# The Dynamic Creativity Framework

## Theoretical and Empirical Investigations

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**Abstract:** The dynamic creativity framework (DCF) represents a new theoretical perspective for studying the creativity construct. This framework is based on the dynamic definition of creativity, and it has both theoretical and empirical implications. From a theoretical point of view, we review the characteristics of the dynamic creative process and its extension into the dynamic universal creative process, encompassing creativity at different layers of complexity. We discuss the key concept of creative potential, considering individual, sociocultural, and material viewpoints, and we show how the DCF is instrumental in clarifying the relationship between creativity and intelligence, between creativity and anticipation, as well as in introducing the concept of 'organic creativity'. From the empirical perspective, we focus on the dynamic creative process broken down into four phases: i) drive, ii) information, iii) idea generation, iv) idea evaluation. We review results obtained through investigations accounting for the dynamic interplay between emotional and cognitive components defining creative performance for each. Experiments were conducted to measure the role of emotions and attention in driving the dynamic process, considering the processing of apparently irrelevant information and the interaction between idea generation and idea evaluation, always taking into account individual differences as measured through personality traits, performance variables, or lifetime achievement. Neurophysiological evidence is considered in discussing dynamic effects in divergent thinking, such as the serial order effect, as well as the possibility to enhance creative potential through neurofeedback. Finally, we report on the effects of different environments on the creative process, highlighting the dynamics produced by context-embeddedness.

**Keywords:** dynamic creative process, creative cognition, emotions, attention, sociocultural creativity, neuroscience of creativity

## Introduction: Dynamics in Creativity Studies

In the radical transformation from the Industrial to the Information Society, creativity studies have become an essential target of scientific research. This is because when information is turned into a commodity, the generation of creative ideas becomes the essential element for the dignity and survival of every human being.

As a consequence, nearly exponential growth in the number of publications on creativity has been visible across the years 2000–2018 (Corazza & de Saint-Laurent, 2020), an analysis that can be projected onto the different regions of the world. In a search on the Web of Science with the keywords *creativity* and *creative*, one can see that more than 10,000 journal articles have been produced during that period. These can be mapped onto geographical regions by considering the affiliation of the main Author to find this distribution: Europe 4,463, North America 3,123, Asia 1,509, rest of the world 1,318. The relative majority of these articles are produced in the field of psychology, although many other disciplines are involved in creativity studies, such as economics, engineering, design, and the arts (Corazza & de Saint-Laurent, 2020). It is evident, therefore, that European psychologists are playing a very important role in this effort.

There are many angles and levels under which creativity studies can be tackled. Our approach has been geared toward the integration of multiple points of view and investigation levels, all based on a vision of creativity as a dynamic phenomenon (Beghetto & Corazza, 2019). We developed a theoretical framework based on the dynamic definition of creativity (Corazza, 2016), identified as the Dynamic Creativity Framework (DCF). The consequences of the adoption of the DCF were investigated at both the theoretical and empirical levels, as described in the following.

## Theoretical Aspects of the Dynamic Creativity Framework

Creativity is a fundamental concept with multifaceted implications for the human race. It has been the driving force behind the exponential growth of our culture (Enquist et al., 2008). A classic approach to the study of creativity includes 4P's: Person, Product, Process, and Press (Rhodes, 1961). This reflects the fact that creativity encompasses the engaged individual or group of individuals, the tangible or intangible products of one's creativity, the creative process with its resources, constraints, and methodologies that might lead to creative products, as well as the environment which embeds all of the previous entities. Creativity is, therefore, a complex construct that can be studied at many different levels: neuroscientific, cognitive, organizational, sociocultural, or even cosmological (Corazza, 2019b). Given this complexity, one of the problems in creativity studies has been to find a unique definition for the construct (Parkhurst, 1999). However, a standard definition of creativity does exist under which creativity can be recognized by measuring the existence of two requirements: originality and effectiveness (Runco & Jaeger, 2012). The two requirements have also found other names, such as novelty and utility or novelty and meaningfulness. As discussed below, adopting this standard definition leads to a static theoretical framework for the study of creativity, with several limitations. These can be overcome by adopting the dynamic definition of creativity (Corazza, 2016) and the ensuing DCF.

### The Dynamic Definition of Creativity

There are several difficulties in the standard definition of creativity. Who is entitled to the objective assessment of originality and effectiveness? What if there is no consensus, even among experts, or if this assessment changes across time and culture? What if an individual or group is engaged in a creative activity, but no product with the desired characteristics emerges? All of these problems descend from adopting a static vision of creativity and can be overcome by introducing the dynamic definition: "Creativity requires *potential* originality and effectiveness" (Corazza, 2016). By introducing the concept of potential inside the definition, it is possible to cover both the instances of creative achievement (which are the subject of the standard definition) and those of creative inconclusiveness. The latter is an extremely important part of the process: most of the eminent creators in the arts, science, and technology share the characteristic that they were able to withstand and persist throughout the difficulties and frustration of creative inconclusiveness.

It should be clear that the adoption of the dynamic definition of creativity shifts the focus of creativity studies from creative products/outcomes to the creative process (Corazza & Agnoli, 2015a). In the dynamic creative process (Corazza, 2020b), there is an emphasis on flexibility in focus and perspective, there is the possibility of including both relevant and irrelevant information, there is an iterative effort for idea generation, with much room for serial effects and individual differences, and there is a dynamic estimation of the ideas produced, which can be indefinitely refined and the value of which can change over time and culture. All of these aspects of the creative process, which have also been studied before, can now find a unified theoretical basis under the DCF. At the same time, new directions for dynamic measurement can be devised which hold the potential to reveal novel aspects of the creative process (Barbot, 2018; Carruthers & MacLean, 2019; Corazza, 2016).

### The Dynamic Universal Creativity Process (DUCP)

As recently discussed (Corazza, 2019b), through the adoption of a dynamic definition of creativity, it can be shown that all creativity episodes are interconnected through the mechanisms of concatenation, dynamic estimation, and exaptation. Exploiting the theory of complexity, it can also be argued that a wide-sense form of creativity can be identified at different layers of existence in our universe: material, biological, psycho-social, and artificial. In essence, when an unpredictable trajectory of evolution emerges at any of these layers, this becomes an episode with the potential for originality and effectiveness. In this view, since the big bang, all episodes can be concatenated into a single active ensemble, which can be identified as the Dynamic Universal Creativity Process, or DUCP (Corazza, 2019b; Corazza & Lubart, 2020). This cosmological view, which assigns a central role to creativity in the development of the universe, is perfectly in line with that of Alfred North Whitehead (Corazza, 2020a), who considered creativity to be the ultimate metaphysical principle.

