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REVIEW

Fostering Creative Thinking Skills Through the Unconscious: A Novel Approach

Maurice Crijns[1] · **Peter Biekens**[2] · **Kave Kianush**[1]

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Abstract

This study introduces an innovative and experimental approach to promoting creative thinking. Prevailing methodologies predominantly emphasize conscious cognition mediated by the executive network, yet logical convergent and divergent thinking represent only a subset of the broader creative spectrum. A critical review of recent neuropsychological research indicates that unconscious cognitive processes originating in the default network constitute a significant source of creative thought. Accordingly, we propose the Six Step Cycle of creativity as a novel framework that explicitly harnesses unconscious processes to generate novel and unexpected insights. The method's efficacy was previously evaluated in a controlled study by researchers at Radboud University (Netherlands) with 198 participants, using standard psychometric assessments, and yielded statistically significant improvements.

Keywords Creative thinking · Unconscious cognition · Default network · Six Step Cycle of creativity

Introduction

Creative thinking is a fundamental capability that enables individuals to address complex challenges and enhance problem-solving efficiency. It has emerged as a critical driver of innovation across diverse fields such as science, technology, the arts, and business. Empirical evidence underscores the economic and strategic significance of creativity, with research demonstrating that organizations that cultivate creative environments tend to achieve superior performance metrics, including revenue growth, market share expansion, and enhanced talent acquisition (Forrester Consulting, 2014).

Historically, creativity was regarded as an innate trait possessed by a select few; however, contemporary research supports a more inclusive view, suggesting that individuals with typical cognitive capacities are capable of creative production (Amabile, 1996). Research examining the relationship between cognitive intelligence and creative thinking reveals a positive correlation up to an IQ of approximately 120. Beyond this threshold, the relationship appears to diminish (Martindale, 1989, p.213). These findings imply that intelligence, while necessary, is not a sufficient condition for creativity (Shi et al., 2017, p.7).

Conventional definitions assert that creativity requires ideas to be both novel and valuable (Runco & Jaeger, 2012). However, debate persists concerning the relative emphasis on novelty versus value (Weisberg, 2015; Hills & Bird, 2018, 2019, p. 694). Some scholars advocate alternative criteria, substituting "useful-valuable" with "satisfying" (Abraham, 2023) or "imaginative" (Brandt, 2021), while others propose that creativity is best conceptualized as internally constrained attention driven by a generative goal (Green et al., 2023). Notwithstanding these differences, consensus remains that creativity must entail novelty.

Popular strategies for enhancing creative thinking—such as working diligently, stepping outside one's comfort zone, engaging in mind-wandering, practicing remote associations, or employing techniques like Steve Jobs' "10-minute rule"—are widely disseminated. Nonetheless, these strategies often lack an integrated theoretical foundation.

Numerous creativity-enhancing methods—such as SCAMPER, schema violation, remote association, brainwriting, Six Thinking Hats, Crazy 8, broadcast search models, crowdsourcing, random connections, simple ideation, and brainstorming—have been empirically examined and

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✉ Peter Biekens
peterbiekens@brainnovation.nl

[1] International Nemrud Foundation, Geldrop, The Netherlands

[2] Fontys University of Applied Sciences, Eindhoven, The Netherlands

validated in scientific research (Gu et al., 2022; Boonpracha, 2023; Hu et al., 2021; Langham, 2020; Mednick & Halpern, 1962; Nunamaker et al., 1991; DeRosa et al., 2004). For example, SCAMPER was developed to facilitate cooperative learning and comprises seven structured activities: Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, and Reverse (Eberle, 1971). This technique is widely applicable within frameworks such as Design Thinking, Lean methodologies, and brainstorming contexts (Eberle, 1971; Osborn, 1953). Brainstorming, a group-based creativity method characterized by spontaneous ideation in response to a given prompt, has generated several variants, including brainwriting, reverse brainstorming, teaming, and mind mapping (Nunamaker et al., 1991; Osborn, 1953; Rohrbach, 1968; Shih et al., 2009).

Although these techniques offer potential benefits, only a few have been rigorously validated in terms of their efficacy for fostering creativity. One notable exception is brainstorming; however, several studies suggest that brainstorming may be ineffective, as individuals tend to generate fewer ideas in group settings compared to when working independently (Furnham, 2000; Mullen et al., 1991; Sawyer, 2007; Taylor et al., 1958). Research further indicates that alternative approaches—such as the collection of individual ideas prior to group discussion—can yield superior creative outcomes (Chrysikou, 2012; Isaksen & Gaulin, 2005; Kavadias & Sommer, 2009).

In a comparative study of SCAMPER, random connection, schema violation, and simple ideation, marginal to significant improvements in divergent thinking were observed; however, no improvement was noted in convergent thinking (Gu et al., 2022, p. 312). A subsequent study evaluating the 5-I training technique reported significant enhancements in divergent thinking indices (Gu et al., 2024, p. 403). While most interventions focus on predesigned creativity-enhancing activities, recent developments explore the role of automated and AI-based feedback systems in creativity training (Hadas and Hershkovitz, 2025). Such systems offer participants real-time metacognitive feedback during divergent thinking tasks, which has been shown to enhance creative performance (de Chantal & Organisciak, 2025; Patterson et al., 2025).

The current foundation of these creativity methods is based on divergent thinking. However, for decades, its adequacy has been called into question. Numerous studies indicate that divergent thinking often fails to produce the anticipated downstream outcomes in creative production (Fletcher & Benveniste, 2022, p. 29).

These doubts are reflected in the criticism regarding the ability of creativity tests to predict future creative achievement (Said-Metwaly et al., 2017, p.285). Historical case studies suggest that major scientific and artistic breakthroughs frequently emerge from unconscious cognitive processes rather than from deliberate analytical reasoning. Prominent examples include Albert Einstein, who reported experiencing key insights while playing the violin, and Dmitri Mendeleev, who envisioned the structure of the periodic table in a dream (Neves et al., 2022; Root-Bernstein & Root-Bernstein, 2010). These anecdotal accounts have contributed to the hypothesis that unconscious cognition plays a pivotal role in facilitating creative insight.

