambient (lower right frame) whereas disconnected in the “past” era (upper left frame) relative to crystalline intelligence.

CONCLUSION

Creativity takes a central part in our civilization and the environment and individual freedom and ability to invent and discover has probably be the central key of success of some societies in the last century. Modern society benefits in some way of a high level of interconnection provided by modern technologies but at the same time the emerging creativity crisis seems to be a backside effect. The permanent need of social interaction trigger spontaneous and active creative methods, the use of digital device reducing even more the individual mental process let for creativity and reflexion. A probable shift from human centered creative process to human-device creative process, the creative freedom and knowledge being regulated through the digital space by the device and complete change in terms of emotion and behavior related to a problem, a question and also on the nature of the outcome. Imitation effects by permanent social comparison and broadcast communication are also amplified. A further step in terms of digital technology and connectivity would consist in a complete digital proactive but divided environment that i) would inhibits creativity and divergent thinking let the place to a full mechanical and probably consumerist approach of creativity^[39] where low level communication aspect is exacerbated and ii) on the other side depending on the adhesion level and the localisation in the knowledge and digital frontier, subject to a rejection level^[40] difficult to evaluate.

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²The evolution of the past innovation process^[10] ?

TABLES

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Deliverables	Nature	Timescale	Abstraction level
Experiments	Physical	Up to many years	Low to high
Software	Digital	From days to years	High
Data	Physical, digital	up to many years	Low to high
Patent	Information	Months	High
Communications poster	Information	Weeks	Medium
Communications oral	Information	Weeks	Medium
Communications papers	Information	Months	High

TABLE 1 Examples of deliverable and outcomes expected from a long term research activity and associated timescale. The idea or concept issue from the discovery can be valorized by a patent or by various form of communications. Experiments or software simulation that often support the creative research process can also be provided complementary physical or digital information.

Outcomes	Nature	Timescale	Abstraction level
Post-it	Written	Minutes	Low
Debate, spontaneous knowledge exchange	Oral	Minutes, hours	Low
Scale model	Physical (easy process)	1-2 hours	Low
Concept, decision (storyboard)	Written	1-2 hours	Low
Fun period, mind opening	Psychological	Hours (low)	Low
Brand, patenting	Written	Weeks	Low, moderate to high

TABLE 2 Example of outcomes expected after a session of creative work. It can be observed that completely different and interesting deliverables of the classical research process can be obtained. Moreover the timescale and the material process illustrates the creativity democratisation using the collaborative approach and also the diverse nature of possible outcomes. Scale model or proof of concept are often made in simple materials with design tool that illustrates this democratisation. On the other side, at the exception of concept patenting, interactive creative process does not replace the long mental abstraction.

Yesterday (emotion) (Human, self-centered)	Today (Human → Device)	Reaction associated to a sollicitation
Curiosity	Connectivity	Who can solve my problem ?
Reflection	Spontaneity	Is the answer on Internet ?
Concentration	Activity	Displacement (facilitated by the hand device)
Observation	Captivating	Collecting photos (intelligence, interpretation is let to the device)
Flexibility	Interactivity	Application based, flexibility limited by the device environment
Self-frustration	Frustration	Device response not satisfying (rapidity, quality, relevance)
Contradiction	Rejection (emotion)	Semantic (artificial intelligence, machine learning, Internet of things)

TABLE 3 Attempt to qualify the shift from human and self-centered attitude in the creative process to human and digital space through a device. These changes in terms of human emotion and related attitude to problem, questions are explained by the speed and the quantity of information access of relative quality. At the same time, in complete contradiction to their reaction use of the digital space, real emotion like frustration and rejection is often expressed through semantic way to the digital space or even directed to the device.

Today creativity (Human → Device)	Evolution Trend	Behavior in a futurist proactive environment (Digital system → Human ?)
Connectivity	Immediately	Emotion recognition: problem, question identification
Spontaneity	Complete	Vocal : knowledge providing
Energy	Virtual	Heath : preserving mental& physics
Captivating	Virtual	Digital environment
Transaction	Permanent	Digital environment, use of symbolic resources
Frustration	System regulated (software)?	Normative emotion regulation through compliance
Rejection	?	?