### Potential in Creativity: Individual and Sociocultural Perspectives

One of the classic tensions between cognitive psychology, psychometrics, and neuroscience on one side, and social and cultural psychology on the other, is that the study of a construct should be mainly addressed from the perspective of the individual or from that of a sociocultural dialogue. In our approach, we have tried to address both sides of this apparent dichotomy to find reconciliation and integration under DCF perspectives. As an example, given the central importance attached to the concept of potential in the DCF, this concept has been addressed under three perspectives (Corazza & Glaveanu, 2020): individual, social, and material. In doing so, and exploiting the three frameworks of the 4P's (Rhodes, 1961), 4C's (Kaufman & Beghetto, 2009), and 5A's (Glăveanu, 2013), it is possible to show that the concept of creative potential can have up to 15 interpretations. In terms of the potential of an individual/person/actor, we can distinguish mini-c potential (one's potential for personal discovery and learning), little-c potential (one's potential for non-professional creative achievement), Pro-c potential (one's potential for professional creative achievement), Big-C potential (one's potential for eminent creativity), and embedded individual potential (creative potential of an actor embedded in a cultural milieu). Considering a process/action, it is possible to identify, discuss, and study the systemic process potential (potential for originality and effectiveness of a creative process depending on the involved system of resources, style, constraints, and challenges), the embedded process potential (potential for originality and effectiveness of a creative process embedded in a cultural milieu, with possible co-creation), and the universal process potential (cosmological potential of the Dynamic Universal Creativity Process). In terms of a product/artifact, four forms of potential can be distinguished: the instantaneous potential (potential for a real-time impression of originality and effectiveness), the experiential potential (potential for episodic memory impression of originality and effectiveness), the condensation potential (potential for time-enduring creative achievement transcending epochs), and the cultural evolution potential (potential impact on the cultural evolution of the human species). Finally, in terms of press/audience/affordance, three forms can be identified: the sociocultural context potential (potential for a dialogue of perspectives), the action potential (potential for originality and effectiveness in the affordances of a socio-material entity), and the virtual world potential (potential for discovering/inventing possibilities afforded by virtual entities in virtual worlds). All of these concepts contribute to one of the propositions of the so-called "Sociocultural manifesto of creativity" (Glaveanu et al., 2019), specifically the one regarding its dynamic nature.

## Intelligence and Creativity

Whereas the emphasis of our work is clearly on the creativity construct, we believe that it would be a mistake to neglect its relationship with the intelligence construct. As Sternberg emphasized:

> "Despite a substantial body of research, psychologists still have not reached a consensus on the nature of the relation between creativity and intelligence …. All possible set relations between creativity and intelligence have been proposed, and there is at least some evidence to support each of them. . . . The question is theoretically important, and its answer probably affects the lives of countless children and adults. We therefore need elucidation of good answers as soon as possible." (Sternberg, 1999, p. 87)

This has fundamental relevance for different branches of psychology: developmental, educational, as well as industrial, and organizational. Indeed, the relationship between these two constructs, which are key to the cultural growth of *Homo sapiens*, has been the subject of much scientific effort, but with the characteristics of a moving target. By exploiting the DCF, introducing equal-level definitions for intelligence and creativity, and a taxonomy for the classification of the embedding context, we were able to identify the conditions under which the two constructs are distinct, as well as those for which they are overlapping (Corazza & Lubart, 2021). For this purpose, the concept of the space-time continuum was introduced, where space represents the conceptual space in which thinking and behavior occur, and time represents that available time span to provide a response. Applying the concepts of tightness and looseness to these two dimensions, it is possible to build a continuum with four quadrants: tight space-tight time (TS-TT), loose space-loose time (LS-LT), loose space-tight time (LS-TT), and tight space-loose time (TS-LT). In a nutshell, intelligence dominates in TS-TT, whereas creativity does so in LS-LT. The two constructs overlap – and their associated cognitive/motivational components are shared – in the two-hybrid quadrants (Corazza & Lubart, 2021).

There are many ways of applying the space-time continuum in the analysis and measurement of the intelligence and creativity constructs. For example, one possibility is to map eminent persons who excelled in intelligence and creativity onto the quadrants of the space-time continuum so that one can classify their type of contribution. As examples, Pico Della Mirandola and Marilyn Vos Savant can be mapped on the TS-TT quadrant, having excelled respectively for memory and IQ score; Guglielmo Marconi and Steve Jobs fit well in the LS-TT quadrant, given their disruptive innovations produced on tight schedules against competition; Marie Curie and Henri Poincaré should belong to the TS-LT quadrant, given their success as scientists who solved problems of the highest complexity; finally, Leonardo da Vinci and Vincent Van Gogh can be considered champions of the LS-LT quadrant, having produced outstanding creative work while living in unfortunate and under-appreciated conditions.

## Organic Creativity and Anticipation

We feel it is important to consider the relationship between the development of creativity and well-being. This is particularly crucial in our modern society, where the growing influence of technology and its impact on our lifestyle and happiness is far from being purely and simply positive. In this framework, we introduced the concept of *organic creativity*, intended as "the potential for originality and effectiveness conducive to personal and social well-being" (Corazza, 2017b, 2019a). This definition builds on the dynamic definition for creativity (Corazza, 2016), adding the general requirement of its interrelationship with human health and happiness. An important point is in order here: clearly, well-being can and should be pursued in many alternative ways that do not necessarily require creative behavior. As an example, mindfulness and meditation are valid routes. However, it is important to emphasize that the critical peculiarity implied by organic creativity is that the pursuit of happiness is coupled with a *productive* behavior intended to exploit all of the potential benefits provided by the technological assets of the Information Society, and not at all detached from it. Once established, this approach calls for new forms of psychological and social intervention, all based on creativity. The importance of organic creativity cannot be overestimated: human dignity itself depends on creative behavior in the Information Society.

Given the continuous evolution from the Information Society to what can today be identified as the Post-Information Society, characterized by exponentially growing levels of interconnectivity and artificial intelligence, organic creativity must be supported by the tools and methodologies of future studies, and in particular by the use in the present of foresight for multiple possible scenarios, a discipline known as *anticipation* (Corazza, 2017a).

We conclude this overview of the theoretical aspects of the DCF by noting that these can become the subject of courses at undergraduate or graduate levels, which should, however, be complemented with practical applications on realistic projects (Corazza et al., 2016).

## Empirical Aspects of the Dynamic Creativity Framework

The empirical investigation of the DCF must face the complexity of measuring the creativity phenomenon, considering its dynamic features. This complexity can be addressed by identifying a *fil-rouge* that encompasses the main peculiarities of the DCF. From a psychological perspective, the individual creative thinking process can represent a limited but valid experimental proxy of the more comprehensive and superordinate DCF. In the individual creative thinking process, we can indeed identify the time/space dynamics in the interactions between the multi-dimensional set of components that lead to the generation of ideas with a potential for originality and effectiveness. Considering the main theoretical models defining a creative thinking process (e.g., see Corazza & Agnoli, 2015b; Lubart, 2001), four main parts can be identified:

(I) drive, comprising the emotional and motivational forces enabling the process;
(II) information, that is, the cognitive functions processing the information which will be used in the generation of ideas;
(III) idea generation, leading to the emergence of potentially original and effective ideas;
(IV) idea evaluation, involving the dynamic extraction of value from the generated ideas.