In support of this view, several scholars including Dijksterhuis and colleagues (2006, p.145) argue that unconscious thought facilitates the generation of less conventional and more original ideas. They further contend that in contexts involving complex decision-making, unconscious processing may outperform conscious deliberation (Dijksterhuis et al., 2006, p.1005). Nonetheless, this position remains contentious. Critics have raised concerns regarding the empirical robustness of such claims, pointing to a lack of consistent evidence supporting the effectiveness of unconscious processes in high-stakes or analytically demanding decision-making scenarios (Calvillo & Penaloza, 2023; Rey et al., 2009, p.378).

Rather than engaging in this theoretical dispute, the current study seeks to examine empirical evidence from neuroscience to elucidate the mechanisms underlying creative cognition. A concise review of the literature on the neural correlates of creativity is presented in the following section.

Literature Review

The human brain is anatomically divided into two hemispheres—left and right—each of which processes sensory information differently. For instance, neurologist Jill Taylor experienced a significant revelation during a severe left-hemisphere haemorrhage; she observed that each hemisphere exhibits distinct functional characteristics, prompting her to seek assistance when she recognized a telephone number without understanding its contextual significance (Taylor, 2006, p.133). Similarly, experimental neuroscientist Michael Gazzaniga demonstrated that severing the connection between the hemispheres, as in certain treatments for refractory epilepsy, can lead to analogous phenomena (Gazzaniga, 2011, p.94).

The left hemisphere is primarily responsible for processing sensory data in a logical and analytical manner, dividing information into meaningful components. In contrast, the right hemisphere synthesizes these disparate pieces by identifying patterns and forming holistic concepts (Wang et al., 2013). An over-dominance of the right hemisphere may result in the production of numerous ideas that lack substantive depth, while a dominant left hemisphere—despite potentially higher IQ—may become overly fixated on details, thereby obscuring the broader picture; in essence, such individuals “cannot see the forest for the trees” (Martindale, 1989, p.220; Cleese, 2022, p.20).

The observed functional differences have contributed to the popular notion of the “creative right brain.” Empirical evidence from non-invasive brain stimulation studies indicates that creative thinking is enhanced by decreasing activity in the left frontal cortex while simultaneously increasing activity in the right frontal cortex (Chi & Snyder, 2011; Fields, 2011). Structural analyses further reveal that the dendritic architecture in the right hemisphere is more extensive, permitting broader integration of inputs. As a result, “right hemisphere neurons have larger input fields than do left hemisphere neurons” and are capable of collecting more diverse information (Kounios & Beeman, 2014, p.13.8). Beaty and Kenett (2020, p.218) further posit that the greater the conceptual distance between ideas, the more novel the resultant synthesis.

This may explain why neurologists observe insight or Eureka! Moments only in the right hemisphere as a sudden burst of high-frequency EEG activity—gamma waves—correlating with the moment of insight (Kounios & Beeman, 2015, p.64). Nevertheless, it is essential to recognize that such creative insights can only emerge when the left hemisphere has effectively processed relevant details. Both hemispheres are integral to the creative process, underscoring the concept of a “whole-brain endeavor” in creative thinking (Beaty, 2018, p.1087).

Research indicates that brain regions associated with high creative performance are primarily distributed across three large-scale brain networks: the default network or default mode network (DMN), the executive network or executive control network (ECN), and the salience network or SN (Beaty et al., 2018). Moreover, creative thought consistently involves the dynamic functional connectivity among the default network, executive network, and salience network, supporting creative cognition across a wide range of domains and tasks (Beaty et al., 2023a, 2023b, p. 433–452; Zamani, 2022). These networks are distributed across both hemispheres, as illustrated in Fig. 1.

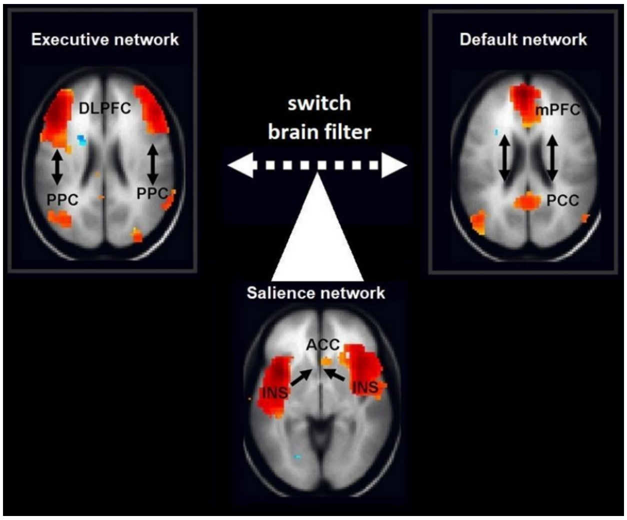


Fig. 1 The three neural networks

The executive network is associated with goal-directed cognitive functions such as planning, working memory, decision-making, and logical reasoning (Niendam et al., 2012, p.6, p.8; Beaty et al., 2018). It is activated during tasks that require high levels of cognitive control and rule-based problem solving, for example, solving mathematical problems with a single correct answer or generating alternative uses for objects in the Alternative Uses Task (Benedek et al., 2014).

The default network facilitates ideation and the spontaneous generation of novel associations, particularly during states of relaxed attention or mind-wandering (Bartoli et al., 2024; Kühn et al., 2014). This network is primarily involved in internally directed cognition, including mind-wandering, self-referential thought, episodic memory, and creative ideation (Bartoli et al., 2024; Beaty et al., 2016). While some of these processes may occur unconsciously, the default network also supports conscious internal mentation. It typically shows increased activity when attention is not focused on external tasks, such as during daydreaming or sleep, but is also recruited during various cognitive operations involving internal information processing (Beaty et al., 2016; Shofty et al., 2022). Causal evidence for the default network’s role in generating original connections among concepts has been documented (Bartoli et al., 2024, p.3409), further supporting the notion that unconscious processing is vital to creativity. In general, the default network supports idea generation while the executive network is involved in subsequent idea evaluation (Beaty et al., 2018, p.1087). Recent findings by Moreno-Rodriguez et al. (2025) further extend this model by demonstrating that the brain’s reward system plays an active role in creative idea evaluation. Their study showed that while the default and executive networks respectively encode originality and adequacy, the subjective value of ideas is represented in reward-related regions such as the ventral striatum and medial prefrontal cortex. Emotional states modulate both the generation and evaluation of creative ideas. Positive, high-activation moods enhance cognitive flexibility, while affect also influences transitions between divergent and convergent thinking (Baas et al., 2008; Ivcevic et al., 2023). This suggests that creativity involves not only idea generation and executive assessment, but also motivational valuation processes that help determine which ideas are worth pursuing.

