

# Who's afraid of a cognitive neuroscience of creativity?

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## Abstract

This article has two goals. First, the ideas outlined here can be seen as a sustained and disciplined demolition project aimed at sanitizing our bad habits of thinking about creativity. Apart from the enormous amount of fluff out there, the study of creativity is, quite unfortunately, still dominated by a number of rather dated ideas that are either so simplistic that nothing good can possibly come out of them or, given what we know about the brain, factually mistaken. As cognitive neuroscience is making more serious contact with the knowledge base of creativity, we must, from the outset, clear the ground of these pernicious fossil traces from a bygone era. The best neuroimaging techniques help little if we don't know what to look for. Second, as an antidote to these theoretical duds, the article offers fresh ideas on possible mechanisms of creativity. Given that they are grounded in current understanding of cognitive and neural processes, it is hoped that these ideas represent steps broadly pointing in the right direction. In the end, the fundamental question we must ask ourselves is what, exactly, are the mental processes—or their critical elements—that yield creative thoughts.

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## 1. Introduction

In response to “Hey Yogi, I think we are lost”, Yogi Berra, former player and general manager of the New York Yankees and one of the best sources for meaningless quotes that side of the Atlantic, once reportedly said: “Yeah, but we are making great time.” This, until quite recently, would have described well the state of the experimental study of creativity. To clarify, there has been, no doubt, considerable progress in many areas of creativity research—social, psychological, developmental, historical, and so on—but laboratory-based science aimed at uncovering the fundamental processes, cognitive or neural, that give rise to creative information-processing in the brain has, after leaving port in a rather promising start some 50 years ago, run fully aground. From a perspective of a few steps back, this is stunning. Given the importance of creative thinking in all aspects of society, one would have thought that psychologists attack this research question with much greater resolve.

For one reason or another, the search for the underlying cognitive and neural mechanisms of creativity did not develop over the past 50 years like other areas of the psychological sciences—relentlessly forwards and upwards, that is. Following a flurry of activity in the 1960s, work that saw the introduction of several useful theoretical and methodological advances—split brain research, the concepts of divergent thinking or remote associations in a semantic network—creativity has been stuck in a rut. As cognitive psychology, joined by neuroscience some time later, delved into the meat-and-potatoes business of higher mental processes, devising new theories and methods at an ever accelerating rate, the experimental study of creativity, even if we allow for some breathers, held on like grim death to the few ideas and methods it developed in the early days of cognitive psychology. One can readily see this in today's original research articles. They routinely begin, in 2007 no less, by describing the work of Guilford or Mednik from the 1960s, not as a historical background for the benefit of the reader, but as part of the rationale that sets up the upcoming experiments. In which area of psychology, I ask you, can you still find this on a regular basis? It is ironic that the field of

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creativity, of all topics, has seen so much perseverance. It is not that this early work is all wrong, oh no; the trouble is that this very respectable first attempt at tackling the problem experimentally has not been developed further, broadly along the same lines as other areas within the domain of cognitive psychology and neuroscience.

This assessment needs to be qualified, as it overstates the case in one critical aspect. It is not strictly true that progress has not been made—it has! But, to add insult to injury, this body of work—the creative cognition approach most prominently among them—has not been adopted widely. Whatever the reason for this oversight by psychologists in general, the result comes out to be nearly the same. That is, after 50 years of exploring only one direction, a direction—divergent thinking—which, to make matters worse, is looking more and more like a cul-de-sac, we have neither a clear conception of the fundamental properties of creative mentation nor a toolkit of methods to get at them.