These four parts defining a creative thinking process can be intended as fundamental attractor states during a dynamic creative process in a thinker's mind. These attractors organize the main components constituting the creative thinking process around stable states, which dynamically interact with each other aimed at the potential generation of original and effective outcomes. Even if these four states can be intended as sequential stages during a creative process, it is worth highlighting that they dynamically interact and influence each other in an emergentist modality so that a recursive iteration between states can change the equilibrium within every single state and therefore reorganize (i.e., re-define) each of the states. The drive state, which essentially conveys the motivational aspects guiding the creative process, activates the entire process and, in particular, the information state, which fundamentally processes internal (i.e., memory) and external (i.e., environmental) information guided by cognitive control and the regulation of the attentional focus. The generative state, which is essentially grounded on internally focused processes, can operate on the basis of the information sources organized through the information state and strictly interacts with the evaluation state, which acts as a meta-control state for the entire process, refining not only the generative process but also the motivational and attentional focus of the process. In the following sections, a collection of results from experimental and correlational studies drawing on this perspective is described.

### Part (I) Creative Drive: Dynamics in the Emotional and Cognitive Determinants of the Creative Thinking Process

What are the forces enabling the creative thinking process, the drivers allowing it to rise and last in time? This question should be considered as the starting point for a comprehensive exploration of the dynamic creative thinking process. This involves the understanding of the motivational and cognitive sources sustaining creativity. Much effort has been devoted to this in creativity studies. The study of the different forms of motivation (e.g., extrinsic and intrinsic motivation; Amabile, 1993; Ryan & Deci, 2000) and of the emotional and mood states sustaining or damaging creative thinking (Baas et al., 2008; De Dreu et al., 2008) highlighted the substantial influence of mood and emotions as the main drivers of the process (Khalil et al., 2019). Research on the relationships between dopaminergic systems and creative cognition revealed how biological motivational (reward) systems are fundamental for driving several cognitive processes during creative thinking (Colzato et al., 2009; Runco et al., 2011; Zabelina et al., 2016). Agnoli & Corazza (2019) recently suggested that emotions (intended as multifaceted phenomena including motivational states, action readiness, etc.; see Scherer, 2009) are the "spinal cord" of the creative thinking process, acting as controllers for the direction of the process and as energetic forces sustaining the cognitive determinants of the process.

In a dynamic analysis of the creative drivers, it is essential to understand a) how these forces dynamically influence the different mental states defining the creative process (thus determining creative performance), b) how these forces are influenced by the process, as well as c) how drivers could emerge dynamically during the process. Moreover, the reasons why individuals are differently able to manage these forces should be taken into account to understand the exceptional variance in the phenomenology of creativity.

In line with these questions, Agnoli et al. (2019a, 2019b) explored the relationship between emotional states and cognitive-attentive processing during a creative process characterized by repeated evaluations, also taking into account the role of individual differences in managing emotional states (i.e., differences in trait emotional intelligence, trait EI; Petrides & Furnham, 2003). The goal was to understand how emotional forces could influence attentional processing in a divergent thinking task designed as a visual version of the Alternative Uses Task (AUT, Guilford, 1967) and thus dynamically influence performance. Emotions were specifically elicited through experimental manipulation. Participants were told that a new algorithm was able to interpret and judge their responses automatically with respect to a large database. In reality, to one group of participants, repeated failure feedback was delivered at the end of each of five blocks of trials ("Your responses were not creative"), while to another group, repeated success feedback was provided ("Your responses were creative."). Since this repeated evaluation condition was experienced by the participants – irrespective of the positive or negative nature of the feedback – as a stressful condition, this state influenced the attentive processing of information. However, as shown in Figure 1, individual differences in managing this stressful condition were essential in driving emotional energy, which induced either a broadening or a narrowing of the focus of attention (as measured by eye-tracking). Whereas high trait EI participants broadened the focus of attention by paying attention also to stimuli that were apparently irrelevant to the task at hand, low trait EI participants narrowed their attentive focus, concentrating only on task requests. Confirming the result that attention broadening increases creative performance (Carson et al., 2003), the inclusion of apparently irrelevant information in the process increased response originality. It is, therefore, possible to note the dynamic interplay between emotions, attention, information processing, individual differences, and originality.

Emotional states increased in negativity for the failure condition and increased in positivity with positive feedback. Whereas increased activation in the positive condition was in general associated with increased performance irrespective of EI trait differences, in the negative condition, individuals low in trait EI dropped in performance (see Figure 2, showing a decrease in originality with the increase of emotional activation), and high trait EI participants showed a progressive increase in performance (in originality) with the increase of emotional arousal (Figure 2) – that is, they were able to exploit negative emotional energy to persist and achieve more in the task.

This study exemplifies the necessity of a dynamic approach in the study of the drivers guiding the creative process, which are emergent phenomena subject to individual differences. In this specific case, the drivers guiding the process emerge as emotional forces (i.e., arousal) resulting from the dynamic interaction between idea generation and idea evaluation, influencing attentional processing at the basis of idea generation and thus defining creative performance. However, the exploitation of this energy is the domain of individual differences, which define creative achievement (i.e., higher performance in a creative task). Individual differences should therefore be considered a main constituent in the dynamics defining the creative thinking process (and not as external influencers of the process), acting as enzymes in the activation of specific energetic drivers, in that they can direct (by activating or discarding) the energy emerging from the process itself.

## Part (II) Processing Irrelevant Information: Openness, Mind Wandering and Hallucinations

As soon as the creative process is primed by emotional forces, pertinent cognitive resources are activated in a charged motivational state. Motivational states are defined

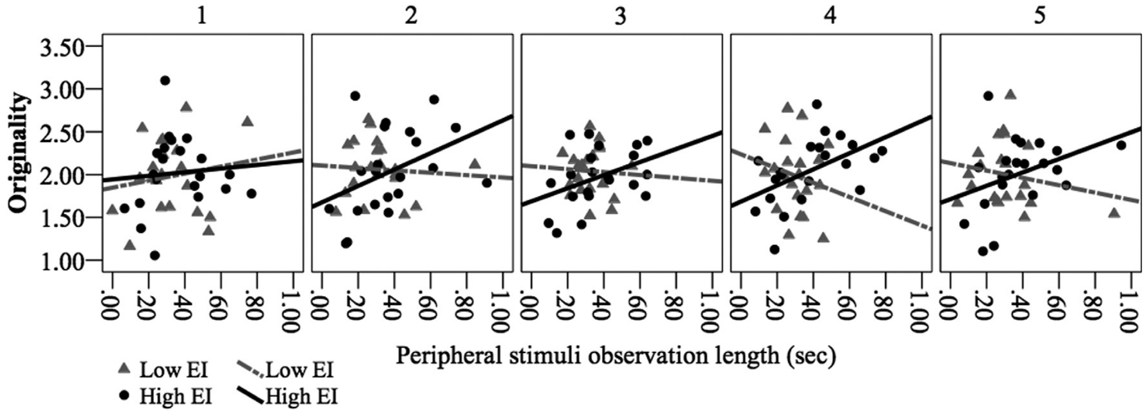


**Figure 1.** Relationship between fixation length of information that was irrelevant for the task (peripheral stimuli) and originality in low trait EI (gray triangles and dotted line) and high trait EI (black dots and continuous line) participants, in the five task blocks at the end for which they received evaluation of their ideas. Figure reprinted from Agnoli et al. (2019a), *Personality and Individual Differences*, *142*, 242–248. © (2019), with permission from Elsevier.

