Empirical treatments of imagination and creativity

Dustin Stokes

Abstract

This paper offers a critical survey and analysis of empirical studies on creativity, with emphasis on how imagination plays a role in the creative process. It takes as a foil the romantic view that, given features like novelty, incubation, and insight, we should be skeptical about the prospects for naturalistic explanation of creativity. It rebuts this skepticism by first distinguishing stages or operations in the creative process. It then works through various behavioral and neural studies, and corresponding philosophical theorizing, that concern the preparation, generation, insight, and evaluation stages of creative processes. The result is not a complete explanation of creativity, but it identifies an explanatory path towards such an explanation, including the features of creativity that motivate that skepticism.

Keywords: Imagination, Creativity, Novelty, Insight, Incubation, Learning, Attention, Imagery, Expertise, Skill

Imagination and creativity are distinct but importantly related concepts. One way to identify, and hopefully substantiate, those relations is through empirical study. However, there is little empirical study on imagination *and* creativity; researchers typically focus on just one or the other. This chapter will attempt a critical survey and framework for empirical study of creativity, with frequent emphasis on imagination and its role in the creative process. In turn, we gain insights into imagination and its many important uses.[1]

[1] See also Arcangeli (this volume).

Begin with a familiar anecdote, Henri Poincaré recounting his insight concerning group theory in physics:

> The incidents of the travel made me forget my mathematical work. Having reached Coutances, we entered an omnibus to go some place or other. At the moment when I put my foot on the step, the idea came to me, without anything in my former thoughts seeming to have paved the way for it, that the transformations I had used to define the Fuchsian functions were identical with those of non-Euclidian geometry (Poincaré 1913).

Anecdotes such as these share some important features. First, the light bulb moment often comes to the thinker unbidden, seemingly "out of nowhere". And further, it often comes when the thinker is not laboring over the target problem, be it in physics or chemistry or painting. And of course the thought that comes to the creative person—often described in terms of 'genius'—involves something importantly new or original. "A-ha, *this* is the solution I needed! I hadn't thought of *that*!" Finally, these three features—insight, incubation, novelty—encourage a characterization of creativity that apparently puts the control over the cognitive breakthrough outside of the agency of the individual person. These features discourage the notion that it is the thinker that intentionally produced the thought. Enter appeal to muses, madness, and Gods. Or, more pedestrian, enter the conclusion that creativity, whatever it is, seems outside the scope of empirical psychological explanation. This is *Romantic Skepticism* about creativity.[2]

It would be easy to dismiss this kind of skeptic on account of their romanticism. "We have science! We don't believe in muses or magic! We have moved on from that dark, medieval age!" This would be easy but mistaken. Mistaken because this skeptic has underscored genuine

---

[2] Traditionally, both Plato (in the *Ion* and the *Phaedrus* 1987) and Schopenhaeur 1859 encourage a similar skepticism. More recently Hospers (1985), Hausman (1975), and Kivy (2001) have (in different ways and degrees) suggested some such form of skepticism. For a recent naturalistic rebuttal to some of these views, see Kronfeldner 2009, 2018. See Paul (this volume) for more on historical accounts of creativity.

features of creative phenomena, and ones that are genuinely puzzling and difficult to explain. These are features that draw us to creativity. They are remarkable, inspiring, surprising, weird. They are among the reasons that we should be interested in creativity as philosophers and scientists. The romantic skeptic should therefore be taken seriously. But that is not to say that we should yield to this skeptic. The way forward is to see just how far we can get, by way of empirical study, in understanding various features of the creative process, including the "weird" features.

Empirical study of creativity uses a general framework that is a familiar one in the mind sciences. Identify distinctive features or dimensions of the target phenomenon and attempt distinctive explanations of those features. We don't take the entire explanatory project on at once. Instead, we "chunk" it. Once these explanations are assembled, we may then ask: does this fully explain the target phenomenon? Even if the answer to this question is 'no', the individual explanations will be illuminating and, hopefully, point towards additional *explananda* and *explanans*, towards "the whole picture". In the case of creativity, the first important explanatory lesson is to abandon the assumption that there is a singular creativity mechanism or psychological faculty. Instead, like many mental phenomena, creativity is likely an assemblage of more basic psychological faculties and abilities. And, as we will see, imagination is one very important such faculty.

This explanatory approach echoes comments made by J.P. Guilford in his famous 1950 Presidential address to the American Psychological Association where he called on researchers to take creativity up as a legitimate target for empirical study. With this prescription came a wave of research on a range of phenomena relative to creativity: personality traits of creative persons, motivation and achievement, development and learning, behavioral study targeting relevant cognitive and perceptual faculties, neurological study on possible underlying neural mechanisms, attention to social, cultural, and institutional contexts of creative activity. This prescription held, and today there is a rich and wide-ranging empirical literature on the various facets of creativity.[3]

That approach implies an important presupposition: the study of creativity is not exhausted by the study of genius. And empirical study should not start with genius as *explanandum*. This too was explicit in Guilford's address, who resisted a standard assumption that creativity correlated in some substantial way with high intelligence (often measured in terms of IQ) and called for researchers to focus on instances of creativity of "lower degrees of distinction", and in a manner sensitive to individual differences. In terms familiar to readers of this volume, Guilford was advocating for emphasis on creativity that involves mere *psychological novelty*, rather than novel achievements relative to history or some large swath of history (Boden 2004; see also Stokes 2011). Notice how this affords an important experimental benefit: the potential subject pool increases exponentially, and the range of useable empirical methods with it.

Now recall our Romantic Skeptic, who highlighted the most puzzling features of creativity: insight, incubation, novelty. The big question for empirical treatments of creativity is whether the broad empirical approach outlined above, grounded in Guilford's address, can genuinely explain

[3] There is a division of the American Psychological Association devoted to aesthetics and creativity; a number of specialist journals (*Psychology of Aesthetics*, *Creativity and the Arts*; *Creativity Research Journal*; *Journal of Creative Behavior*; *International Journal of Creativity and Problem Solving*); multiple special issues of journals, literature reviews, and anthologies; and even an encyclopedia now in its 3rd edition (Runco and Pritzker 2020). For more, see Paul and Stokes 2023.

some or all of these features. The familiar risk is that the empirical approach will collapse into a deflationary account that ultimately neglects those important puzzling features. The antidote to this threat is to resist reductionist science. The most satisfying empirical treatment of creativity will require sensitivity to rather than elimination of the seemingly mysterious features that fuel romantic mystification.[4]

II. Operations of the creative process

A natural way to go about chunking a complex phenomenon like creativity is to identify stages or operations that make it up. One recent such characterization is the *Geneplore* model in cognitive psychology, which recognizes a stage of idea *generation* and a second stage of idea *exploration* (Finke 1996; Smith, Ward, & Finke 1995).[5] That model can be traced to a four-stage model endorsed by Graham Wallas (1926), initially articulated in a lecture by mathematician Henri Poincaré ((1908 [1913, 383–394]). Here there are four stages: Preparation, Incubation, Illumination, Verification. More recently, Paul and Stokes (2023) modify the Poincaré/Wallas model as follows:

1. *Preparation*—learning, practice, knowledge and skill acquisition in a given domain.
2. *Generation*—of new ideas
3. *Insight*—a conscious experience of a new idea
4. *Evaluation* – assess the idea for application and value
5. *Externalization*— express the idea in an observable form

[4] For more general discussion of distinct theoretical approaches to creativity, see Langkau (this volume).
[5] This model has philosophical pedigree in the distinction made by philosophers of science between the *context of discovery* and the *context of justification*. See Murphy (this volume).