The salience network functions as a regulatory switch between the default and executive networks (Goulden et al., 2014, p.180). Studies report a negative or anticorrelated relationship between these networks, such that a decrease in executive network activity corresponds with increased default network activity. Notably, the right anterior insula (AI) appears to initiate this network switching (Menon, 2011, p.501).

Furthermore, the salience network functions as an intermediary system, regulating the transition between the default and executive networks by selectively amplifying relevant insights while inhibiting extraneous or irrelevant information (Menon, 2011). Specifically, this network operates as a cognitive filter, protecting the executive network from sensory overload and enabling efficient allocation of cognitive resources. It allows organisms to prioritize critical information, thereby focusing limited cognitive capacities on the most pertinent stimuli (The Decision Lab, 2019). This concept aligns with Chrysikou's matched filter hypothesis for cognitive control, which suggests that evolved mechanisms coordinate lower-level sensory and motor processes around internally driven cognitive goals, effectively managing potential cognitive overload (Chrysikou et al., 2014).

The salience network further determines the threshold at which sensory input reaches conscious awareness. Zhou et al. (2021) emphasize that the salience attribution mechanism directly influences which stimuli capture attention, thereby guiding cognitive processing. Additionally, Kühn et al. (2014) suggest that the salience network identifies potentially valuable ideas generated by unconscious default network processes and forwards these insights to the executive network for higher-order cognitive evaluation.

The filtering criteria employed by the salience network are influenced by an individual's habitual cognitive patterns, including personal preferences, assumptions, and inherent biases. Persistent reliance on habitual cognitive processes can result in inflexible filtering, subsequently reducing an individual's openness to novel or unconventional ideas. In contrast, young children, who initially lack entrenched cognitive patterns, typically exhibit greater cognitive flexibility. Their learning processes are driven primarily by wonder and curiosity, which allow broader receptivity to novel stimuli (Storoni, 2024).

Under typical conditions, the brain's cognitive filter tends to inhibit unconventional ideas generated within the default network. However, Chrysikou et al. (2014) propose that it is possible for the cognitive filter to dynamically adjust its filtering thresholds according to task demands or external interventions, such as specific cognitive training regimens (e.g., Six Step Cycle), neural stimulation techniques (e.g., transcranial magnetic stimulation [TMS], transcranial direct current stimulation [tDCS]), or pharmacological agents (e.g., lysergic acid diethylamide [LSD]). Empirical evidence supports this hypothesis; for instance, inhibition of the medial prefrontal cortex via neural stimulation has been shown to decrease mind-wandering tendencies (Bertossi et al., 2017). Similarly, inhibition of the left prefrontal cortex (associated with the executive network) significantly enhances the quantity and speed at which individuals generate unconventional uses for common objects, though it does not enhance typical or common uses (Chrysikou et al., 2013).

Creative cognition is characterized by dynamic interactions among the default, executive, and salience networks. Although the default network is crucial for generating innovative ideas, these ideas require subsequent evaluation by the executive network; isolated default network activation—such as during daydreaming or sleep—is insufficient for achieving groundbreaking creative output (Ritter & Dijksterhuis, 2014, p.7). Recent neuroscience research demonstrates that individuals with optimal functional connectivity between the default and executive networks are more likely to generate original and effective ideas across domains (Beaty et al., 2018; Beaty et al., 2023a, 2023b, pp. 444–446; Fink & Benedek, 2019, p. 233). Chen et al. (2025) found that a moderate, dynamic balance between networks supports the highest levels of creativity: the brain can freely generate ideas via the default mode network (DMN) while selectively evaluating and refining them through the executive control network (ECN). When the DMN dominates and the ECN is scarcely engaged, many ideas are produced, but they tend to be chaotic or impractical. Conversely, when the ECN exerts excessive control, rigid focus and heightened self-monitoring can stifle novel associations.

Complementing these correlational findings, Luchini et al. (2025) provided causal evidence by demonstrating that covert neurofeedback aimed at increasing default and executive network coupling led to significant improvements in creative idea generation, particularly in the originality of responses on divergent thinking tasks.

Specifically, enhanced functional connectivity between the inferior prefrontal cortex and the default network has been associated with improved cooperation between conscious cognitive control and unconscious imaginative processes (Shofty et al., 2022; Beaty et al., 2014, 2016, p.92). Moreover, studies by Beaty et al., (2019, p.22; Beaty, 2018, p.1090) and Chhade et al., (2024, p.1) suggest that such connectivity patterns can reliably predict an individual's creative potential. This robust predictive capacity may have practical implications for selecting individuals for complex and innovative tasks in various organizational settings.

Another distinguishing characteristic of creative individuals is their level of cortical arousal. Research indicates that during creative tasks, highly creative individuals tend to exhibit defocused attention and relatively low cortical activation. In contrast, individuals with lower creative capacity often exhibit hyper-focused attention and high cortical arousal, which may impede the generation of original ideas (Martindale, 1999, p.142). Importantly, it appears that the variability in cortical arousal, rather than the basal level alone, is a key factor in creative performance (Kaufman et al., 2010, p.223). In controlled experiments, medium- and low-creative groups displayed consistently low alpha-wave activity (indicative of high cortical arousal) across various tasks, whereas highly creative individuals demonstrated the ability to flexibly transition between focused attention and relaxation—a process critical for creative thought.

Creative cognition relies on the interplay between conscious and unconscious processes, each supported by distinct neural networks. Conscious, goal-directed cognition—mediated by the executive control network—is particularly effective for resolving routine or well-structured problems. In contrast, the resolution of complex or ill-defined challenges often depends on unconscious processes facilitated by the default mode network. Effective creative methodologies should therefore draw upon the complementary functions of both systems—while also accounting for how spontaneous and task-unrelated thought processes may support idea generation.