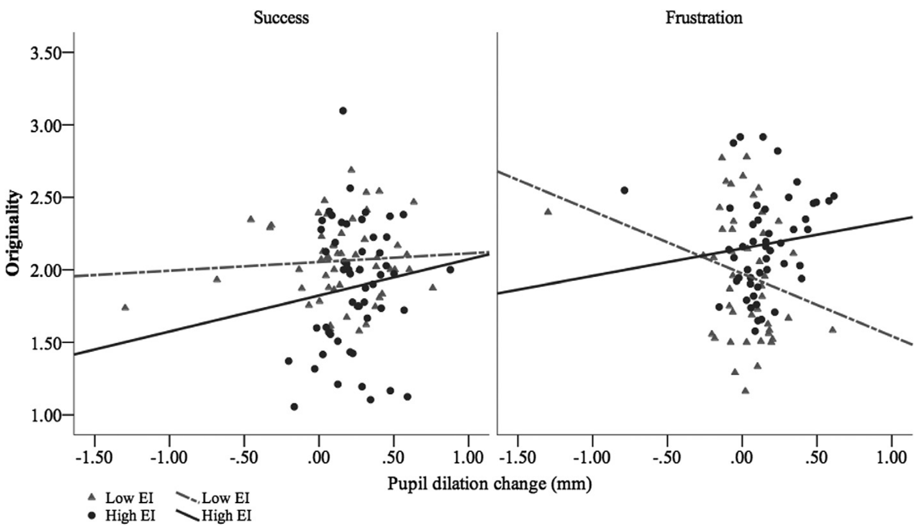


**Figure 2.** Relationship between affective arousal (pupil dilation change) and originality in low trait EI (gray triangles and dotted line) and high trait EI (black dots and continuous line) participants in the positive–success (left panel) and in the negative–frustration (right panel) condition. Figure reprinted with permission from Agnoli et al. (2019a), *Personality and Individual Differences*, *142*, 242–248. © (2019), with permission from Elsevier.

by emotional and cognitive constituents, with the latter being particularly related to attentional processes. The top-down control of attention is a primary topic of research in creative cognition (and motivation), showing, for example, how attention is directed toward the goal of preserving resources during idea generation (Benedek & Fink, 2019). Understanding cognitive control within the process, and specifically the role of attention, is extremely important for understanding the dynamics of the creative process (Benedek et al., 2016; Benedek & Fink, 2019; Zhang et al., 2020). However, the existing literature presents mixed results. Several studies have shown the importance of attentional mechanisms aimed at preventing external distractors from interfering in the process (Annerer-Walcher et al., 2020; Benedek, Schickel, et al., 2014; Ceh et al., 2020; Walcher et al., 2017); however, a number of studies have also offered evidence that inspiration coming from apparently irrelevant information might be essential in obtaining outstanding outcomes. An attitude that promotes broadening the focus of attention (strictly associated with a curious mindset and open-minded tendencies; Peterson et al., 2002) has also emerged as a clear precursor of highly creative achievement (Carson et al., 2003), which seems antithetical to the idea of highly focused attention as a positive factor in creative performance. The creative thinking process may thus emerge both from attention toward task-relevant goals (a top-down mechanism of internally oriented attention) and from spontaneous attentional shifting to an apparent distraction (Zabelina, 2018; Zabelina & Andrews-Hanna, 2016). This claim is in line with the

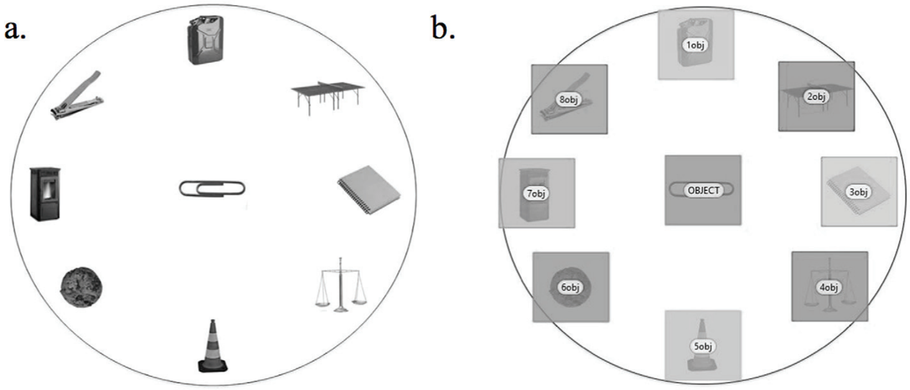


**Figure 3.** Two examples of AUT stimuli, with the target object in the center and eight irrelevant objects surrounding it. Figure reprinted with permission from Agnoli et al. (2019a), *Personality and Individual Differences*, *142*, 242–248. © (2019), with permission from Elsevier.

literature that describes creativity as emerging from a balance between a continued persistence to succeed and the ability to switch flexibly between different concepts (Hommel, 2015; Nijstad et al., 2010; Zhang et al., 2020). According to the dual pathway to creativity model (De Dreu et al., 2008; Nijstad et al., 2010), flexibility and persistence represent the two pathways to achieving creativity. The flexibility pathway is characterized by low levels of cognitive control, higher mind-wandering, and distractibility (Dreisbach & Goschke, 2004; Nijstad et al., 2010). This pathway seems to depend strongly on defocused attention. However, persistent processing is also necessary to maintain focus on the task long enough to find original and effective outcomes (De Dreu et al., 2012; Vartanian, 2009). The persistence pathway seems thus to depend on focused attention. This apparent paradox may be resolved through a deeper understanding of the dynamic role of attention in the creative process that reflects the idea that different attentional mechanisms assume different roles depending on the state of the system: broadening vs. narrowing of attention can produce benefit vs. detriment on creative performance depending on the moment in which they occur in the process.