These stages or phases will often not proceed in such linear fashion. Instead, creativity more likely involves a complicated cycle of these operations, with regular feedback between them. Still, they provide a nice delineation of the creative process, where distinct operations will be grounded in distinct but sometimes overlapping cognitive processes. The following sections will focus primarily on operations 1 through 4, with an eye towards identifying empirical studies relevant to the features of creativity that drive romantic skepticism: insight, incubation, novelty.

II.1 Preparation

The preparation phase or operation in creative processes is perhaps the easiest to characterize, since the mental components involved have received significant empirical study. Here the relevant literature includes work on learning, practice, skill and expertise.[6]

In a now seminal publication, Fitts and Posner (1967) identified three phases for learning. With an emphasis on motor skill, they distinguished what they called a cognitive stage, associative stage, and autonomous stage. The cognitive stage involves identification of the task or skill to be learned, with explicit use of whatever declarative or propositional knowledge the agent has, and conscious, laborious attention to one's movements. At the associative stage, the sequence of actions has been learned, with some actions still requiring conscious attention and others becoming automatic. At the autonomous stage, the action can be controlled fluidly and automatically. The need for conscious attention and declarative knowledge is mostly left behind, with procedural knowledge driving performance.

[6] See also Kind (this volume).

This model plausibly applies beyond motor learning, to cognitive and perceptual learning. Suppose you are interested in discerning crows from ravens. Initially, you will have to consciously search for known distinguishing features: ravens have longer, more curved beaks and fluffy feathers around their throat; ravens' tails appear wedge shaped when in flight. To discern the raven from the crow you will have to use your knowledge to look for these distinguishing raven-features. With practice, you'll more readily pick up on some such relevant feature (while perhaps still having to consciously look for others) to discern the raven. And with even more practice, you may automatically, without effort or inference pick up those distinguishing features. You may "just see" that it's a raven without having to consciously attend to distinctive features or draw an inference.

In each of these cases—motor, cognitive, perceptual learning—practice makes…automatic. (Nobody's perfect.) To be highly skilled in an activity, to be an expert violinist or mathematician or birdwatcher, one must engage in hours of effortful training and practice. Importantly, the practice required for mastering a skill is most effective when it involves feedback and correction in addition to repetition. Different theorists have quantified success in different ways. Howard Gardner famously coined "the ten-year rule" (Gardner 1993). Similarly, Anders Ericsson and his colleagues found that expert-level performance—in a wide range of domains: sport, medicine, music, dance, engineering—may require 10,000 hours of "deliberate practice", "an extended process of skill acquisition mediated by large, but not excessive daily amounts of deliberate practice" (Ericsson, Krampe, & Tesch-Römer 1993; see also Ericsson et al. 2006).

One way that this kind of expert motor or perceptual skill acquisition may benefit an individual, and afford space for creative performance, is by reducing the cognitive load of that individual when they perform in their domain. A world-class ballet dancer will perform many movements automatically, sometimes with "flow" (see Ivy 2022). And a world-class footballer may better perceive patterns in opposing players, movements of opposing players, movements of the ball. This automaticity frees up cognitive resources in working memory. Insofar as novel thought or action often requires imagination in some form (see Gaut 2003; Stokes 2014; further discussed below)—to improvise a new dance movement, to spontaneously move with the ball between defenders—and imagination requires working memory, then the expert will have a performance advantage. Because this advantage pertains both to idea generation and evaluation, it will be discussed again below (II.4).

Another angle for empirical investigation into the preparation phase of creativity concerns identifying and analyzing a problem space. Psychologists have often studied creativity under the guise of problem-solving, but they have also emphasized *problem-finding*. A "problem" could be a puzzle or task with a clear solution but can also be construed broadly to include creative aims like proving a scientific theorem, innovating a violin solo, producing a new painting in a familiar style of depiction. Creativity can enter here insofar as a creative outcome may first require identifying an interesting problem (Abdulla et al. 2020). Indeed Einstein indicated that problem finding will sometimes involve more novelty than the solution to that problem.

> The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science. (Einstein & Infeld 1938, 92)

Note here that placing the creative act in a distinctive stage is not clear cut: as Einstein indicates, the problem-finding may require imagination and fall under the spontaneous and novel insight stage, while the solution involves skillful execution at the preparation, evaluation and perhaps the externalization stages. Creative work is messy and rarely proceeds in a neat step-wise manner.

II.2 Generation

The generation phase of creative processes involves development of new ideas. The novelty here may be mere psychological novelty—an idea novel relative to that agent's psychology. And plausibly, such novelty may be generated through conscious, deliberate mental effort, or through unconscious mechanisms. Empirical researchers have studied both.

A model first articulated by Donald T. Campbell (1965) and later championed by Dean Simonton (1999, 2011, 2012, 2022) is BVSR, which posits that creativity involves *blind variation and selective retention*. Put in terms of the geneplore model, BVSR claims that ideas are generated through a process of blind variation, and then explored via selective retention. The first is supposed to involve generation of ideas that are not guided or determined by prior knowledge or judgments of value. Such idea generation is thus blind insofar as it is not directed by "the creator's prior knowledge of the variation's utility" (Simonton 2022, 5; see Kronfeldner 2018 for criticism). This may include remote association and mind wandering. The selective retention stage, by contrast, is neither blind nor random. It is "sighted": guided by the creator's judgments of the idea's value. Plausibly, this conceptual exploration stage will often be guided by one's imagination: considering various possible outcomes, scenarios, and values of the varied ideas generated.

Recent neuroscience provides evidence for neural activity that may correlate with the blind variation role. The *default mode network* (DMN) is an area or network of the cortex posited to be less active when one is focused on an external task and more active when one is not focused externally (Raichle et al. 2001; Buckner & DiNicola 2019). Idea generation and variation as posited by BVSR will plausibly involve imagination, memory recall, daydreaming, conceptual manipulation, and these are the very processes with which DMN activity correlates. So while DMN is in no way a creativity-specific mechanism or module (indeed, controversy abounds about where to precisely draw its neural and functional boundaries), it does comport well with the "free" production of ideas that creativity seems to so often involve. Researchers working on DMN and creativity suggest that this "divergent thinking" works in tandem with conscious, executive control,

> In general, we contend that the default network influences the generation of candidate ideas, but that the control network can constrain and direct this process to meet task-specific goals via top-down monitoring and executive control. (Beaty et al. 2016; see also Mayseless et al. 2015; Beaty et al. 2019)

Peter Carruthers identifies the DMN as one possible mechanism for "constrained stochasticity"(Carruthers 2020).