One such process that operates largely outside conscious awareness is incubation, which refers to temporary disengagement from focused problem-solving. This phenomenon has been shown to enhance idea generation by allowing unconscious processes to recombine mental content in novel ways (Ellwood et al., 2009; Liu et al., 2023; Ritter & Dijksterhuis, 2014). During such off-task moments, individuals often experience mind-wandering, which reduces fixation and promotes associative thinking (Baird et al., 2012). Neuroimaging studies support this view by demonstrating increased default mode network activity during incubation, reflecting a shift toward internally driven cognitive processing (Knyazev et al., 2021; Malach, 2024). Although often overlooked in creativity interventions, these findings highlight the importance of defocused attention and non-linear processing in creative insight. Zamani et al. (2023) emphasize dynamic transitions between generative and evaluative mental states during creative thought. The framework conceptualizes creativity as a multi-phase process involving flexible shifts between idea generation and evaluation. It can be concluded that creative cognition benefits most from flexible interactions between deliberate, executive functions and spontaneous, unconscious processes—supported by targeted shifts in neural network activation.

Development of the Six Step Cycle

This paper presents a theoretical framework developed through an extensive review of neuroscientific and psychological literature on creative cognition. From this body of research, five core neurocognitive principles emerged as consistently supported mechanisms that underlie creative thought. These principles form the conceptual foundation for a six-step model—the Six Step Cycle—and reflect converging evidence from empirical studies across cognitive neuroscience and creativity research:

1. Hemispheric balance: Functional asymmetry between the brain's hemispheres is common; however, excessive dominance of one hemisphere may impair the contributions of the other, thereby limiting integrative cognitive performance (Martindale, 1989, p. 220; Kounios & Beeman, 2014, p. 13.8).
2. Executive network functionality: The executive network supports high-level cognitive operations including information synthesis, logical reasoning, and critical evaluation. These processes are essential for structuring problems and refining solutions (Beaty et al., 2016, p. 88; Beaty et al., 2018, p. 1087).
3. Cognitive filtering by the salience network: The salience network also functions as a filter, suppressing atypical or unconventional information that may conflict with dominant cognitive schemas. Reducing this filtering effect is essential for allowing latent, innovative ideas to reach conscious awareness (Chrysikou et al., 2014, p. 341; Zhou et al., 2021).
4. Salience network dynamics: The salience network governs the adaptive switching between the executive and default networks, a mechanism that is critical for effective creative thinking (Goulden et al., 2014, p. 180; Menon, 2011, p. 501).
5. Default network and unconscious processing: The default mode network underlies spontaneous, associative thought and unconscious information processing. It has been identified as a principal source of original and breakthrough ideas (Shofty et al., 2022; Bartoli et al., 2024, p. 3409; Beaty et al., 2016, p. 89).

These principles were mapped onto recurring phases in creative problem-solving, resulting in the construction of a six-step model. The development process followed an iterative, design-based approach. Initial versions of the framework were refined through multiple cycles of expert consultation, practitioner feedback, and exploratory applications in educational contexts. This iterative process ensured conceptual alignment with cognitive neuroscience and practical applicability.

While the current paper primarily presents the theoretical rationale and structure of the model, the associated training protocol has previously been empirically validated in a controlled university setting (Ritter et al., 2020). The design and results of this validation study are summarized in the following section, with full methodological details available in the original publication and accompanying data repository.

Six Step Cycle of Creativity

The neuroscientific principles resulted in a novel approach labelled as the Six Step Cycle of Creativity. This cycle reflects a cognitively natural pattern of problem-solving. In everyday situations, individuals often begin with a focused attempt to solve a problem using familiar strategies—a basic form of convergent thinking. Only when this approach proves insufficient do they shift toward broader exploration and alternative solutions, entering a more divergent mode (Basadur et al., 1982; Kowaltowski et al., 2010; Mumford et al., 2012). The Six Step Cycle mirrors this progression: it begins with analytical structuring, followed by ideation, and then returns to evaluation and refinement. Rather than prescribing an idealized or strictly linear sequence, the model emulates the brain's intuitive way of navigating complex, open-ended challenges.

Building on this psychological logic, the model also integrates established creativity methodologies into a structured framework that aligns with neuroscientific insights. It is designed to maximize cognitive synergy between deliberate, analytical reasoning and unconscious ideation. The cycle follows the natural progression of brain activity during creative problem solving and unfolds in six sequential stages: (1) Problem comprehension, (2) Convergent thinking, (3) Divergent thinking, (4) Detached thinking, (5) Stop thinking, and (6) Processing during sleep (Fig. 2).

At the start of the cycle, the executive network is activated, which engenders a high degree of focus on the problem. Steps 1 to 3 involve cognitive processes associated with the executive network. These steps are adequate for addressing creativity tasks of limited complexity and strict time constraints. Schäfer et al. (2024) emphasize that executive functions, particularly cognitive flexibility and working memory, significantly correlate with problem-solving capabilities in science education at elementary levels.

Fig. 2 The six step cycle

Step 4 to 6 facilitate the exploration and utilization of unconscious cognitive resources mediated by the default network. These stages become essential for engaging with complex creative challenges where time constraints are less critical, allowing deeper unconscious processing.

When a solution is not immediately apparent during Steps 1 to 3 and cognitive fatigue ensues, the salience network deactivates the executive network and activates the default network, thereby facilitating the unconscious absorption and processing of the previously gathered data. When, during any of Steps 4 to 6, the default network signals a potential solution in a preliminary, unrefined form, the salience network reactivates the executive network to create awareness and enable conscious elaboration of the idea.

The classic model of creative thinking recognizes the value of Step 4 to 6. This stage is defined as incubation (Wallas, 1926). Later models sometimes split or expand stages, adding a fifth like Synthesis or Evaluation (Carson, 1999). In general, each phase of the cycle maps onto a recognized stage in the creative process, from preparation to evaluation (Carson, 1999; Moriarty & Robbs, 1999; Ritter et al., 2020). However, few have operationalized a technique to deliberately use and shift between conscious and unconscious modes of thinking.