TABLE 4 Extrapolation of the previous table for future creativity in a complete hyper-connected proactive digital normative individual-centered environment characterised by symbolic resources. Individual or group frustration, novelty would not be regulated anymore by cultural, religious, economic or national considerations but mechanically software defined with a level of rejection or adhesion difficult to estimate at the present time. It is not easy to understand that in this futurist environment human or small group creativity would be completely inhibited. Imitation effects would also probably be maximised by similar connexion, stimulation, answer provided by the digital space. An open question is that in a complete digital system, the individual could be even in a sense aware of a problem, a question that trigger a creative process; cultural, knowledge, differences being completely and mechanically regulated.

FIGURES

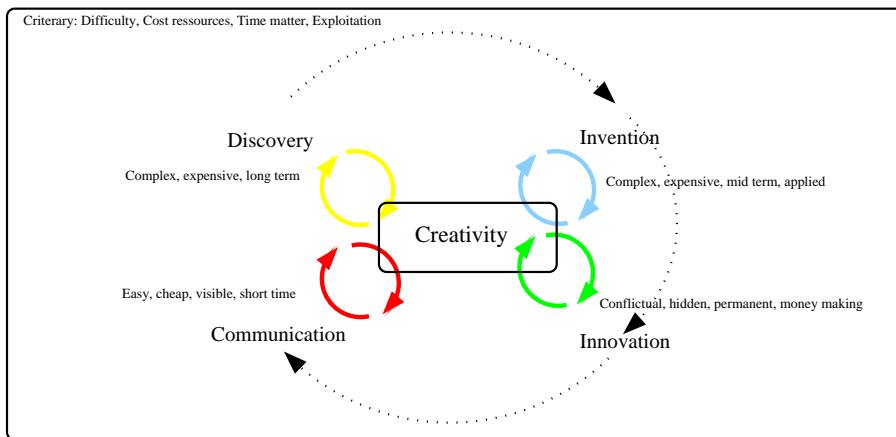


FIGURE 1 It is often claimed that “the linear global innovation process is dead” ^[11]. However have we foresee all the consequences ? Different outcomes results from a creative process: discovery, invention, innovation and finally communication. Each outcome is often confused by many actors and difficult to apprehend without experienced it. These outcomes are strongly different on many criterion such as difficulty, cost, ressources, timelines and exploitation.

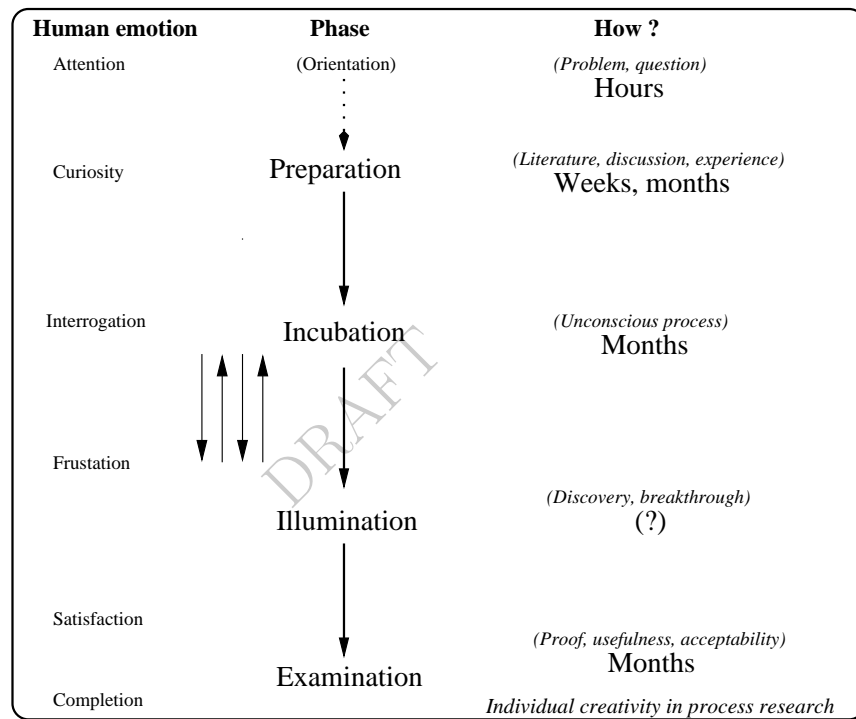


FIGURE 2 Empirical description of the mental individual creative processes inspired from the work the “art of thought” of Wallas^[22,24].