Therefore, it is essential to experimentally dissect the temporal dimension of the creative process to understand the dynamic role of attentional processing. In this view, it is useful to study information processing and idea generation separately. This is clearly an analytical device to help our understanding, as in reality, these two states are deeply intertwined. Participants in a study by Agnoli et al. (2015), which had a setup similar to the AUT setup described in the previous section, were shown a computer screen displaying a series of common objects for which they were asked to produce alternative original uses. In addition, irrelevant objects were displayed in a circle around each target object (see Figure 3). The purpose was to understand attentive mechanisms for this task in these conditions. An eye-tracker was used to measure the focalization of attention on the target object vs. the irrelevant objects. After a period of free observation, participants were told to press the space bar, making the objects disappear, and were then asked to produce alternative uses. This paradigm made it possible to separate the information processing and idea generation phases. Moreover, individual differences in the openness personality trait were measured. Results showed that the processing of irrelevant information was positively related to performance in idea generation and, in particular, to originality. Further, individual differences in the openness personality trait were central in defining achievement in this task and, in particular, in processing irrelevant information. As consistently confirmed by the literature (for a review, see Corazza & Agnoli, 2020), openness was associated with better performance in creative tasks as well as higher lifetime creative achievement levels. Specifically, this study showed that the processing of irrelevant information (length of observation of irrelevant information as measured by eye-tracking) interacted with openness trait in predicting creative performance (i.e., originality) and creative achievement (as measured by the Creative Achievement Questionnaire; Carson et al., 2005), and through a moderation model, it was demonstrated that irrelevance processing is the cognitive/attentive mechanism that moderates the relationship between openness and creative performance and lifetime achievement.

The importance of different dispositions in the use of information in creative thinking can also be highlighted in the study of mind wandering (see Vannucci & Agnoli, 2019). With mind wandering, we identify an attention shift from the primary task "away from the here and now towards one's private thoughts and feelings" (Smallwood et al., 2007, p. 818). Again, mixed results emerge from the literature on the relationship between mind-wandering and creativity. On one side, mind-wandering appears to be detrimental to creative performance if activated during the idea generation phase, introducing distractors into the process (Hao et al., 2015). On the other side, increased mind wandering has been associated with increases in creative performance (Baird et al., 2012; Gilhooly et al., 2012).

Recent studies have demonstrated the multi-dimensionality of mind wandering, emphasizing the importance of distinguishing between spontaneous (without intention) and deliberate (with intention) mind-wandering (Seli et al., 2016). In a recent study (Agnoli, Vannucci, et al., 2018), distinguishing between these two forms of mind wandering, deliberate mind-wandering emerged as being associated with originality in divergent thinking tasks. This finding highlights the importance of deliberate cognitive controls over the creative process; specifically, the ability to switch attention from the actual ongoing task to apparently unrelated information could be crucial for creative ideation in that it could allow a richer array of information to be used during ideation. The role of mind-wandering on creative performance was also recently confirmed by a study on patients affected by Narcolepsy Type 1 (NT1; D'Anselmo et al., 2020), which showed that narcoleptic symptomatology (and, in particular hypnagogic hallucinations) interacted with patients' mind-wandering tendencies, influencing their creative performance. Hypnagogic hallucinations have been interpreted as triggers for mind wandering in NT1 patients, suggesting that narcoleptic patients might use specific symptoms in their creative thinking process in order to increase their creative potential.

## Part (III) Idea Generation: Temporal Dynamics in Cognitive and Neurophysiological Processes Associated With Divergent Thinking

In the last two decades, the neurophysiological study of creative behavior, and in particular of divergent thinking, has produced a number of results on the dynamics and organization of specific cerebral functions involved in such a complex phenomenon (see e.g., Fink & Benedek, 2014). Monitoring brain activity through electroencephalography (EEG) during divergent thinking tasks allows researchers to tap in the temporal dynamics underlying the progressive generation of creative ideas. Reading neurophysiological results within the dynamic theoretical framework puts the focus on time-dependence (Corazza, 2020b): ideation is far from a static process, as it works dynamically at both its interior and in joint action with other components, such as the evaluation of ideas (see Mastria et al., 2018). For this reason, we define idea generation as a dynamic phenomenon that changes as a function of the time dimension in this study. In the following, we discuss empirical findings in support of this dynamic perspective on the neurophysiological study of creativity.

During a divergent thinking task, such as the AUT, the fluency of ideas progressively decreases, whereas the potential for their originality grows over time. At the behavioral level, this pattern is classically called the "serial order effect" (Christensen et al., 1957; Johns et al., 2001; Phillips & Torrance, 1977). A possible explanation may be that individuals tend to progressively inhibit more conventional ideas, which come to mind first, in search of more original ideas (Benedek, Jauk, et al., 2014; Wang et al., 2017). The dynamicity of such a phenomenon can also be observed at the neurophysiological level because it is possible to trace specific temporal brain dynamics as a function of the varying quality of ideas produced during idea generation. One brain wave, in particular, is especially sensitive to the temporal dynamics underlying the serial order effect: the alpha band in the frequency range of 8–12 Hz. Focusing on this band, a recent study (Agnoli et al., 2020) developed a novel experimental design, a structured version of the AUT that allowed researchers to track the sequential generation of alternative ideas in four ordered and distinct time periods (see Figure 4).

The results showed that alpha power progressively increased as a function of time over the temporoparietal scalp region (especially in the right hemisphere), from the first (most obvious) alternative use to the fourth (most original) response produced by participants (see Figure 5A). Notably, these results also revealed that alpha power predicts ideational originality, as assessed by external judges, as a function of the temporal order of the generated alternative response and that this effect dynamically changed as a function of the considered scalp region and hemisphere. Interestingly, as shown in Figure 5B, the participants' creative achievement level in the task, measured by comparing low originality achievers to high originality achievers, was strongly correlated to alpha power as a function of time on the involved scalp area and hemisphere. Specifically, only high originality achievers showed extensive increases in alpha power over the right central and posterior scalp regions.

These results demonstrate the existence of dynamic patterns of alpha-band brain oscillations that change as a function of the temporal production of alternative responses during divergent thinking and highlight the importance of considering individual differences. This is a concrete example of the adoption of a dynamic, rather than static, perspective in the study of creative thinking using a neurophysiological approach.

As we have seen, individual creative potential plays a crucial role in the DCF (Corazza, 2016, 2020b). It is interesting to understand the implications of this fact at the neurophysiological level, exploring the possibility of dynamically enhancing creative potential, for example, through neurofeedback. A study representative of this research direction (Agnoli, Zanon, et al., 2018) investigated the effectiveness

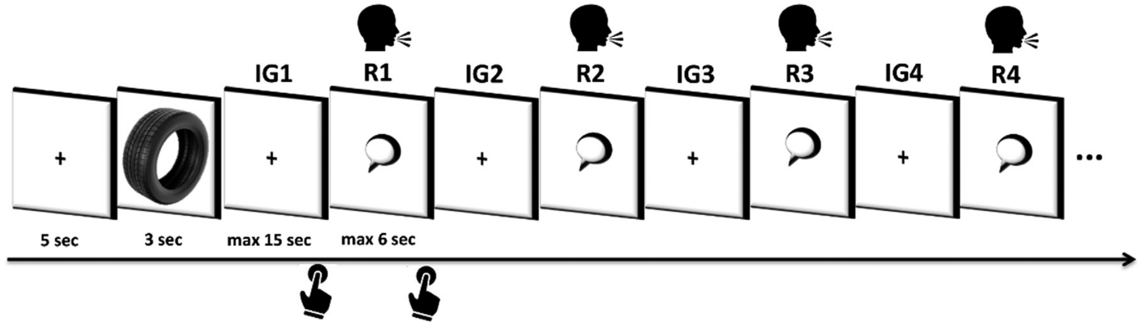


**Figure 4.** In each trial, participants were required to provide four alternative responses (i.e., R1; R2; R3; R4) for the same object in four distinct idea generation intervals (i.e., IG1; IG2; IG3; IG4). Figure redrawn from Agnoli et al. (2020), *NeuroImage*, *207*, Article 116385. © (2020), with permission from Elsevier.