Six Step Cycle and the Neuroscientific Principles

1. Hemispheric balance

   The cycle serves as a framework for training creativity-relevant personality traits, with particular attention to the influence of environmental factors, as research indicates that external context can facilitate creative training (Amabile, 2013; Mouchiroud et al., 2022). At the onset of the training, participants complete an online assessment to evaluate the functionality of both cerebral hemispheres. In instances where an imbalance is detected, particularly reduced functionality in the right hemisphere, targeted stimulation is applied. Such stimulation is critical because an over-dominance of one impairs an individual's overall creative capacity.
2. Executive network functionality

   Step 1—understand the problem

   Every creative challenge commences with a comprehensive understanding of the problem. During this phase, individuals engage in conscious analysis and, systematically collect pertinent information if required.

Empirical experience suggests that this initial phase is frequently underestimated. Individuals often assume they have fully grasped the problem when, in fact, routine thinking and preexisting biases may obscure its complexity. As Dijksterhuis and Nordgren (2006, p.98) note, “jumping to conclusions” is a common pitfall in conscious thought, while Lewis et al., (2018, p.491) observe that preconceptions and prejudices can actively block creative leaps by preventing the recognition of otherwise evident solutions. To mitigate these biases, the training promotes open-mindedness and increase awareness of the limitations imposed by habitual thinking.

For complex problems characterized by numerous interrelated variables, it is imperative to conduct a thorough analysis. Insufficient input data precludes the formation of novel neural networks necessary for generating breakthrough insights. As Gomez (2007, p.33) notes, significant insights typically emerge only after prolonged, systematic search processes, sometimes spanning months or years. In such cases, it is essential to allocate adequate time for research and the systematic collection of relevant information. Greiff et al. (2014, p.3) assert that effective knowledge acquisition involves constructing a parsimonious yet viable representation of the problem’s most critical aspects. In essence, without sufficient input, the likelihood of producing innovative output is minimal.

Emotional factors, such as fear, can also impair accurate problem comprehension. While fear may serve as a natural safeguard and motivational factor—as suggested by Benoit and Miller (2022) and Rausch (2024, p.7)—excessive fear may inhibit creative thinking. Lee et al., (2017, p.233) provide evidence that individuals experiencing heightened fear tend to generate lower creativity ratings. During this step, the training offers tools to manage fear and prevent its inhibitory effects.

Finally, motivation plays a pivotal role in the process of understanding complex problems. Amabile (2013, p.136) emphasizes that intrinsic motivation—driven by interest, enjoyment, satisfaction, and the challenge of the work itself—is closely associated with higher levels of creativity, as opposed to extrinsic motivators, which cannot be effectively trained. The motivation to solve a challenge cannot be trained.

Step 2—convergent thinking

Convergent thinking is defined as the methodical progression from an initial idea (point A) to a logically deduced solution (point B). This stage is particularly effective for addressing problems of low complexity that rely on established facts and routine procedures. As Schäfer et al., (2024, p.3) state, many problems can be resolved by retrieving task-specific knowledge and systematically applying it. Convergent thinking typically yields a single correct answer, a proficiency commonly reinforced through conventional educational practices.

Step 3—divergent thinking

Divergent thinking, or lateral thinking, involves deliberately generating multiple ideas or solutions to a given problem. In this phase, individuals consciously create numerous associations and explore a broad range of possibilities. This process is particularly effective for problems of moderate complexity and those with open-ended parameters. Although many contemporary creativity methodologies emphasize divergent thinking, individuals unable to find a suitable solution may feel pressured to intensify their efforts, potentially generating low-quality ideas, stress, and circular reasoning. Such impasses signal the need to advance to the next stage of the creative cycle.

3. Cognitive filtering by the salience network

Brain filter

During the initial phases (Steps 1–3), the salience network’s brain filter is recalibrated by default. This recalibration enables the brain to permit the passage of relevant, unconventional ideas from the unconscious. The effective execution of these steps is therefore a prerequisite for harnessing the creative potential inherent in unconscious processes. Subsequent stages of the cycle reinforce the maintenance of this recalibrated filtering mechanism, ensuring that salient ideas remain accessible for further development (Chrysikou et al., 2014).

4. Salience network dynamics

Step 4—detached thinking

Step 4 represents one of the most challenging phases of the cycle, as it requires a decrease of conscious arousal and an increase of unconscious arousal. Achieving this state necessitates a temporary disconnection from external stimuli. Chrysikou et al., (2014, p.341) note that although our elaborate sensory and motor systems provide detailed information about the external world, this abundance can also introduce significant interference and confusion. Therefore, reducing sensory input—through passive, low-effort activities—can facilitate this transition. To minimize external distractions, individuals are advised to select environments that permit disconnection from sensory noise; optimal conditions for detachment vary among individuals. For example, some may find that simply resting their feet on a desk and gazing out a window suffices, while others might prefer listening to music (Scherder & Wawoe, 2015a).

Storoni (2024, p.23) characterizes this phase as a “low-energy gear two-state,” in which attention intermittently detaches from active work and drifts inward—a condition considered optimal for spontaneous creativity. Exemplars such as John Cleese and Steve Jobs illustrate distinct approaches: Cleese achieves mental detachment by situating himself in natural, relaxed settings, during which the persistent internal dialogue subsides, and nascent ideas emerge (Cleese, 2014). In contrast, Jobs reportedly disengaged from a challenging problem by taking a barefoot walk, thereby distancing himself from the office environment and allowing unconscious insights to manifest; recent research supports the notion that walking produces a unique mental state conducive to creativity, by permitting attention to “float” while maintaining cognitive engagement (Storoni, 2024, p.60).

5. Default network and unconscious processing

An optimal detached state is characterized by an increase in low-frequency brain waves, typically 4 Hz or lower. Once this detachment state is achieved, the problem should remain in the periphery of awareness without active, deliberate focus, thereby allowing ideas to surface naturally. In this state, one functions as a detached observer, with diminished emotional involvement—a condition often described as reduced “brain chatter” (Taylor, 2006, p.32). Consequently, the subtle signals and vague impressions from the unconscious may emerge. During this phase, the salience network becomes active, concurrently deactivating the executive network—a neurophysiological configuration that has been associated with optimal creative thinking (Knyazev, 2021, p.466).