Carruthers offers a relevant distinction between creative idea generation that is online versus offline. "Creative improvisation in jazz is online, whereas having a new idea occur to one "out of the blue" while in the shower is offline" (Carruthers 2020). He offers a general two-part distinction. Working memory is where mental representations can be considered and manipulated. And top-down attention on those representations maintains existing items in working memory and can bring other representations into that workspace. In the background of working memory, as it were, is a *saliency network* (Corbetta and Shulman 2002; Corbetta et al. 2008; Menon and Uddin 2010). As Carruthers emphasizes, this so-called network is responsible for relevance rather than salience, since it evaluates mental representations for relevance to the agent's standing goals, tasks, and values. Thinking about attention in terms of competition (Mole 2011; Desimone and Duncan 1995), this network may determine that an unattended mental representation or perceptual input is indeed relevant to the agent's present and standing goals, tasks, and values. That mental representation may then "win out" for attentional resources and come into working memory, thereby becoming a conscious mental representation for the agent. [7]

Mind-wandering and its value to novel idea generation can be understood along this general model. One may be involved in a challenging and perhaps monotonous task. Carruthers considers learning verbs in a new language. In such a context, one's mind may begin to wander. It may wander close or far—say to a potential holiday where the new language is spoken, or to medical appointments that one is dreading. Here the saliency (or relevance) network will monitor mental representations as one's mind wanders, and against one's standing goals, tasks, and values. If a representation is deemed relevant by the network—perhaps the mind has wandered to Paris, and then to the Latin Quarter, and then to Rue Descartes, and then to…a-ha!...some morsel in the Meditations relevant to an ongoing philosophical project—then a switch to top-down attention and working memory ensues:

[7] See also Nanay, on attention and creativity (this volume).

> The result is that a novel idea pops suddenly into mind as a potential solution. Sometimes, when consciously explored and evaluated against a wider range of criteria the idea turns out not to work; but sometimes it does. Here novelty has emerged from the way in which concepts, memories, and fragments of memory have become stochastically activated by seemingly-irrelevant features of a totally different context (Carruthers 2020, 4461).

Thus one's goals and values constrain a stochastic process of unconscious idea generation, where those constraints will influence which of those ideas arise in conscious working memory.[8]

Notice how this is an empirical treatment of the romantic skeptic's central bogeymen: incubation, insight, and novelty. Indeed some have suggested that it is these features that anchor skepticism about (empirical) explanation of creativity (see Stokes 2007 for an overview). However, in addition to Carruthers' analysis, there is ample space for optimism about explaining unconscious incubation (and related phenomena).

Incubation (and resulting insights, discussed further below) features centrally in many famous anecdotes: Archimedes in the tub, Newton and a falling apple, Kekulé and a daydream of a serpent. Here is Einstein,

> I was sitting in a chair in the patent office at Bern when all of a sudden a thought occurred to me. "If a person falls freely he will not feel his own weight". I was startled. This simple thought made a deep impression on me. It impelled me toward a theory of gravitation. (Einstein, "Kyoto Lecture", 1922)

In these and many other instances, the creative insight seems to come after a period where the person is engaged in something other than creative problem solving, in some cases cognitively

[8] For some recent work on mind-wandering, see Christoff et al. 2016; Murray 2021.

demanding and in some cases not. Both behavioral and neural studies have illuminated this phenomenon.

Consider the tip-of-the-tongue phenomenon. You can't recall an actor's name from a familiar film. You "think harder" and the name isn't forthcoming. Somebody else says "it will come to you, forget about it for a second". And, often enough, the name surfaces to consciousness a bit later. Behavioral studies have vindicated this intuitive strategy. Here researchers task two groups with a challenging problem and fixate both groups on an incorrect solution to that problem. In the first group they encourage subjects to, as it were, "think harder"—to continue to struggle with the problem directly. They distract the second group with a distinct, cognitively demanding problem. When that second group is tasked to return attention to the original target problem after a bit of "forgetting about it", those subjects significantly outperform the subjects of the first group (Smith and Blankenship 1989, 1991).

In some respects, these incubation effects are predictable given contemporary understanding of the effects of cognitive effort and attention on *neural plasticity*. The human brain is functionally and structurally plastic, constantly undergoing changes in network connectivity in response to development and external stimuli (Brown and Sherrington 1912; Kolb and Gibb 2011). This has long been known about brain maturation, but it is now considered to be a permanent feature of the brain. The mature brain also regularly changes as a result of environmental changes and individual experience and learning, and all the way down to perceptual areas of the human cortex.[9] The neuroscientist Donald Hebb made this general observation in the mid-twentieth century:

> [A]ny two cells or systems of cells that are repeatedly active at the same time will tend to become "associated", so that activity in one facilitates activity in the other. (Hebb 1949 [2002, 70])

Attention and effort on a task or problem can facilitate these neural changes (Posner et al. 1997). And what's crucial for understanding incubation, is that these changes can continue—they can "reverberate" as Hebb put it—even after one has removed attention from a task or problem. Those changes continue, subconsciously, altering synaptic connections and their strengths. Insofar as those connections correlate in some way to conceptual connections and relations between ideas, when one returns attention to a task or problem, novel ideas may emerge as a result of the changes to the plastic brain. Phenomenologically, this may surface as an a-ha moment or burst of insight. (See Thagard & Stewart 2011; Ritter & Dijksterhuis 2014; and Heilman 2016.)

The above modes of idea generation are, for the most part, offline (in Carruthers' terms). But novel ideas may be generated online as well. Here imagination will figure centrally. Whether psychological or historical, novelty requires some kind of flexibility, some potential for augmenting, revising, or perhaps even inventing a concept or idea. For this reason, recent philosophers have argued that creative thought and action requires a cognitive process that is "decoupled" from action (Gaut 2003), or that is "non-truthbound" (Stokes 2014). And

[9] Kami et al. 1995; Pascual-Leone et al. 2005; Draganski and May 2008; Schwartz et al. 2002; Karmarkar and Dan 2006; Maya-Vetencourt and Origlia 2012.

imagination serves such a role especially (even if not constitutively) well (Gaut 2003, 2009, 2010; Stokes 2014, 2016). Imagination of various forms enjoys a flexibility or playfulness. It does not function to accurately represent the world, and so it provides opportunity to "try out" ideas, situate those ideas in a context or problem-solving space, identify new conceptual combinations, formulate hypotheses and strategies however wild they may be. Because it is typically decoupled from action or doxastic commitment, imagination serves this role of "cognitive manipulation".

Consider a series of studies where subjects are asked to imagine and draw non-existent objects—houses, animals, persons (Karmiloff-Smith 1990; Cacciari et. al 1997; Ward 1994, 1995). The studies suggest a pair of theses. First, application of learned concepts is highly constrained. Subjects tend to depict items that are in line with their standard concepts: the houses, animals, and persons tend to be drawn with features that compose or constitute these familiar concepts. Subjects seem to "retrieve a specific instance of a given category and pattern the new creation after it, regardless of whether they were required to imagine and draw an artefact such as a house or a natural kind such as an animal" (Cacciari et al. 1997, 157). So one's concepts of existents appear to be truth-bound. To construct something novel relative to a category—and this is the second thesis—one must manipulate the concept in some way. So if a subject is attempting to visually imagine (and then draw) a new kind of house, say a house-person, one will need to abandon using the concepts HOUSE and PERSON in a way bound to accurately representing the houses and persons of the world. Neither concept, used by itself, will enable the subject to image a house with a mouth for a door and eyes for windows. It isn't that such a house-person is an especially novel image (although it may be for some young children). It is that one has to make cross-category changes; one has to cognitively manipulate rather than apply concepts in truth-bound ways. And this kind of cognitive manipulation is best performed by the imagination (Stokes 2014).