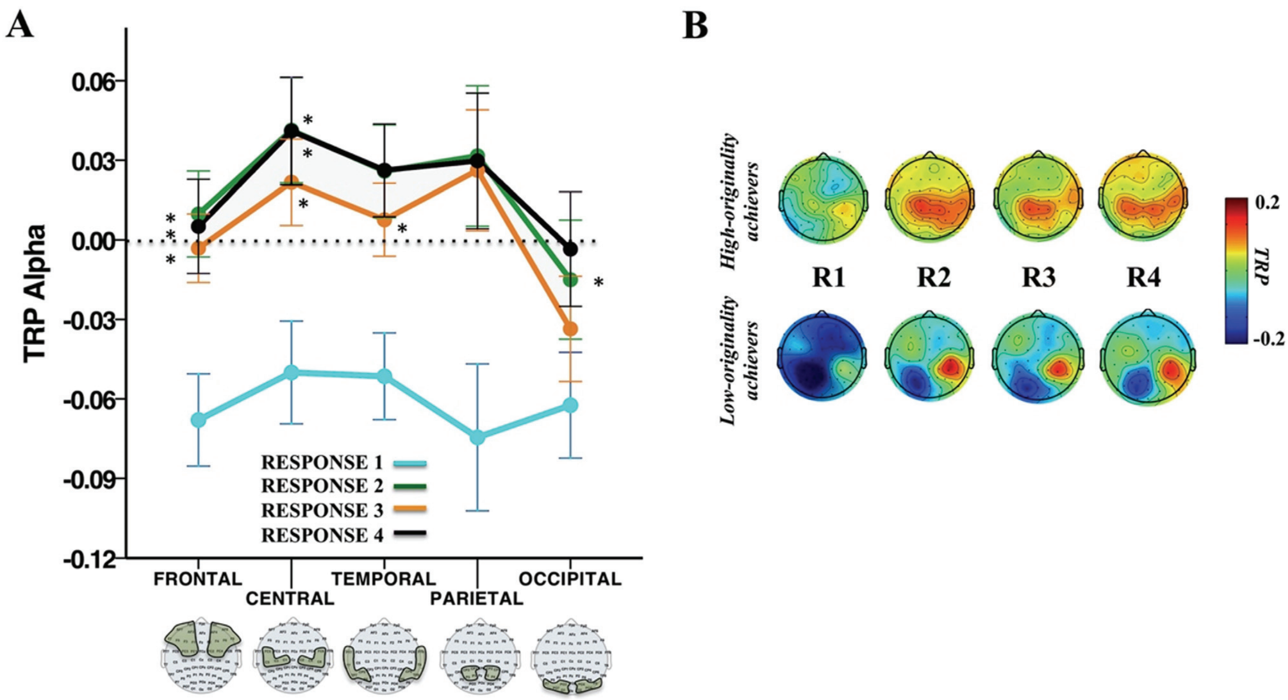


**Figure 5.** (A) Task-related alpha changes in the five cortical areas (frontal, central, temporal, parietal, and occipital) as a function of the four alternative uses generation (R1, R2, R3, and R4). (B) Scalp maps depicting the topographical distribution of task-related alpha changes for each response as a function of participants' creative achievement level in the task. Figure redrawn from Agnoli et al. (2020), *NeuroImage*, *207*, Article 116385. © (2020), with permission from Elsevier.

of a novel, rapid (2-hours) neurofeedback training (NFT) procedure designed to enhance alpha/beta band power as well as the participants' creative potential. The loop was closed over the right parietal region (previously associated with creative thinking; see, e.g., Benedek et al., 2011, 2016; Benedek, Schickel, et al., 2014; Fink et al., 2007, 2011). Visual feedback (i.e., a video stream characterized by a dynamic sequence of different pictures of natural scenarios) was provided when the alpha or beta activity in the target region increased more than 30% above the resting state level. A sham condition was included, coupled with both alpha and beta NFT training. The first result was that the NFT protocol effectively increased the time when alpha/beta activity in the right parietal region exceeded the threshold, but this did not happen in the sham condition (see the insert in Figure 6).

After each NFT session, an AUT was administered. Interestingly, the beta NFT protocol strongly improved AUT performance, particularly in those participants characterized by low creative achievement (see bar charts in Figure 6). As a whole, these findings demonstrate a causal and progressive involvement of enhanced specific brain oscillatory activities in improving individual creative potential, opening important reflections about potential practical benefits in