To the best of our knowledge, Kounios and Beeman were the first to visualize Step 4. In a Remote Associates Test (RAT) experiment, participants’ brain activity was measured using EEG. Participants solved RAT problems—such as finding a common link for the words “pine”, “crab”, and “sauce”—either by consciously searching through possible combinations or through sudden unconscious insight “Apple!”. The brain signatures for conscious and unconscious solutions differed significantly. At the moment of insight, low-frequency brainwaves were replaced by a sudden burst of high-frequency activity, known as gamma waves. Additional fMRI measurements revealed that these gamma bursts originated from the right temporal lobe, just above the ear (Kounios et al., 2015, p.59–65).

Step 5—Stop Thinking

In step 5, individuals are encouraged to deliberately cease focused thinking about the problem. Frustration is common when preceding stages do not yield immediate solutions, leading many to abandon the task. However, this step is designed to facilitate the dissipation of cognitive fixation: rather than continuing to focus on the challenge, one must intentionally disengage. This does not imply total cognitive inactivity but rather a conscious decision to shift focus away from the problem. Engaging in unrelated activities—such as shopping, showering, socializing, gaming, or playing music—can be beneficial (Scherder & Wawoe, 2015b). Historical anecdotes, including those involving Albert Einstein, suggest that diversion can lead to the emergence of critical insights through spontaneous, unconscious processing. Ellwood et al., (2009, p.6) demonstrated that breaks involving tasks completely unrelated to the original problem significantly enhanced idea production compared to continuous engagement or engagement in similar tasks. Furthermore, anecdotal evidence from creative individuals like Joanne Rowling and Frank Hornby indicates that periods of deliberate refraining from the challenge can catalyze creative insights.

During the incubation phase, the unconscious mind processes the information gathered during earlier stages without the interference of focused conscious thought. As a result, unexpected flashes of insight may occur, such as during a car journey or similar mundane activities. This phenomenon, known as incubation, is well-documented in creativity research. Ritter and Dijksterhuis (2014, p.1), Schäfer et al. (2024), and Liu et al. (2023) all highlight the contribution of unconscious processes during off-task periods. Gallete et al. (2012, p.146) further reported that engaging unconscious processes during incubation periods is associated with significant increases in productivity. Additionally, Amabile et al., (2005, p.492) describe incubation as the unconscious recombination of thought elements previously activated during conscious work—underscoring the necessity of thorough initial engagement to provide sufficient material for recombination.

Neuroscientific evidence reinforces the critical role of the incubation period in creative cognition. Malach (2024, p.2) notes that the creative process encompasses a crucial stage of incubation that occurs below the threshold of conscious awareness, as illustrated by spontaneous neuronal fluctuations observed via fMRI (Malach, 2024, p.3). Temporal dynamics of incubation vary, with Amabile et al., (2005, p.367) identifying incubation periods of up to two days as optimal for creative thought.

Step 6 –Sleep

Step 6 is arguably the most potent phase of the cycle. A comprehensive meta-analysis of 94 studies concluded that sleep enhances creative problem solving by facilitating the integration of available neural information (Marguilho et al., 2015, p.136). Furthermore, tasks that are novel or require new cognitive strategies have been shown to engage REM sleep (Hoss, 2018, p.2).

Anecdotal evidence further underscores the creative power of sleep: historical figures such as Elias Howe, Niels Bohr, James Watson, Paul Horowitz, and Alan Huang have all reported receiving breakthrough ideas in dreams. Barrett (2011, p.33) encapsulates this phenomenon by stating that “dreams are simply thought in a different biochemical state.”

Despite the apparent restfulness of sleep, the brain remains highly active during REM sleep, exhibiting wave patterns similar to wakefulness. However, due to the suppression of voluntary muscle activity during REM sleep, cognitive processes can occur without the constraints imposed by external sensory input.

During sleep, the brain is engaged in both memory consolidation and the reactivation of neural circuits, a process that facilitates the reorganization and integration of experiences (Lee & Wilson, 2002). For example, research involving rodents navigating a labyrinth has demonstrated that during sleep, neural replay of maze navigation occurs at significantly accelerated speeds compared to wakeful states (Lee & Wilson, 2002). Similar findings have been reported in human studies employing virtual maze tasks (Wamsley & Stickgold, 2018).

The brain engages in extensive scenario replay as a mechanism for problem-solving (Lewis et al., 2018). During sleep, the brain’s cognitive filtering mechanisms are significantly reduced, facilitating a state where unconventional ideas and solutions can emerge without being impeded by habitual cognitive constraints such as conventions, morals, assumptions, or biases. According to Neves et al. (2022), dreaming is particularly conducive to novel idea generation due to its unique biochemical state, characterized by diminished influence from everyday logic, social norms, and external sensory stimuli. This unrestricted replay of various scenarios significantly enhances the probability that one such simulation provides a viable solution. It is precisely this characteristic of unrestricted cognitive exploration that underscores the efficacy of sleep in enhancing creative problem-solving.

Individuals instinctively recognize this cognitive resource, as demonstrated by the common advice to “sleep on a problem.” Empirical evidence supports this intuitive strategy: Amabile et al. (2005) found that after practicing mathematical tasks, 59% of participants who slept for eight hours experienced significant insights upon awakening. This suggests that the practice of suspending conscious cognitive effort to allow unconscious processes to operate during sleep can substantially enhance problem-solving abilities.

Given that deliberate engagement of unconscious processing during sleep does not occur naturally for most individuals, the model advocates for gentle stimulation of the unconscious before sleep. Barrett (2011) provides practical guidelines for “training your dreams.” Additionally, the training protocol incorporates auditory and olfactory cues to enhance sleep-mediated problem solving. For example, Bendor and Wilson (2012, p.1439) demonstrated in an experiment with rats that a task-related auditory cue during sleep can bias neural replay toward the associated spatial memory. Similar results have been observed in human subjects (Gonçalves et al., 2017, 2018; Ritter et al., 2012).

Such sensory cues are particularly effective at sleep onset. EEG recordings indicate that the transitional state between wakefulness and sleep is associated with heightened creative activity (Lacaux et al., 2021, p.1). A wearable device like Dormio wakes up an individual during the first phase of sleep and may serve as creativity booster (Lacaux et al., 2021, p.5).