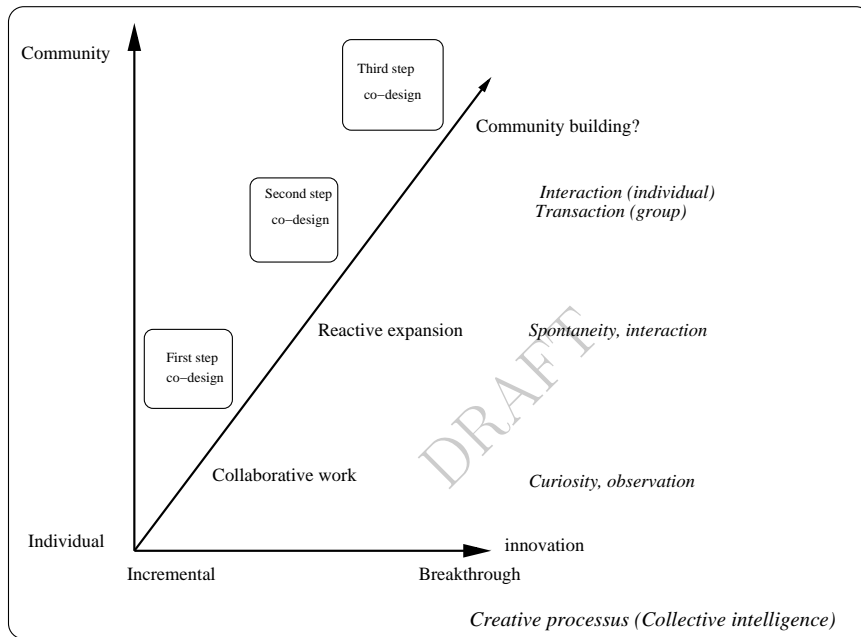


FIGURE 3 Collaborative creativity process based on collective intelligence and small group communication. Initially, the co-design approach aims at concurring the individual creative research process by maximising the interaction between participants in a short period of brainstorming, creative group^[28].

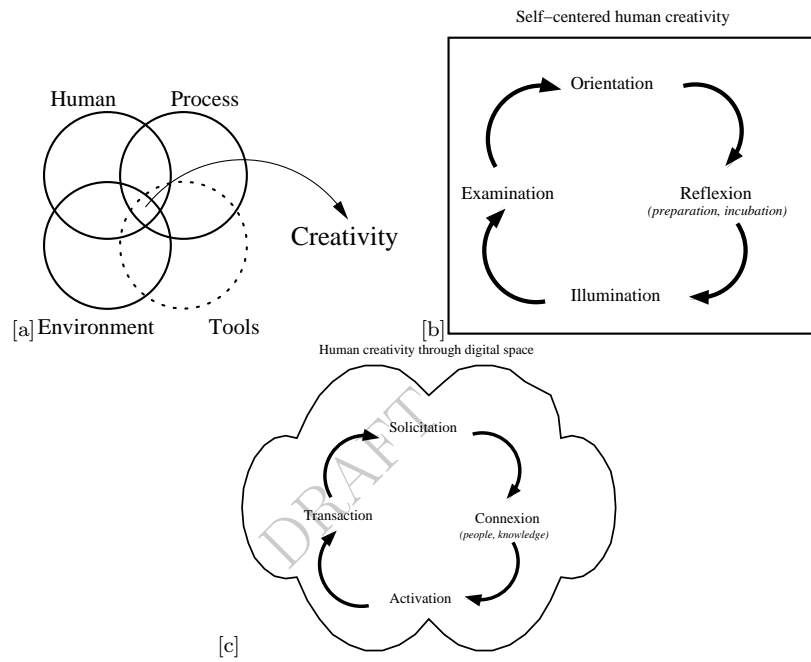


FIGURE 4 a) Creativity is both influenced and the result of human, process and environment. Probably, the influence of the tools used in human thought has been underestimated. b) Illustration of the paradigm shift from a self-centered human creativity to a human device related creativity through the digital space. c) The internal personal reflection, concentration process seems to have been replaced by emotion state close to “activation” corresponding to the act of captivating the environment or interacting with the device.