Empirical studies on visual imagery further corroborate. There are significant correlations between creative problem solving and standard measures of imagery, including capacities for image generation, inspection, transformation, and vividiness (Finke 1990, 1996; Zemore 1995; Morrison & Wallace 2001; Pérez-Fabello and Campos 2007). A more recent study extends these findings. Researchers tested subjects with a creative imagery and drawing task (Palmiero et al. 2015). Subjects were asked to first mentally construct an item into a potentially useful object from a range of different components (see Figure 1). They were then given a brief period to memorize their mentally constructed image, and then to sketch it on paper. Finally, they were asked to identify how the item could be a useful invention within an assigned category (e.g. FURNITURE). Researchers also measured those same subjects on imagery tasks: verbalizer vs. visualizer cognitive style, image vividness, image generation, image inspection, image transformation. The results are intriguing. On the one hand, both being a visualizer (by contrast to a verbalizer) and scoring highly on image transformation tasks significantly correlated with high performance on the creativity task. Vividness of imagery positively correlated with the originality of the subjects' invented items, but negatively correlated with the practicality of those inventions. So as vividness of imagery goes up, the utility of resulting ideas goes down while originality goes up.

The importance of the playfulness of imagination to creative idea generation can also be argued on evolutionary grounds (Carruthers 2002, 2006; Picciuto & Carruthers 2014). Begin by noting that the capacity for pretense and make-belief develops early in humans. Then further note that, as researchers in archeological sciences maintain, there was a creativity explosion in the human species around 40,000 years ago (Mithen 1996). Insofar as imagination is an appropriate mechanism for generating and exploring new ideas in adults, then it would plausibly present a fitness advantage to those who have it. The capacity for pretense, Carruthers and others thus argue, evolved under this very adaptive pressure. Pretense gets selected for in the long run as practice for adult creativity. This both makes sense of the early childhood development in pretend play, and of the ubiquity of human creativity.

II.3 Insight

Much of the above discussion about idea generation blends into the territory of insight. After all, the notion of idea generation seems to make sense only if an idea is generated. And that generation often takes the form of insight. This is another instance where the distinctions between operations in the creative process are just messy. Things are further complicated by the fact that the term ‘insight’ is not used univocally. In some instances, it refers to the relative novelty or originality of an idea. In other instances, it is a phenomenological concept, denoting the sudden onset or a-ha! moment of an idea. A recent definition found in psychological research highlights both features of insight,

> we define insight as any sudden comprehension, realization, or problem solution that involves a reorganization of the elements of a person’s mental representation of a stimulus, situation, or event to yield a nonobvious or nondominant interpretation (Kounios and Beeman 2014, 74).

A standard empirical approach is to study insight as it occurs in problem solving. What distinguishes *insight problems* is that they require non-mechanical or non-algorithmic solutions and, related, some kind of conceptual restructuring of the problem. One standard behavioral method for studying insight uses "Compound remote associates problems" (CRA). For example,

> Each of the three words in (a) and (b) below can form a compound word or two-word phrase with the solution word. The solution word can come before or after any of the problem words.
>
> a. french, car, shoe
> b. boot, summer, ground[10]
>
> (Bowden et al. 2005, 324; from Paul and Stokes 2023)

Although simple, CRA problems are supposed to involve insight for their solution, where that solution occurs suddenly and with little or no feeling of effort. Researchers test this subjective a-ha feature by asking subjects to report how "warm" they feel they are relative to solving a problem (think of playing "warmer/colder" in a simple object search game). By contrast to non-insight problems, subjects report sometimes abrupt changes in the feeling of warmth as they get near a solution to the insight problem (Metcalfe & Wiebe 1987; see also Dominowski 1995; Laukkonen & Tangen 2018).

These kinds of insight problems can be solved quickly and unambiguously. Recently researchers have employed neuroimaging technology to study insight and corroborate behavioral results (Luo & Niki 2003; Mai et al. 2004). And when subjects report insight solutions,

> EEG shows a burst of high-frequency (gamma-band) EEG activity over the right temporal lobe, and fMRI shows a corresponding change in blood flow in the medial aspect of the right anterior superior temporal gyrus (Jung-Beeman et al. 2004; cited in Kounios & Beeman 2014, 78)

[10] Solutions: a. horn; b. camp

So while insight may remain difficult to fully understand, empirical researchers have developed ways to study minimal instances of the phenomenon, and have made a start at identifying neural correlates. The importance of these advances should not be understated: moments of insight are some of the most romanticized and, accordingly, ones that drive skepticism about explaining creativity.

II.4 Evaluation

There is no guarantee that a novel idea, however generated, will be a good one. It may not suit the problem, it may be uninspiring, or it may simply be one among many of the agent's new ideas (when only one can be used). A new idea may be "original nonsense". There is then still much work to do in evaluating a new idea for its application to some problem or context.

Importantly, effective modes of evaluation will vary from context to context. Olfactory and flavour profiles will be relevant to determining the value of a novel culinary idea (Horng and Linn 2009), but not for evaluating musical ideas and performance, where instead considerations like technical virtuosity will factor (Eisenberg and Thompson 2003). And evaluation in both contexts will presumably be much different from what we find in more heavily action-oriented contexts such as sport (Zahno and Hossner 2020).

One common factor for evaluation across domains, however, concerns how the idea will "play out" in a context: will the dish be balanced and flavorful, will the performance be emotionally moving, will the play in the sport result in points scored? One way empirical researchers approach this feature of idea evaluation is by studying errors, where subjects miscalculate how well an idea will in fact play out. In one study, subjects were tasked to evaluate ideas in the context of public policy (for example, a proposal for how to revitalize urban schools), where the evaluation had to concern both the likely resources needed to implement the idea and the likely outcomes of the idea, once implemented (Dailey and Mumford 2006). When subjects were familiar with the domain in question, they were more accurate in their predictions about outcomes, but tended to underestimate the resource requirements for implementing the idea and overestimate the public acceptance of the idea. Thus some basic familiarity or expertise seems to yield over-optimism; accuracy on one measure and errors on others. They also found that when subjects were put in contexts that induced *implementation intentions* to actually put the idea into action, they made fewer errors in their predictions about resource needs and likely outcomes. (See also Blair and Mumford 2007)

Whatever the context, carrying out these future-looking evaluations points clearly to two general and related phenomena: expertise or skill, and imagination. Sometimes evaluation involves a relatively straightforward appeal to one's relevant skills and knowledge. In other instances, one's expertise and skill will be relevant, but if the idea is novel enough one may have to imagine beyond that existing skill and knowledge basis to consider the idea's potential. Finally, there are plausibly cases where the two come together, where imagination is used as a kind of skill.

Again consider Fitts and Posner's (1967) three stage learning process: cognitive, associative, and autonomous. Suppose one is learning to kick a football (soccer ball). It may initially involve a rather clunky application of an instructed (and thus loosely known) set of movements. Anyone who has taught or coached a child to play the sport will be familiar. With practice, some of those movements are internalized, while others may still require explicit attention. Perhaps the learner has internalized how to move the leg but may still need to focus on making contact with the ball on the laces of their shoe and not their toe. Finally, with more practice, one can achieve largely automatic skill performance. One can, as we say, “just do it" and strike the ball without executive attention or deliberation.