All this, or so is the hope, is about to change. This precipitates, in my view, that we make use, in a systematic manner, of the extensive knowledge base of cognitive psychology. A solid start here is the creative cognition approach [1]. In its basic conception, it stops the deadly error of seeing creativity as either a monolithic entity or as exclusively one thing but not another, say, the result of defocused but not focused attention. The approach breaks down creativity into its cognitive subcomponents and distributes them, right at the outset, throughout the information-processing system. Only when creativity is parceled out into its various operations can neuroscience get a handle on the issue. If this is not done, we are left with an amorphous monster, such as divergent thinking, that is so broad a construct that it will remain forever intractable by the methods of neuroscience, no matter how high the spatial or temporal resolution of future imaging gizmos. If done properly, however, neuroscience can look for those processes that might differentiate creative from noncreative information-processing at the neural level, which, in turn, can inform explanatory mechanisms at the cognitive level. This, at any rate, is what has made cognitive neuroscience so powerful. There is no reason why this approach shouldn't work for creativity.

To help this research program along and prevent it from derailing prematurely—or anywhere along the way, really—it is useful, perhaps even necessary, to give a few deep-seated and cherished but ultimately misbegotten and mistaken notions their proper neuroscientific funeral. They must be identified and consciously abandoned because they are not benign crutches for the imagination but pernicious fallacies of thinking that, as long as we keep them, seduce us into taking paths that lead nowhere good. The targets scheduled for demolition in this article are four nested ideas that have long outlived their usefulness.

## 2. Four targets scheduled for demolition

Let's start with outdated idea number 1: Creativity is divergent thinking. People in the field of creativity know, of

course, that it isn't, but the seductive danger of thinking of creativity as a monolithic entity comes nicely into focus here as this mistake somehow keeps on creeping in. The underlying error arises when we, as part of our attempts to operationalize creativity, construct psychometric measures of divergent thinking that we then come to equate, perhaps for lack of alternatives, with the real deal. It is obvious upon further inspection—certainly was so to Guilford himself—that creativity can just as easily be the result of a convergent process. This raises the following question. What, then, is it about divergent thinking that is creative? What use is the concept for the experimental study of creativity, by which I mean the identification of the fundamental processes that make information-processing, well, creative, if divergent thinking can also result in non-novel outcomes and convergent thinking in novel ones? The fact that this concept ever came to dominate the field of creativity, by such a margin and for so long no less, is strong testament to the seductive tendency to think of creativity as one thing—divergent thinking, in this case—but not some other thing. Creativity, of course, involves both.

Against this, you may argue that divergent thinking is still useful—somehow—to study some aspect of creativity. And it is here that you enter the pernicious trap that prevents you from seeing the deeper, underlying nature of creativity. First, you must ask yourself what, exactly, it is that is creative about divergent thinking and delineate it from the noncreative aspects of divergent thinking. This must be followed by a careful examination of whether or not current tests of divergent thinking can actually detect this difference. To some, these tests only measure divergent production and divergent production is not a process, at least not one at a sufficient level of specificity. Rather, it is more an *outcome* of a set of specific underlying processes. This makes these instruments a dead end in the search for the fundamental nature of creativity for the simple reason that they do not get us to where we want to go—learning something about underlying mechanisms. Second, and much more debilitating, is the problem that divergent thinking is way too broad a construct to be of any real use as a process. It is a compound construct that must be dissolved into its constituent processes before meaningful research can be done. In short, the concept of divergent thinking doesn't do any explanatory work for the study of creativity and it is high time that we heave it into the dustbin of outdated ideas. It is a case of a good idea that became, over time, a straitjacket out of which the field of creativity has yet to fully escape.

This brings us to my personal favorite, outdated idea number 2: Creativity is in the right brain. Psychologists now recognize that this, too, is a fallacy and it wouldn't be worth mentioning in a list of demolition targets if it weren't for the fact that neither the underlying basic error in thinking that led to this real humdinger of a conclusion has been properly exposed and discarded nor have its unwanted, ghastly side effects been properly counteracted.