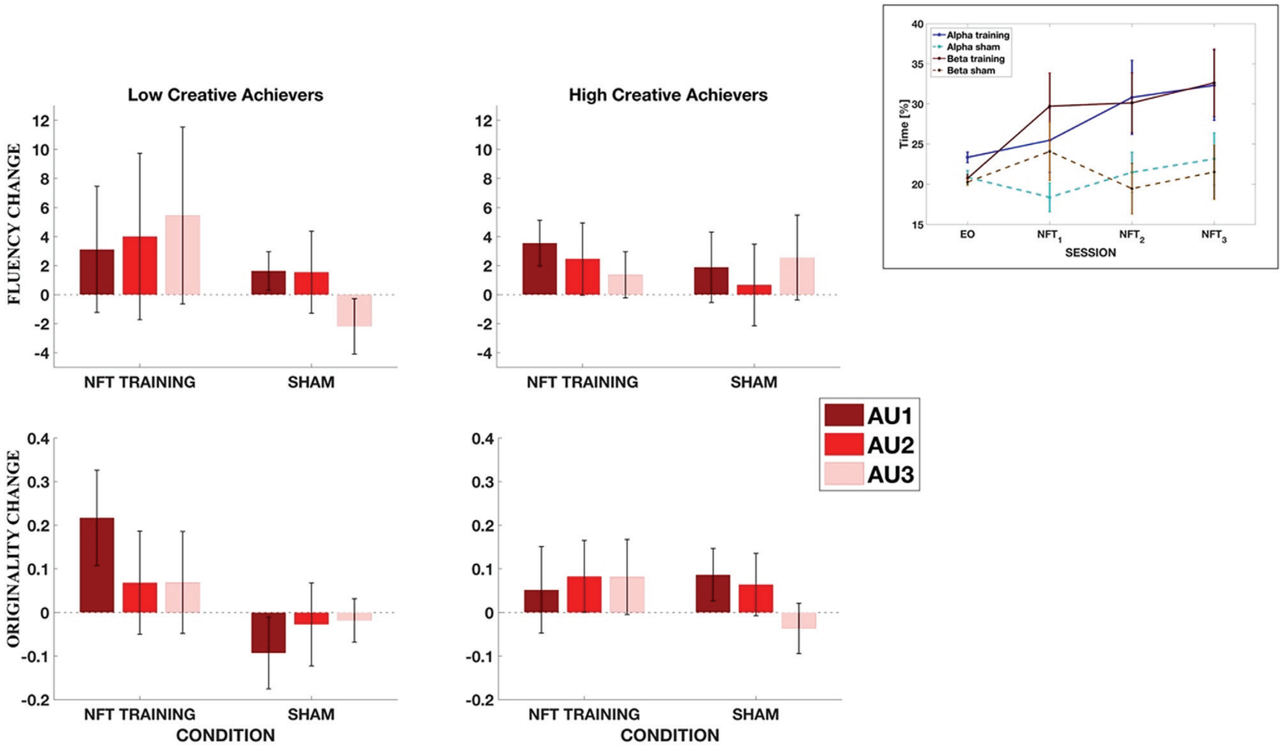


**Figure 6.** The insert shows the mean percentage of time (%) above threshold for both protocols (Alpha and Beta) as a function of SESSION (EO, NFT 1, NFT2, and NFT3), and CONDITION (Training and Sham). The bar charts show mean differences in fluency (top bar chart) and originality (bottom bar chart) as a function of SESSION (AU1, AU2, AU3) and CONDITION (NFT Training, Sham) for low and high creative achievers in the Beta NFT protocol. Figure redrawn from Agnoli, Zanon, et al. (2018), *Neuropsychologia*, *118*, 99–106. © (2018), with permission from Elsevier.

our daily lives offered by such a short training procedure based on brain physiology. Once again, individual differences in terms of creative achievement play a key role and should be considered in recognizing creative behavior and its potential improvement.

## Part (IV) Idea Evaluation: The Role of Emotions

The interactive relationship between idea generation and idea evaluation is pervasive in most psychological theories of the creative thinking process. Compared to other components of creativity, evaluation has a clear social element to its nature as it entails a direct or indirect comparison with the sociocultural environment in which the creator is embedded. The possibility of feeling frustration or joy during evaluation is high because of the subjectivity in defining originality and effectiveness within a specific sociocultural milieu. An interesting question arises: how does emotional state affect evaluation?

To answer this question, we built an ad hoc experimental paradigm (Mastria et al., 2019) in which emotions acted as drivers of the idea evaluation process. The task was designed as a proxy for an external evaluation process, requiring participants to evaluate exogenous (generated by others) ideas under diverse emotional engagement. The aim was to understand how diverse emotional states (positive, neutral, and negative) influence the process of idea evaluation. The hypothesis at the beginning of such a study was that positive emotions would lead to assessments of higher quality in others' ideas, which would result in higher scores, whereas negative emotions would lead to more critical evaluations. In practice, we asked participants in a state of emotional engagement to evaluate the creativity of exogenous ideas involving uses for everyday objects, which were pre-classified as non-creative, moderately creative, and highly creative (see Figure 7). We expected that the impact of emotion on idea evaluation would change as a function of the level of idea creativity.

We observed that positive emotions, compared to negative or neutral ones, facilitated accurate evaluation of non-creative and highly creative uses. The evaluation of moderately creative uses was specifically sensitive to negative emotions, perhaps due to a sense of uncertainty (Mueller et al., 2012) about whether those ideas were appropriate (e.g., a bicycle as a slide), resulting in participants in negative emotional states assigning lower scores for creativity.

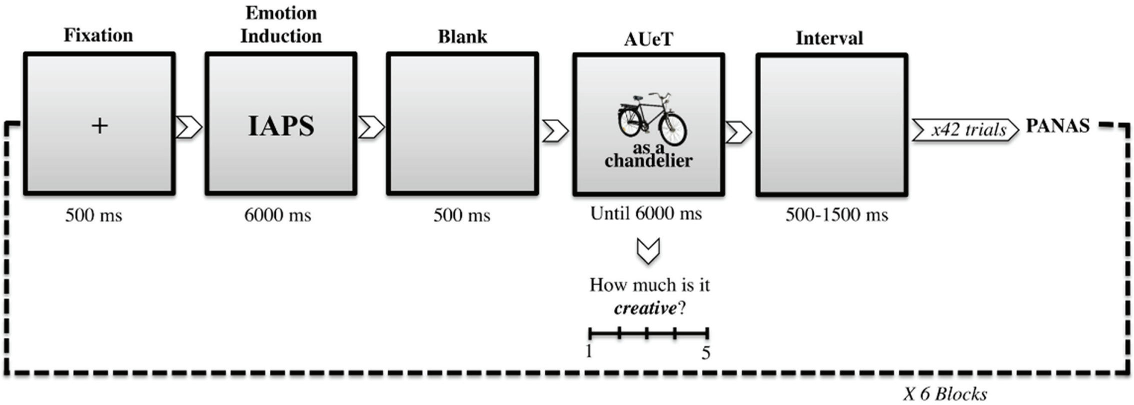


**Figure 7.** In each trial, after a fixation cross of 500 ms, a natural scene (derived from the International Affective Picture System, IAPS; Lang & Bradley, 2007) was visible for 6,000 ms. After a blank screen (500 ms), a picture of an object and a verbal description of a proposed use was shown until the participant evaluated the creativity of that use using the 5-point scale. A variable interval of 500–1,500 ms preceded the next trial. Figure redrawn from Mastria et al. (2019), *PLoS One, 14*(7), Article e0219298.