But even for the skilled player, there will be instances where performance is not automatic in this way. Suppose a new move or movement (relative to the player) is being considered, say a new juggling or dribbling move towards goal. One way to determine if the idea will play out is to simply try it and see. But when time and energy are limited, this may not be optimal. And for the expert, it may not be needed. At least in some cases, the elite player’s knowledge and experience base may allow them to very quickly determine that the idea will not work, *or* that it has enough prospect for success that trying it out in action is worth the energy spent. This is an instance where one’s existing skill level and expertise allows evaluation of an idea even before putting it into action. This is plausibly an important evaluative advantage for experts, within their domains, in contexts of creativity.[11]

This advantage may not be just cognitive or inferential, but may partly reside in perceptual skills. Some kinds of expertise are richly perceptual, in sport, in medical imaging, in art, in forensics, in birdwatching, and so on. Using a range of methods—behavioral, neural imaging, eye-tracking—researchers have studied experts in these and other domains. The convergence of evidence here

[11] Another advantage is that experts simply have more ideas. See Sawyer (2012) on this *productivity thesis*.

suggests that for some experts, they don't just better judge or know how to perform within their domains, but they better perceive relevant object categories, patterns, and diagnostic features in their domains (Bukach and Gauthier 2006; Scott 2011; Stokes 2021a, 2021b; Stokes and Nanay 2020). The forensics expert may immediately and accurately perceive a fingerprint match, the goalkeeper an offensive pattern of play. Although no studies (that this author knows of) have tested it, a related and provocative hypothesis is that in domains such as these, the expert may sometimes be able to better evaluate the potential for a new idea through enriched perceptual experience within their domain of expertise, whether it's forensics, finches, or football.

But what about those instances of idea evaluation where the novelty of that idea runs much further than one's existing expertise and experience? Here imagination serves an important role. Across varied domains, what the agent does in order to evaluate how an idea may play out is to, quite simply, play it out *in her imagination*. This is enabled by the fact that imagination enjoys a playfulness, a flexibility because it is decoupled from action and is non-truthbound. But by the same token, imagination can be workful. It can be put to particular uses and constrained according to some existing parameters—theoretical and practical—and there is a rich history of philosophers acknowledging this workfulness (Gendler and Hawthorne 2002; Kind and Kung 2016). Whether in carrying out an idea in a thought experiment towards some scientific end or situating a decision in some nearby possible world to identify likely outcomes, we frequently use imagination for our theoretical and everyday projects.[12] This is why imagination is central not just to idea generation, but to idea evaluation. It affords identification of ideas that are at least worthy of more time-consuming and laborious pursuit, and those that are better left behind. This

[12] See Stuart (this volume), and Murphy (this volume).

cognitive labor may not be the most exciting or romantic of operations, but it is crucial to carrying many insights out to something fruitful, to something genuinely creative.

Finally, there are two important ways that expert skill and imagination come together in the creative process. First, expert-level skill in a domain frees up cognitive resources for an individual. Again consider perceptual expertise. Experts may better perform in a domain because they better perceptually represent relevant crucial features, details, and patterns of objects and events in that domain. This enables not just accuracy, but effortless and therefore more efficient pick up of relevant perceptual information. For the expert footballer or painter, the visual system is picking up information that the non-expert would have to laboriously judge or reason about. And this would plausibly free resources in working memory. With those available resources, the expert can think in ways often needed for creative innovation: to imagine some alternative move, to free associate, to perform potentially useful mental imagery, to "cognitively manipulate" concepts and content within their domain. And in some cases, this kind of imaginative evaluation of the ideas in a space may yield something minimally or richly creative. Although there is not space to execute the argument here, one plausible way this may occur in certain domains involves mental imagery. Recent neuroimaging studies suggest that visual perception, visual short-term memory (VSTM), and visual imagery all share neural resources (Albers et al. 2013; Tong 2013; Dijkstra et al 2019; Pearson and Keogh 2019). And so if the expert better perceives features in her domain, resources in working memory remain available for imagery. An expert surgeon may thus visually image a surprising angle for incision to save a life. An elite footballer may rapidly image a move that outwits her opponent and positions her to score a goal. And so on.[13]

This last set of research may serve also to buttress a second thesis concerning the relation between skill and imagination. Amy Kind has recently argued that imagination is a bona fide skill: a mental capacity that can be learned, is under intentional control, and can be improved (Kind 2020, 2023, and this volume). Kind argues that contrary to skeptics, imagination can be practiced and is subject to feedback. One familiar place that imagination is practiced and in ways subject to feedback is in counterfactual reasoning. Another is in make-believe, be it children's games of pretense or in adults' uptake of fictions.[14] Kind's imagination-as-skill thesis can be further supported by some of the same research on perceptual expertise discussed above. Here the emphasis is not on skill acquisition but on skill performance. In the perceptual expertise literature, expert-level classification is marked along some standardized performance threshold for a domain. A standard way to test these experts is to develop experimental manipulations that interfere with that level of performance, in turn to identify the visual behaviors and strategies used.[15] This same approach, broadly characterized, might serve to identify individuals with exceptional imaginative skill. And if visual perception and visual imagery share neural correlates, then one might expect that better perceivers within a domain would also be better at visually imagining within that domain. Accordingly, refinement of perceptual skill in a domain may also refine one's imaginative skill within that domain (see Kind 2023; Stokes 2023), and foster opportunity for creativity.

---

[13] See Stokes (unpublished ms) for a full analysis of this line of thought.
[14] See Buschbaum et al. 2012; Harris 2000; Walton 1990.
[15] For just a few illustrative examples, see Gauthier et al. 2003; McKeef et al. 2010; Rossion and Curran 2010.

All of this underscores the importance of imagination to the creative process. And it underscores that that role is not limited to idea generation or insight. Instead, imagination of various forms would seem to play a crucial role in the evaluation of ideas, and sometimes in skillful, expert-level ways.

III. Conclusion

We began with a skepticism grounded in the kind of romantic anecdote that populates literature on creativity. Centrally, that skepticism casts doubt on empirical explanation of creativity, and by emphasis on some of the most mysterious features of creativity: insight, incubation, novelty. What the above shows is that empirical researchers have in fact made substantial progress at studying and making sense of those very "weird" features. This approach resists reducing the phenomenon, and remains sensitive to the multi-faceted and often messy nature of the creative process. It shows how various operations in that process can be studied by different methods, thus dispelling some of their mystery. And it leaves space for philosophical analysis to lay groundwork and fill gaps left by underdetermining empirical data. This does not paint "the whole picture". But it does paint one that depicts a clear advantage for an empirical approach to creativity, one that shifts the burden of proof back to the skeptic.[16]

Works cited

Abdulla, Ahmed M., Sue Hyeon Paek, Bonnie Cramond, and Mark A. Runco. 2020). "Problem Finding and Creativity: A Meta-Analytic Review." *Psychology of Aesthetics, Creativity, and the Arts*, 14(1): 3–14. Doi:10.1037/aca0000194

[16] Thanks to Amy Kind and Julia Langkau for helpful comments on an early draft.

Albers, A.M., Kok, P., Toni, I., Dijkerman, H.C., de Lange, F.P. 2013. “Shared Representations for Working Memory and Mental Imagery in Early Visual Cortex.” *Current Biology* 23, 1427–1431.