To start with the latter, the left-brain/right-brain craze that has taken hold in popular culture underscores the need, in clear and vivid form, of how important it is to systematically demolish ideas gone bad. For every problem, there is one solution which is simple, neat and wrong. As is so often the case when science moves on, the overthrown ideas take on a life of their own, fueled, as they must be, by forces entirely outside logical reasoning. Such was the case for the creative right brain meme. Following the initial work by Roger Sperry [2], the field of hemispheric specialization was so overflowing with frenzied enthusiasm that a few sweeping, flag-waving generalization might be forgiven. But when a meme possesses so much intuitive sex appeal, more care must be taken before it is let out of the bag. As Michael Gazzaniga, who studied split-brain patients for decades, put it in an interview: “Some scientists oversimplified the idea, and clever journalists further enhanced them. Cartoonists had a field day with it all.” As more data poured in, it became quickly clear the idea is flatly mistaken. That’s, of course, not a problem, as science is inherently self-corrective, but while this drama of self-correction played itself out in the scientific community, we let loose a runaway train that has become next to impossible to stop. There is the business seminar on how to think with both sides and a seemingly endless supply of books and magazines promising an easy step-by-step program on how to tap into your creative right-brain potential. You might as well ask someone to make better use of the thalamus.

As for the experimental study of creativity, are there still some useful generalizations that we can take away from all the research on laterality? There are, as it happens. Knowledge on which hemisphere does what, or more accurately, which hemisphere does what better will inform our search for the ‘where’ and ‘how’ of the various processes involved in creativity. But when it comes to the cerebral hemispheres, creativity involves, once again, both.

The primary target for demolition here, however, are not myths circulating in the public at large but the basic error in thinking that underlies this kind of myopic theorizing in general. The error comes into clear view when we examine the many close cousins of the right-brained-creativity idea that are currently making their rounds. These mutants of the original are so infectious that they have spread widely throughout the domain of psychology. To compound the trouble, they come in so many cute and convincing disguises, newly neuroanatomically upgraded as they are, that they are rarely recognized for the threat they pose. You can spot them, for instance, when you read in the latest neuroimaging study that sudden insights activate, say, the superior temporal gyrus or the anterior cingulate cortex. What, we have to ask ourselves, does information of this kind tell us about the nature of insight? Unless this is carefully flashed out, which it hardly ever is, such statements do not only fail to explain anything, certainly as far as fundamental processes go, but seduce us into believing that we are hot on the trail of some kind of explanatory mechanism when in fact we got caught in an illusion generator.

The prefrontal cortex has become the latest frontrunner in the mad dash to localize creativity in the brain, but one can find claims in the contemporary literature for the whole funhouse of brain structures in the telencephalon—hippocampus, amygdala, visual cortex, and, why not, the basal ganglia. The next thing in tow, given the carefree drift of things, is surely the cerebellum or some unpronounceable nucleus in the medulla. But this is not all. There is also the second type of meaningless statements that is just as menacing. Take your pick: Creative individuals use more of their brains; their brains are more efficient (whatever that means); they have more dopamine receptors, or more neurons, or those little nerve cells are more densely packed. The list of platitudes is practically endless.

What is the fallacy here? These artifacts of misguided thinking simply result from the continual bad habit of treating creativity as a monolithic entity. Creativity researchers know, of course, that this isn’t the case and waste no time explicitly renouncing any allegiance to this idea. They all tell you that there is no special brain structure, no unitary process, and no magic switch that turns on the proverbial light bulb. Implicitly though, perhaps due to a lack of a solid understanding of brain function, they hang on to it, albeit in a more refined form. Claims like the ones above show that it has not yet sunk in how thoroughly distributed in the brain the superduper complex behavior of creativity must be. The trouble with these sorts of simplistic generalizations is, at least at this point, that we haven’t yet managed to break down creativity into parts specific enough to make the search for the localization of function meaningful. In other words, we have made some progress in chopping down creativity into more sizeable but still very much complex chunks only to proceed to commit the same deadly error, that is, treating those compound chunks as monolithic entities. Nearly all currently available psychometric measures of creativity draw on a combination of mental processes and are therefore methodological sledge hammers. Research using them must be carefully described, rather than, as is currently in vogue, discussed in terms of the whole of creativity. It is conceivable, indeed rather likely, that we will soon find evidence of types of creative thinking that are independent of the prefrontal cortex, superior temporal gyrus, cerebellum, or densely packed little nerve cells. As it stands now, given our current methods, what we are going to find in terms of the neural basis of creativity depends entirely on how we decide to look. We might as well try to locate the neural centers for thinking.