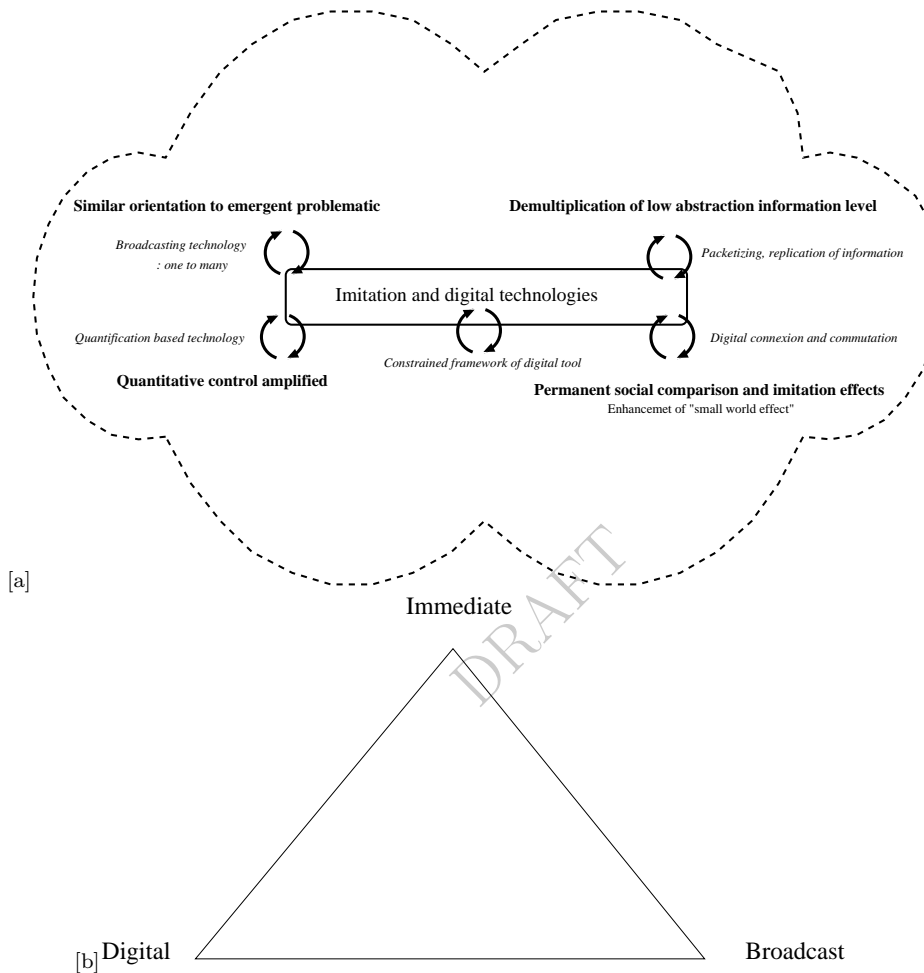


FIGURE 5 a) A key question is that imitation effect detrimental to creativity seems to be amplified by the use of modern technologies and the constrained framework provided by digital tools. Some hypothesis related to technology and application modern technologies can be drawn to explain the increase of imitation effects. b) Detrimental mechanisms of information relative to the art of thought and creation. Probably, the digital connexion provided by devices characterised by immediatly and also broadcasting of low information levels or knowledge depth could explained some side effects.

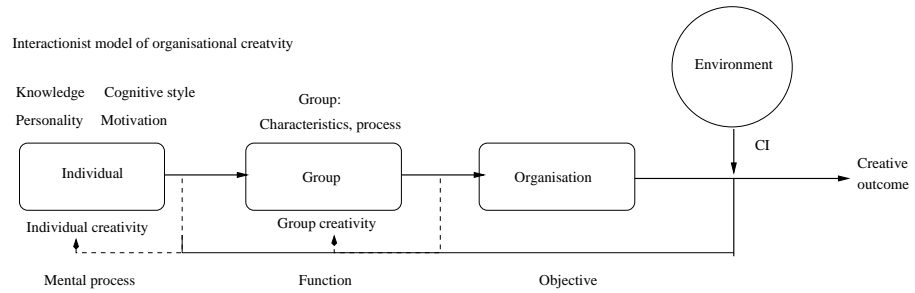


FIGURE 6 Interactionist model of creativity taking into group, organisational and environmental creativity [37].