Beaty, Roger E., Mathias Benedek, Paul J. Silvia, and Daniel L. Schacter. 2016. “Creative Cognition and Brain Network Dynamics.” *Trends in Cognitive Sciences* 20(2): 87–95. Doi:10.1016/j.tics.2015.10.004

Beaty, Roger E., Paul Seli, and Daniel L Schacter. 2019. “Network Neuroscience of Creative Cognition: Mapping Cognitive Mechanisms and Individual Differences in the Creative Brain.” *Current Opinion in Behavioral Sciences*, 27(June): 22–30. Doi:10.1016/j.cobeha.2018.08.013

Blair, Cassie S. and Michael D. Mumford. 2007. “Errors in Idea Evaluation: Preference for the Unoriginal?” *The Journal of Creative Behavior* 41(3): 197–222. Doi:10.1002/j.2162-6057.2007.tb01288.x

Boden, Margaret. 2004. *The Creative Mind: Myths and Mechanisms*, second edition, London/New York: Routledge. Doi:10.4324/9780203508527

Bowden, Edward M., Mark Jung-Beeman, Jessica Fleck, and John Kounios. 2005. “New Approaches to Demystifying Insight.” *Trends in Cognitive Sciences* 9(7): 322–328. Doi:10.1016/j.tics.2005.05.012

Brown, T.G., Sherrington, C.S. 1912. “On the Instability of a Cortical Point.” *Proceedings of the Royal Society of London. Series B, Containing Papers of a Biological Character* 85: 250–277. https://doi.org/10.1098/rspb.1912.0050

Buckner, Randy L. and Lauren M. DiNicola. 2019. “The Brain’s Default Network: Updated Anatomy, Physiology and Evolving Insights.” *Nature Reviews Neuroscience* 20(10): 593–608. Doi:10.1038/s41583-019-0212-7

Bukach, C.M., Gauthier, I., Tarr, M.J. 2006. “Beyond Faces and Modularity: The Power of an expertise Framework.” *Trends in Cognitive Sciences* 10, 159– 166. https://doi.org/10.1016/j.tics.2006.02.004

Buchsbaum D., Bridgers S., Weisberg D. & Gopnik A. 2012. The power of possibility: causal learning, counterfactual reasoning, and pretend play. *Phil. Trans. R. Soc.-Bio. Sci.* 367: 2202-2212

Cacciari, Cristina, Maria Chiara Levorato, and Piercarla Cicogna. 1997. “Imagination at Work: Conceptual and Linguistic Creativity in Children.” in *Creative Thought: An Investigation of Conceptual Structures and Processes.*, Thomas B. Ward, Steven M. Smith, and Jyotsna Vaid (eds.), Washington, DC: American Psychological Association, 145–177. Doi:10.1037/10227-007

Campbell, Donald T. 1960. "Blind Variation and Selective Retentions in Creative Thought as in Other Knowledge Processes." *Psychological Review* 67(6): 380–400. Doi:10.1037/h0040373

Carruthers, Peter. 2002. "Human Creativity: Its Cognitive Basis, Its Evolution, and Its Connections with Childhood Pretence." *The British Journal for the Philosophy of Science* 53(2): 225–249. Doi:10.1093/bjps/53.2.225

____2006. *The Architecture of the Mind: Massive Modularity and the Flexibility of Thought*, Oxford: Clarendon Press. Doi:10.1093/acprof:oso/9780199207077.001.0001

____ .2020. "Mechanisms for Constrained Stochasticity." *Synthese* 197(10): 4455–4473. Doi:10.1007/s11229-018-01933-9

Corbetta, M., Patel, G., & Shulman, G. 2008. "The reorienting system of the human brain: From environment to theory of mind." *Neuron 58,* 306–324.

Corbetta, M., & Shulman, G. 2002. Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience 3,* 201–215.

Christoff, Kalina, Zachary C. Irving, Kieran C. R. Fox, R. Nathan Spreng, and Jessica R. Andrews-Hanna. 2016. "Mind-Wandering as Spontaneous Thought: A Dynamic Framework." *Nature Reviews Neuroscience* 17(11): 718–731. Doi:10.1038/nrn.2016.113

Dailey, Lesley, and Michael D. Mumford. 2006. "Evaluative Aspects of Creative Thought: Errors in Appraising the Implications of New Ideas." *Creativity Research Journal* 18(3): 367–384.

Desimone, R., & Duncan, J. 1995. "Neural mechanisms of selective visual attention." *Annual Review of Neuroscience* 18*:* 193–222

Dijkstra, N., S. E. Bosch, and M. A. J. van Gerven. 2019. "Shared Neural Mechanisms of Visual Perception and Imagery." *Trends in Cognitive Sciences* 23: 423–34.

Dominowski, Roger L. 1995. "Productive Problem Solving." in Smith, Ward, and Finke 1995: 73–95.

Draganski, B., May, A. 2008. "Training-Induced Structural Changes in the Adult Human Brain." *Behavioural Brain Research, Biobehavioural Plasticity* 192, 137–142. https://doi.org/10.1016/j.bbr.2008.02.015

Einstein, Albert, "Kyoto Lecture", 14 December 1922, from notes in Japanese taken by Jun Ishiwara and published as *Einstein Koen-Roku*, Tokyo: Tokyo-Tosho, 1977.

Einstein, Albert and Leopold Infeld. 1938. *The Evolution of Physics: The Growth of Ideas from Early Concepts to Relativity and Quanta*, New York: Simon and Schuster.

Eisenberg, Jacob and William Forde Thompson. 2003. "A Matter of Taste: Evaluating Improvised Music." *Creativity Research Journal* 15(2–3): 287–296. doi:10.1080/10400419.2003.9651421

Ericsson, K. Anders, Neil Charness, Paul J. Feltovich, and Robert R. Hoffman (eds.). 2006. *The Cambridge Handbook of Expertise and Expert Performance*. New York/Cambridge: Cambridge University Press. doi:10.1017/CBO9780511816796

Ericsson, K. Anders, Ralf T. Krampe, and Clemens Tesch-Römer. 1993. "The Role of Deliberate Practice in the Acquisition of Expert Performance." *Psychological Review* 100(3): 363–406. doi:10.1037/0033-295X.100.3.363

Finke, Ronald A. 1990. *Creative Imagery: Discoveries and Inventions in Visualization*, Hillsdale, NJ: L. Erlbaum Associates.

_____1996. "Imagery, Creativity, and Emergent Structure." *Consciousness and Cognition*, 5(3): 381–393. doi:10.1006/ccog.1996.0024

Fitts, P.M. and Posner, M.I. 1967. *Human Performance*. Brooks/Cole, Belmont.

Gardner, Howard. 1993. *Creating Minds: An Anatomy of Creativity Seen through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Gandhi*, New York: Basic Books.

Gaut, Berys. 2003. "Creativity and Imagination." in Gaut and Livingston 2003: 148–173 (ch. 6).
____2009. "Creativity and Skill." in Krausz, Dutton, and Bardsley 2009: 83–104.

____ 2010. "The Philosophy of Creativity." *Philosophy Compass* 5(12): 1034–1046. doi:10.1111/j.1747-9991.2010.00351.x

Gauthier, I., Curran, T., Curby, K. M., & Collins, D. 2003. "Perceptual interference supports a nonmodular account of face processing." *Nature Neuroscience* 6(4), 428–432.

Gendler, Tamar & Hawthorne, John (eds.). 2002. *Conceivability and Possibility*. New York: Oxford University Press.

Harris, Paul L. 2000. *The Work of the Imagination*. Wiley-Blackwell.

Hausman, Carl R. 1975 [1984]. *A Discourse on Novelty and Creation*, The Hague: Martinus Nijhoff. New edition Albany, NY: SUNY Press.

Hebb, D. O. 1949 [2002]. *The Organization of Behavior: A Neuropsychological Theory*, New York: Wiley, Reprinted Mahwah, NJ: L. Erlbaum Associates.

Heilman, Kenneth M. 2016. "Possible Brain Mechanisms of Creativity." *Archives of Clinical Neuropsychology* 31(4): 285–296. doi:10.1093/arclin/acw009

Horng, Jeou-Shyan and Lin Lin. 2009. "The Development of a Scale for Evaluating Creative Culinary Products." *Creativity Research Journal* 21(1): 54–63. doi:10.1080/10400410802633491

Hospers, John. 1985. "Artistic Creativity." *The Journal of Aesthetics and Art Criticism* 43(3): 243–255. doi:10.2307/430638

Ivy, Spencer. 2022. "The Role of Creativity in Expertise and Skilled Action." *Synthese* 200 (456):1-22.