A follow-up study employing targeted dream incubation (TDI) further substantiated these findings. TDI leverages continuous sensory processing during sleep onset to introduce specific themes into dreams (Horowitz et al., 2023, p.318). The efficacy of TDI was confirmed by test results, which indicated that the Sleep Incubation group significantly outperformed comparison groups, including those not receiving such cues (Horowitz et al., 2023, p.328).

A related model has been proposed by Zamani et al. (2023), who emphasize dynamic transitions between generative and evaluative mental states during creative thought. Their framework presents creativity as a multiphase process involving flexible shifts between idea generation and evaluation. While this aligns with the iterative nature of the Six Step Cycle, our model adds further specificity by distinguishing foundational preparatory stages (problem comprehension and early convergence), as well as less commonly addressed phases such as incubation, disengagement, and sleep. Thus, although both models converge on the essential cyclicality of creative cognition, the Six Step Cycle offers additional granularity concerning functional mechanisms and timing, grounded in contemporary neuroscientific research.

Six Step Cycle—Modulation of Cortical Arousal via Neural Headsets

Variability in cortical arousal represents a key cognitive characteristic associated with creativity as mentioned. Creative individuals demonstrate a distinct capacity to fluidly transition between states of focused attention and relaxed cognition. This capability allows them to maintain focused cognitive engagement during tasks demanding high attention, such as IQ tests, while adopting a relaxed cognitive state during creative tasks.

The modulation of cortical arousal starts with Step 4 requiring a transition from conscious to unconscious thought processes. Neural headsets employing neurofeedback techniques facilitate the rotation of cortical arousal. Real-time feedback provided by these devices enables individuals to discern between states of focus and relaxation. Gamification elements further support the training process, assisting individuals in smoothly transitioning between these cognitive states, as depicted in Fig. 3. Notably, most training participants were unable to modulate their brain waves without these prior exercises.

Six Step Cycle—A Spiral Process

Any possible solution requires rigorous evaluation, necessitating a reiteration of the Six Step Cycle beginning with the initial stage of problem comprehension, specifically oriented toward evaluating the generated solution. Should the evaluated solution fail to meet predefined criteria, or no solution is found, the cycle is repeated.

Each iteration of the cycle contributes to the formation of new neural networks and fosters novel cognitive connections, resulting in a cumulative spiral of incremental insights and knowledge. This iterative and rigorous approach to complex problem-solving aligns with the observation that meaningful insights and breakthroughs typically arise after extended periods of persistent cognitive exploration (MacKinnon, 1987).

Six Step Cycle—Idea Execution

The generation of creative ideas represents merely the initial stage; effective implementation poses distinct and significant challenges. The Six Step Cycle method, while primarily developed for ideation, can also be systematically applied to idea execution. The process commences with a thorough comprehension of the execution-related challenges, including the creation of a preliminary roadmap identifying potential obstacles, with particular emphasis on those eliciting risk aversion. According to Chrysikou (2012), fear and risk aversion frequently hinder the pursuit of innovative solutions, as demonstrated by notable cases such as the establishment of Amazon by Jeff Bezos. Following initial comprehension, the second step involves a detailed analysis of identified risks and the development of strategies to mitigate them effectively. Should immediate solutions prove elusive, the successive stages of the Six Step Cycle should be systematically employed, ensuring comprehensive exploration and resolution of identified implementation challenges.

Fig. 3 Training with neural headsets

Six Step Cycle—An Integrative Framework

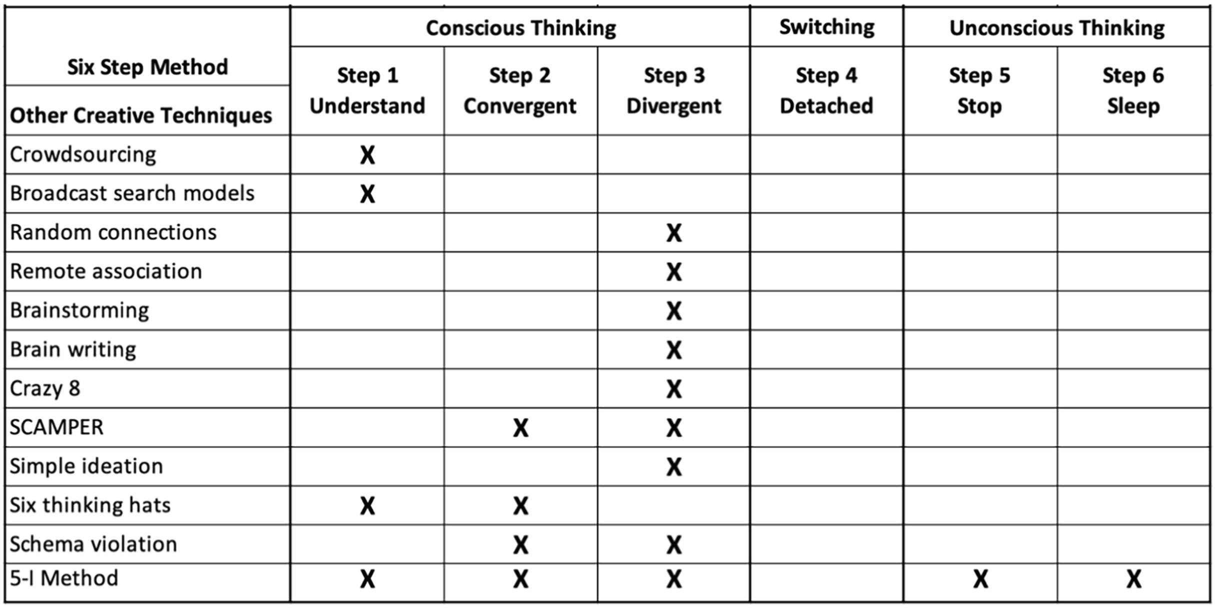
The Six Step Cycle complements the existing methods by explicitly integrating unconscious cognitive processes into the creative workflow. In general, current methods offer little to no structured engagement with unconscious cognitive processes. In particular, Step 4 Detached Thinking is consistently absent. While Steps 1 to 3 align with traditional practices—focusing on analytical, convergent, and divergent thinking—Steps 4 to 6 engage the default network to facilitate spontaneous ideation and the emergence of creative insights. As such, the Six Step Cycle functions as a basic template for all creativity methods, providing a comprehensive structure accommodating conscious and unconscious phases of the creative process. How most current creativity techniques fit into the Six Step framework is illustrated in Table 1. The creativity techniques addressed are selective and by no means exhaustive.