Particular model of reactive human–device centered model of creativity through digital space

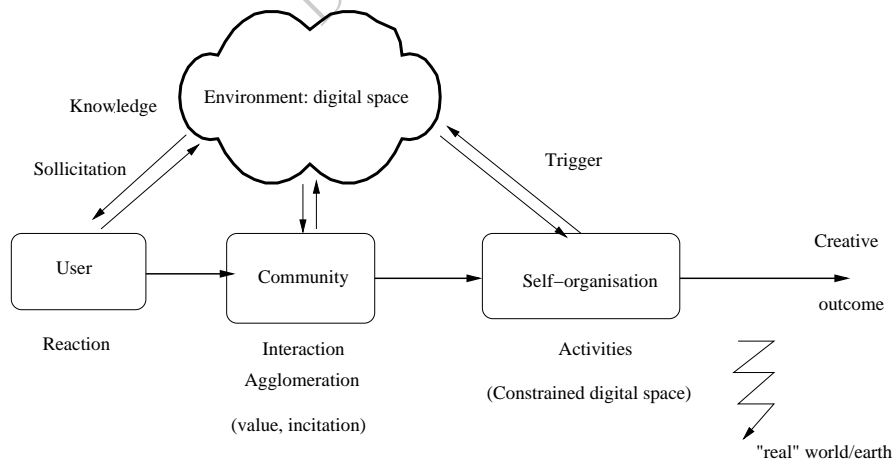


FIGURE 7 Potential description of an interactionist model of creativity through the digital space.

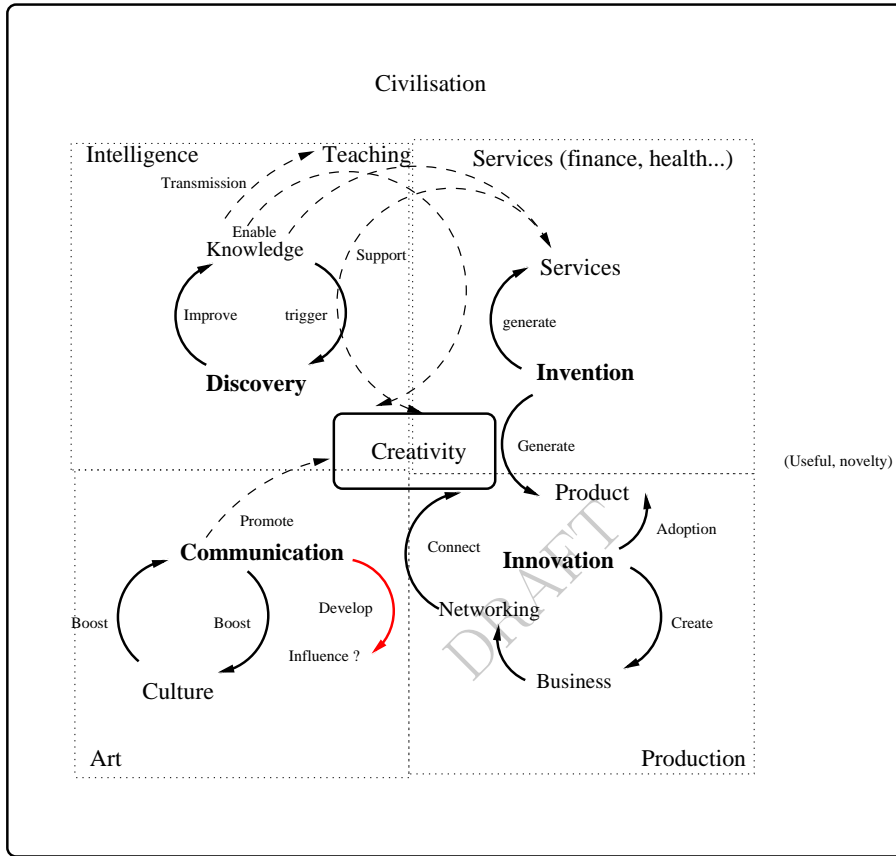


FIGURE 8 Creativity, his outcomes and interrelated domains. An illustration of some relationship between different fields of the society (Art, Intelligence, Production, Services). It could be observed that a discovery will improve our global intelligence (knowledge and understanding) and this new knowledge could be the support for transmission through teaching. It can also be observed that with invention and innovation of new product and services, the notion of usefulness and novelty has a meaning but it neglect completely the civilisation aspect illustrated by the left side (intelligence, knowledge and art). The main key issues is related to the first figure and the outcomes of global creativity and next also the loss of symbolic domain in the digital era.