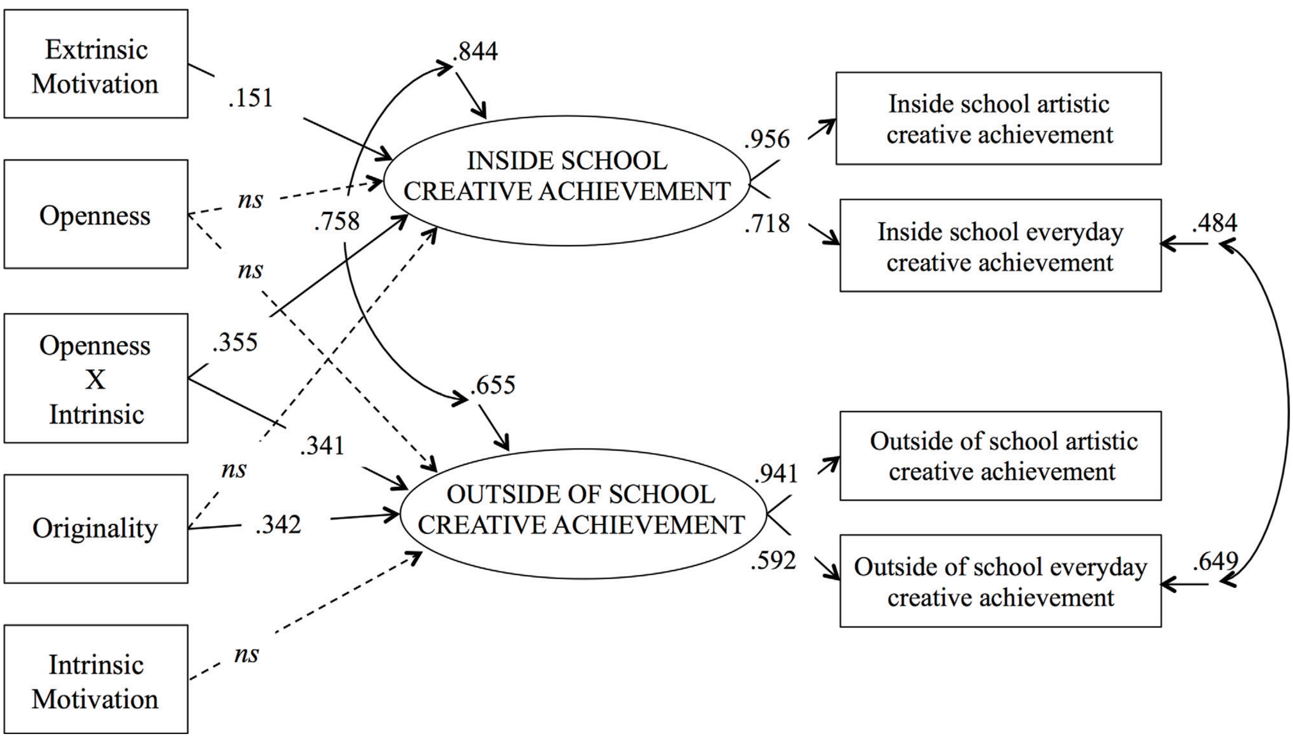


**Figure 8.** Structural model predicting inside and outside school creative achievement through the inclusion of different layers of variables. Openness × Intrinsic = interaction of openness to experience with intrinsic motivation. Figure reprinted from Agnoli, Runco, et al. (2018), *Thinking Skills and Creativity*, *28*, 167–176. © (2018), with permission from Elsevier.

This study offered preliminary evidence of the impact of evaluators' emotions on their judgments of the creativity of others' ideas as a function of the nature of the idea.

As a whole, emotions seemed to be intrinsically embedded in and to pervade the process of idea evaluation and the entire creative thinking phenomenon, acting as effective "controllers" of the dynamic creative process (Agnoli & Corazza, 2019).

## The Creative Process in Context: Exploring the Determinants of Creative Achievement

Although laboratory experiments are essential for the control and manipulation of variables, we must recognize that the creative thinking process is deeply embedded in sociocultural context (Glaveanu et al., 2019). Several studies have addressed the role of different domains as enablers of the dynamic effects of context, considering domain-general vs. domain-specific characteristics of the creative process (Feist, 1998; Kaufman & Baer, 2005; Silvia et al., 2009), or specifically aiming at the study of creativity in the arts, in science, as well as in various professional domains (Botella & Lubart, 2016; Botella et al., 2018; Corazza & Agnoli, 2018). Along this line, we addressed the role of context through a series of correlational studies. The common starting point for these studies was the necessity to consider multiple layers of analysis (see the test battery in Agnoli et al., 2016). As a first example, using a sample of undergraduate students, researchers investigated the interaction of personality traits, motivational tendencies, and creative cognition to understand the constituents of creative achievement within and outside of the school environment (Agnoli, Runco, et al., 2018). This study showed the dynamic weight of different elements in predicting creative achievement in the two contexts, with common (domain-general) and different (domain-specific) elements defining achievement within and outside of school. The interactive role between openness and intrinsic motivation emerged as a common element defining creative achievement in both contexts, whereas the role of the ability to produce original ideas emerged as a significant predictor of creative achievement only inside schools (Figure 8).

A similar approach was used to explore creative achievement in the advertisement domain (Agnoli, Mastria, et al., 2019). This study showed how experience, along with the openness personality trait, is a central element in exploiting creative abilities to succeed in this domain.

## Discussion and Conclusions

In conclusion, we hope we have convinced readers about the usefulness of adopting the Dynamic Creativity Framework (DCF) as a *fil-rouge* in the investigation of the creativity construct, an approach that is ripe with implications at both the theoretical and empirical levels. Considering the theoretical aspects, the dynamic definition of creativity can inspire investigations of not only creative achievement but also creative inconclusiveness, including creative mortification and the possibility of recovering from it. This kind of study can have a very important bearing on the development of creative identity. The introduction of the DUCP might lead to a transdisciplinary consideration of the creativity phenomenon, which could involve psychologists, engineers, physicists, economists, ethologists, philosophers, cosmologists, and many other scientists. The extension of the meaning of creative potential beyond the characteristics of the single individual could stimulate the design of environments and conditions that foster creativity, as well as the study of the history of creative ideas that transcend their own creators. The introduction of the space-time continuum for the study of the relationship between intelligence and creativity has many possible extensions, such as in the design of models for the introduction of creativity in education systems, for the conception of new approaches to creative leadership in business, as well as for development and coaching of creative careers. Finally, the concept of organic creativity might offer guidance in the development of training and interventions geared towards increasing well-being in the general population as well as in special groups.

Considering the empirical aspects, we described a series of examples of experimental paradigms derived from the adoption of DCF, which represent useful sources for the empirical exploration of this theoretical framework. In particular, if we stipulate that the creative process is not static, but it is ontogenetically dynamic in its nature, empirical paradigms in this framework should be able to capture the emergentist nature of the process by introducing variable manipulations and/or controls aimed at understanding the nature of changes in creative performance or achievement. Change can be understood as the result of the dynamic interaction between creative thinking constituents leading to variations in the within-subject creative thinking process and the dynamic expression of the creative process between different individuals sharing the same experimental/environmental context. Using these two approaches in the analysis of change captures the phenomenology of creative thinking performance and achievement. We have discussed not only paradigms offering a time analysis in the expression of creative performance (e.g., in the study of the EEG correlates predicting originality or in the study exploring the effects of evaluative feedback on idea generation) but also paradigms allowing the exploration of interactions between conative and cognitive components of the process with individual differences in their expression (e.g., in the understanding of emotional states on the evaluation of ideas or in the study of the interaction between attentional processing and personality traits), thus permitting an analysis of differences in the phenomenology of the process. Our intention with these examples was to provide a first direction for potential research within the DCF framework. However, many issues are open for future research, such as the investigation of dynamic estimation methodologies, the conception of new empirical protocols for the measurement and observation of creative determinants in complex dynamics, or the applications of the theoretical framework for the study of creativity in developmental, educational, and organizational psychology. We hope this excursus into the DCF framework can act as a driver for further exploration of the dynamic creative process.

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