Six Step Cycle—Validation

The effectiveness of the Six Step Cycle was previously evaluated in a controlled university setting. The findings of this study have been published in Ritter et al. (2020), which reported statistically significant improvements in creative performance among participants. The study involved 263 undergraduate students from an applied university in the Netherlands. To achieve a statistical power of approximately 0.80, 198 students were recruited for the training group. An additional 65 students, who were not enrolled in the training course, served as the control group. The participants had a mean age of 19.72 years (SD = 1.82), with ages ranging from 18 and 26. Both the training and control groups were comparable in terms of educational level (all were first-year students) and academic background (all enrolled in business-related programs).

A between-subjects design was employed, with creative performance assessed at three time points over an eight-month period: a pretest, a mid-test after three months, and a post-test five months later. The control condition allowed to rule out a potential practice or learning effects on the creativity measures. Importantly, the creativity tasks differed from those practiced during the training to avoid

Table 1 Six Step template for other creativity methods



Six Step Method	Conscious Thinking			Switching	Unconscious Thinking	
Other Creative Techniques	**Step 1 Understand**	**Step 2 Convergent**	**Step 3 Divergent**	**Step 4 Detached**	**Step 5 Stop**	**Step 6 Sleep**
Crowdsourcing	X					
Broadcast search models	X					
Random connections			X			
Remote association			X			
Brainstorming			X			
Brain writing			X			
Crazy 8			X			
SCAMPER		X	X			
Simple ideation			X			
Six thinking hats	X	X				
Schema violation		X	X			
5-I Method	X	X	X		X	X

confounding effects of task familiarity. Seven creativity tasks were administered to assess divergent thinking, convergent thinking, and creative problem-solving abilities. Three versions of each task were applied. Outcome measures included *fluency*, *flexibility*, *originality*, *usefulness*, and *creativity*.

Statistically significant improvements in creative performance were observed in the training group. On both divergent thinking measures—the verbal Alternate Uses Task (AUT) and the Visual Imagination Task (VIT)—participants in the training group generated significantly more ideas, while the control group showed no such change. Cognitive flexibility, as indicated by the number of distinct idea categories, also increased significantly in the training group. This suggests an enhanced ability to break cognitive patterns and overcome functional fixedness—effects not observed in the control group. However, a significant decline in the perceived usefulness of the generated ideas was observed in the training group over time, from the pretest to the mid-test and post-test. In terms of convergent thinking, an increase in Remote Associates Test (RAT) performance was observed in the training group, but not in the control group. At the post-test, the training group also outperformed the control group in creative problem-solving tasks, with a higher percentage of participants successfully solving these challenges.

In addition to gains in fluency and flexibility, the training also led to significant improvements in idea originality and creativity. Originality scores increased particularly on the Visual Imagination Task, and expert-rated creativity also improved over time. These outcomes further support the Six Step Cycle's effectiveness in enhancing both the quantity and quality of creative output (Ritter et al., 2020).

All methodological details and full datasets are available in the original publication (Ritter et al., 2020) and via the Radboud University repository (https://doi.org/10.17026/dans-zuz-q6zd) and the Open Science Framework (https://osf.io/znw5h/register/5730e99a9ad5a102c5745a8a).

Discussion

The evaluation conducted at Radboud University primarily involved Western adults, and the efficacy of the training was not assessed across different age groups or cultural contexts. For instance, an fMRI study demonstrated that individuals from Western cultural backgrounds tend to perform better on tasks emphasizing independent (absolute) dimensions, whereas individuals from East Asian contexts perform better on tasks emphasizing interdependent (relative) dimensions (Hedden et al., 2008, p.12).

A multidisciplinary research approach is required to advance our understanding of creative thinking. In particular, it is essential to empirically validate various creativity methods through rigorous testing. The study by Ritter et al. (2020) focused solely on evaluating the effectiveness of the Six Step Cycle, and while the results were statistically significant, they do not permit a direct comparison between the Six Step Cycle and alternative creativity methods. Future research should include comparative analyses to determine the relative efficacy of different training approaches.

Another critical variable is the time required to solve creative problems, particularly during Steps 4, 5, and 6 of the cycle. Due to practical constraints, the current study did not assess this component. Furthermore, no follow-up data regarding the long-term effects of the training are available. Conducting follow-up measurements at longer intervals (e.g., three and six months after training completion) using standardized creativity tests can establish the sustainability of acquired skills. Greater long-term effects observed in participants trained with the Six Step Cycle would constitute a significant differentiating criterion.

The development of creative thinking skills through targeted training is both feasible and necessary. Observations within the Dutch educational system suggest that creative thinking is often treated as an ancillary skill rather than a core competency. Current curricula tend to emphasize cognitive skills—such as reading, writing, and mathematics—while neglecting the training required to navigate unpredictable, real-world challenges. Although cognitive skills are undoubtedly important, there is a critical need for a more balanced educational approach that includes systematic training in creative thinking.

Research should also examine the applicability of this training method across diverse educational and professional contexts. Although direct evidence is currently limited, neuroscientific insights indicate that individuals across various domains—including the arts, sciences, and business—may enhance their creative potential and problem-solving abilities through systematic cognitive training.

In summary, future research should explore the comparative efficacy, long-term impact, and broader applicability of this framework across diverse populations and contexts.

Of particular interest is the level of cortical arousal and switching capability between focused attention and detached observation in creative individuals mentioned. We advocate the use of neural headsets to train this capability. Moreover, EEG monitoring may serve as a reliable indicator of insight-based problem solving or analytical reasoning, as shown by Kounios and Beeman (2015).

Conclusion

This study introduces a novel framework for fostering creative thinking by systematically leveraging unconscious cognitive processes. The neuroscientific principles derived from the literature review have been translated into an evidence-based approach to enhancing creativity. Grounded in contemporary neuroscience and supported by empirical research, the Six Step Cycle integrates established creativity techniques into a coherent, structured methodology that maximizes cognitive synergy. The findings underscore the potential of unconscious cognition as a critical yet underutilized resource in creative problem-solving.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing Interests The authors declare no competing interests.

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