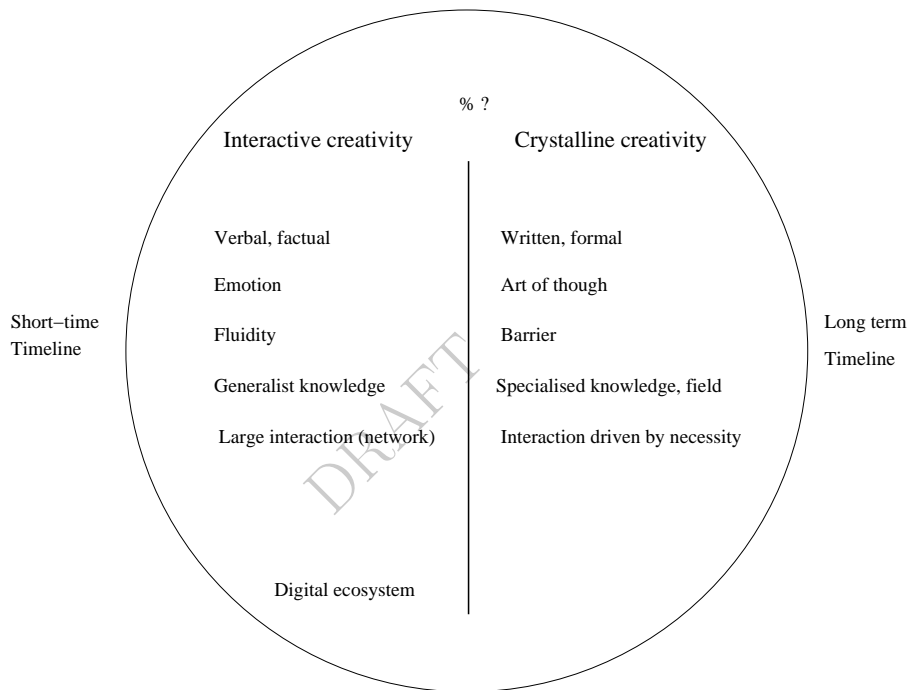


FIGURE 9 This figure summarizes the conflict between interactive and crystalline creativity completely different in terms of communication modes, tools, characteristics, interaction level and aim. The level degree between interactive and crystalline creativity is probably a key driver in terms of perceived economical performance.

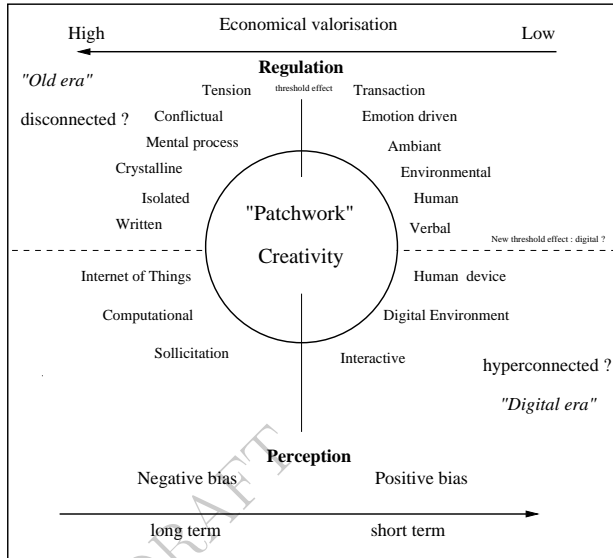


FIGURE 10 This figure attempts to summarize the different processes (mental, perception, emotion, interaction and finally computational) related to creativity. Creativity can be perceived with a positive or negative bias depending on many factors (civilisation, history) and takes probably a central part in the regulation of inherent societal contradictions. The conflict and contradiction between crystalline and interactive intelligence and their economical springing is probably more deeper that it was thought. In highly connected society, both human, interactive and environmental processes are positively perceived whereas on the other side crystalline and conflictual process are negatively biased while often exposed as a key success factor in the worldwide economical competition. The “outdated” threshold effect^[42] that characterize the minimum intelligence and knowledge related to problem solving, divergent thinking,.. has probably be replaced by a new threshold digital world where most of the mental process is not able to takes place letting the place to interactive and short time mental thinking. Global creativity is not so amorphous^[42] but more a “patchwork” mirroring the creative outcomes of the society^[?]], the perception and also the economical regulation associated reflecting a global fragmented bipolar societal which barely coexists at the age of the digital hyperconnected era ?

DRAFT

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