Jung-Beeman, Mark, Edward M Bowden, Jason Haberman, Jennifer L Frymiare, Stella Arambel-Liu, Richard Greenblatt, Paul J Reber, and John Kounios. 2004. "Neural Activity When People Solve Verbal Problems with Insight." *PLoS Biology*, 2(4): e97. doi:10.1371/journal.pbio.0020097

Kami, Avi, Gundela Meyer, Peter Jezzard, Michelle M. Adams, Robert Turner, and Leslie G. Ungerleider. 1995. "Functional MRI Evidence for Adult Motor Cortex Plasticity during Motor Skill Learning." *Nature* 377(6545): 155–158. doi:10.1038/377155a0

Karmiloff-Smith, Annette. 1990. "Constraints on Representational Change: Evidence from Children's Drawing." *Cognition* 34(1): 57–83. doi:10.1016/0010-0277(90)90031-E

Karmarkar, U.R., Dan, Y. 2006. "Experience-Dependent Plasticity in Adult Visual Cortex." *Neuron* 52: 577–585. https://doi.org/10.1016/j.neuron.2006.11.001

Kind, A. 2020. "The Skill of Imagination." In Ellen Fridland & Carlotta Pavese (eds.), *Routledge Handbook of Skill and Expertise*. Routledge. pp. 335-346.

____2023. "Issues of Expertise in Perception and Imagination: Commentary on Stokes." *Philosophical Studies*. https://doi-org.ezproxy.lib.utah.edu/10.1007/s11098-023-02018-1

Kind, Amy & Kung, Peter (eds.).2016. *Knowledge Through Imagination*. Oxford, United Kingdom: Oxford University Press UK.

Kivy, Peter. 2001. *The Possessor and the Possessed: Handel, Mozart, Beethoven, and the Idea of Musical Genius*.New Haven, CT: Yale University Press.

Kolb, B., Gibb, R. 2011. "Brain Plasticity and Behaviour in the Developing Brain." *Journal of the Canadian Academy of Child and Adolescent Psychiatry* 20 265–276.

Kounios, John and Mark Beeman. 2014. "The Cognitive Neuroscience of Insight." *Annual Review of Psychology* 65(1): 71–93. doi:10.1146/annurev-psych-010213-115154

Kronfeldner, Maria E. 2009. "Creativity Naturalized." *The Philosophical Quarterly* 59(237): 577–592. doi:10.1111/j.1467-9213.2009.637.

_____2018. “Explaining Creativity.” in Gaut, B. and Kieran, M (eds) *Creativity and Philosophy*. London: Routledge. 213–229.

Laukkonen, Ruben E. and Jason M. Tangen. 2018. “How to Detect Insight Moments in Problem Solving Experiments.” *Frontiers in Psychology* 9(March): article 282. doi:10.3389/fpsyg.2018.00282

Luo, Jing and Kazuhisa Niki. 2003. “Function of Hippocampus in ‘Insight’ of Problem Solving.” *Hippocampus* 13(3): 316–323. doi:10.1002/hipo.10069

Mai, Xiao-Qin, Jing Luo, Jian-Hui Wu, and Yue-Jia Luo. 2004. “‘Aha!’ Effects in a Guessing Riddle Task: An Event-Related Potential Study.” *Human Brain Mapping* 22(4): 261–270. doi:10.1002/hbm.20030

Maya-Vetencourt, J.F., Origlia, N. 2012. “Visual Cortex Plasticity: A Complex Interplay of Genetic and environmental Influences.” *Neural Plasticity* 631965. https://doi.org/10.1155/2012/631965

Mayseless, Naama, Ayelet Eran, and Simone G. Shamay-Tsoory. 2015. “Generating Original Ideas: The Neural Underpinning of Originality.” *NeuroImage* 116(August): 232–239. doi:10.1016/j.neuroimage.2015.05.030

McKeeff, T., McGugin, R., Tong, F., and Gauthier, I. 2010. “Expertise increases the functional overlap between face and object perception.” *Cognition* 117(3): 355-60.

Menon, V., & Uddin, L. 2010. “Saliency, switching, attention and control: A network model of insula function.” *Brain Structure and Function 214:* 655–667.

Metcalfe, Janet and David Wiebe. 1987. “Intuition in Insight and Noninsight Problem Solving.” *Memory & Cognition* 15(3): 238–246. doi:10.3758/BF03197722

Mithen, Steven J. 1996. *The Prehistory of the Mind: The Cognitive Origins of Art, Religion and Science*, New York: Thames and Hudson.

Mole, C. 2011. *Attention Is Cognitive Unison: An Essay in Philosophical Psychology*. Oxford: Oxford University Press.

Morrison, Robert G. and Benjamin Wallace. 2001. “Imagery Vividness, Creativity and the Visual Arts.” *Journal of Mental Imagery* 25(3–4): 135–152.

Murray, S., Liang, N., Brosowsky, N., & Seli, P. 2021. “What are the benefits of mind wandering to creativity?” *Psychology of Aesthetics, Creativity, and the Arts.* Advance online publication. https://doi.org/10.1037/aca0000420

Palmiero, Massimiliano, Raffaella Nori, Vincenzo Aloisi, Martina Ferrara, and Laura Piccardi. 2015. “Domain-Specificity of Creativity: A Study on the Relationship Between Visual Creativity and Visual Mental Imagery." *Frontiers in Psychology* 6 (December). doi:10.3389/fpsyg.2015.01870

Paul, Elliot Samuel and Dustin Stokes. 2023. "Creativity." *The Stanford Encyclopedia of Philosophy.* Edward N. Zalta & Uri Nodelman (eds.), https://plato.stanford.edu/archives/spr2023/entries/creativity

Pascual-Leone, A., Amedi, A., Fregni, F., Merabet, L.B. 2005. "The Plastic Human Brain Cortex." *Annual Review of Neuroscience* 28 377–401.

Pearson, J. and R. Keogh. 2019. "Redefining Visual Working Memory: A Cognitive-Strategy,

Brain-Region Approach." *Current Directions in Psychological Science* 28: 266–73.

Pérez-Fabello, María José and Alfredo Campos. 2007. "Influence of Training in Artistic Skills on Mental Imaging Capacity." *Creativity Research Journal* 19(2–3): 227–232. doi:10.1080/10400410701397495

Picciuto, Elizabeth and Peter Carruthers. 2014. "The Origins of Creativity", in Paul and Kaufman 2014: 199–223. doi:10.1093/acprof:oso/9780199836963.003.0011

Plato, *Plato: Complete Works*, John M. Cooper and D.S. Hutchinson (eds). 1997. Indianapolis, IN: Hackett Publishing.

Poincaré, Henri. 1908 [1913]). *Science et Méthode*, Paris: Flammarion. Translated as "Science and Method" in *The Foundations of Science: Science and Hypothesis, The Value of Science, Science and Method*, George Bruce Halsted (trans.), (Science and Education 1), New York: The Science Press, 1913. [Poincaré 1913 available online]

Posner, Michael I., DiGirolamo, Gregory, J., Fernandez-Duque, Diego. 1997. "Brain mechanisms of cognitive skills." *Consciousness and Cognition*. 6(2-3):267-90. doi: 10.1006/ccog.1997.0301. PMID: 9262412.

Raichle, Marcus E., Ann Mary MacLeod, Abraham Z. Snyder, William J. Powers, Debra A. Gusnard, and Gordon L. Shulman. 2001. "A Default Mode of Brain Function." *Proceedings of the National Academy of Sciences*. 98(2): 676–682. doi:10.1073/pnas.98.2.676

Ritter, Simone M. and Ap Dijksterhuis. 2014. "Creativity: The Unconscious Foundations of the Incubation Period." *Frontiers in Human Neuroscience* 8(April). doi:10.3389/fnhum.2014.00215

Rossion, B., & Curran, T. 2010. "Visual expertise with pictures of cars correlates with RT magnitude of the car inversion effect." *Perception* 39(2): 173-83.

Runco, Mark A. and Steven R. Pritzker (eds.). 2020. *Encyclopedia of Creativity*, third edition, Amsterdam: Academic Press.

Sawyer, R. Keith. 2012. *Explaining Creativity: The Science of Human Innovation*, second edition, New York: Oxford University Press

Schopenhauer, Arthur. 1859. [WWV], *Die Welt als Wille und Vorstellung*, third edition, Leipzig. First edition in 1811 and expanded in 1844. Translated as *The World as Will and Representation*, two volumes, E. F. J. Payne (trans.), Indian Hills, CO: The Falcon's Wing Press, 1958. Reprinted New York: Dover Publications, 1966. Citations, WWV, with volume and page are to the 1966 edition

Schwartz, S., Maquet, P., Frith, C. 2002. «Neural Correlates of Perceptual Learnong: A Functional MRI Study of Visual Texture Discrimination." *Proceedings of the National Academy of Sciences of the United States of America* 99: 17137–17142. https://doi.org/10.1073/pnas.242414599

Scott, L.S. 2011. "Face Perception and Perceptual expertise in Adult and Developmental Populations." in: *Oxford Handbook of Face Perception*. https://doi.org/10.1093/oxfordhb/9780199559053.013.0011

Simonton, Dean. 1999. "Creativity as Blind Variation and Selective Retention: Is the Creative Process Darwinian?" *Psychological Inquiry* 10(4): 309–328.

____2011. "Creativity and Discovery as Blind Variation: Campbell's (1960) BVSR Model after the Half-Century Mark." *Review of General Psychology*. 15(2): 158–174. doi:10.1037/a0022912

____2012. "Creativity, Problem Solving, and Solution Set Sightedness: Radically Reformulating BVSR." *The Journal of Creative Behavior* 46(1): 48–65. doi:10.1002/jocb.004

____ 2022. "The blind-variation and selective-retention theory of creativity: Recent developments and current status of BVSR." *Creativity Research Journal.* Advance online publication. https://doi.org/10.1080/10400419.2022.2059919

Smith, Steven M. and Steven E. Blankenship. 1989. "Incubation Effects." *Bulletin of the Psychonomic Society* 27(4): 311–314. doi:10.3758/BF03334612

____1991. "Incubation and the Persistence of Fixation in Problem Solving." *The American Journal of Psychology* 104(1): 61–87. doi:10.2307/1422851

Smith, Steven M., Thomas B. Ward, and Ronald A. Finke (eds.). 1995. *The Creative Cognition Approach*, Cambridge, MA: MIT Press.

Stokes, Dustin. 2007. "Incubated cognition and creativity." *Journal of Consciousness Studies* 14 (3):83-100.

_____2011. "Minimally Creative Thought: Minimally Creative Thought." *Metaphilosophy* 42(5): 658–681. doi:10.1111/j.1467-9973.2011.01716.x

____2014. “The role of imagination in creativity.” In E. Paul & S. B. Kaufman (eds.), *The philosophy of creativity*. Oxford University Press.

____2016. Imagination and Creativity. In Amy Kind (ed.), *The Routledge Handbook of the Philosophy of Imagination*. Routledge.

_____2021a. “On perceptual expertise.” *Mind and Language* 36 (2):241-263.

_____ 2021b. *Thinking and Perceiving: On the malleability of the mind*. London: Routledge.

____2023. “Perceptual malleability: attention, imagination, and objectivity.” *Philosophical Studies*. https://doi-org.ezproxy.lib.utah.edu/10.1007/s11098-023-02020-7

____(unpublished ms) “Creativity and perceptual expertise.”

Stokes, Dustin & Nanay, Bence. 2020. “Perceptual skills.” In Ellen Fridland & Carlotta Pavese (eds.), *Routledge Handbook on Skill and Expertise*. London: Routledge

Thagard, Paul and Terrence C. Stewart. 2011. “The AHA! Experience: Creativity Through Emergent Binding in Neural Networks.” *Cognitive Science* 35(1): 1–33. doi:10.1111/j.1551-6709.2010.01142.x

Tong F. 2013. “Imagery and visual working memory: one and the same?” *Trends in Cognitive Science* 17(10):489-90. doi: 10.1016/j.tics.2013.08.005

Wallas, Graham. 1926. *The Art of Thought*, London: J. Cape.

Walton, Kendall. 1990. *Mimesis as Make-Believe*. Cambridge, MA: Harvard University Press.

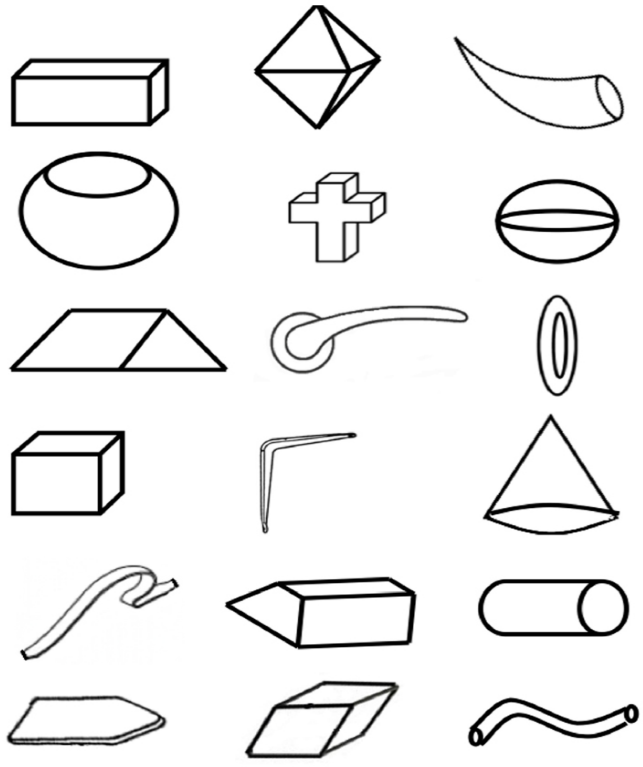
Ward, Thomas B. 1994. “Structured Imagination: The Role of Category Structure in Exemplar Generation.” *Cognitive Psychology* 27(1): 1–40. doi:10.1006/cogp.1994.1010

____1995. “What’s Old about New Ideas?” in Smith, Ward, and Finke 1995: 157–178.

Zahno S, Hossner EJ. 2020. “On the Issue of Developing Creative Players in Team Sports: A Systematic Review and Critique From a Functional Perspective.” *Frontiers in Psychology*, Oct 29;11:575475. doi: 10.3389/fpsyg.2020.575475. PMID: 33192880; PMCID: PMC7658096.

Zemore, Sarah E. 1995. “Ability to Generate Mental Images in Students of Art.” *Current Psychology* 14(1): 83–88. doi:10.1007/BF02686876

Figure 1:



Furniture

Transportation

Tools

Sport Goods

Weapon

Toys