To better understand the fallacy that creativity, as a whole or in the parts we understand it now, is localizable, it is instructive to examine a historical parallel from the annals of cognitive neuroscience. When it comes to higher cognitive functions, neuroimaging techniques have radically changed our view of what, exactly, is localized. Consider memory. We all know that memory is a distributed function. Many individual processes are coordinated to form the memory of, say, your grandmother. Some areas contribute specific visual features, others add auditory

elements, some provide emotional components, and still others contain information about your past interactions with her. Like the internet, your grandmother—or a specific feature such as her voice, for that matter—is not implemented in a single location; however, *single processes* that combine to make your grandmother—like the computers that enable the internet—are localized. This is important to remember when looking at pretty neuroimaging pictures of the brain after using a methodological sledge hammer. There is no such thing as a neural center for a complex behavior or mental process.

The fallacy can also be seen from another angle. Considerable individual differences exist in the anatomy of the human brain and everybody utilizes slightly different cortical regions to implement the same behavior. Often this is no more than a matter of millimeters but can also be as drastic as the contralateral side of the brain, as is the case in hemispheric language dominance. For instance, Broca's aphasia, a disorder of speech production, may be due to lesions outside Broca's area while lesions to Broca's area may not lead to Broca's aphasia [3]. Speech production is still localized, just not in the exact same cortical area for everyone. In light of this, imagine now the difficulty of interpreting the results of an experiment that combines neuroimaging with a task requiring creative story telling. Apart from the fact that we are dealing with a complex task that recruits a whole host of individual processes, which, to remind you, we haven't yet properly identified, these individual processes are also moving targets! If we want to make real progress in the search for a mechanistic explanation we must heed the lessons of the past and prevent ourselves—no matter how difficult—from relapsing into thinking that, at the current theoretical resolution with which we see the issue, creativity can be localized someplace specific. It might help to remind yourself, given what we know about neural processes, that this belief must be wrong.

Once you are clear about this, we can consider alternatives. Simonton [4] has made a strong case for the notion that creativity is essentially a Darwinian process, that is, it entails a variation-selection process. Ideational combinations are generated all the time but a selection process is required to determine which ideas are truly creative as opposed to merely new. Once we apply this notion rigorously at the level of brain processes, several confusions evaporate at once because it allows us to make a critical distinction, that is, between the computation of novel combinations of information on the one hand—the variation component—and their evaluation as creative on the other—the selection component. To see why this is such a significant step forward, recall that cognitive neuroscience has been running a full-stream research program for decades now on how higher-order evaluative structures, such as the prefrontal cortex, go about performing their duties of selecting behaviors based on external and internal goals [5,6]. More pointedly, this distinction makes it possible to link critical elements of creativity—the selection processes—seamlessly to what we know about normative

information processing, in terms of anatomy and process modularity.

This leaves us with the variation component, the production of ideational combinations. Here, too, we can build a bridge to already existing knowledge in cognitive neuroscience. The functional specificity of the brain suggests that neural circuits that process specific information to yield noncreative combinations of that information must be the same neural circuits that are operational to generate creative combinations of that information [7]. This is to say, with the exception of working memory in prefrontal regions, which is capable of generating novelty from information normally coded elsewhere in the brain, the recombination of bits and pieces of information into novel configurations must come from the very neural circuits that normally store those bits and pieces of information. This must be conceded simply as part of our understanding of the brain as a nonlinear information processor. Indeed, novelty is simply inherent in such a complex biological system. This is very bad news for the localizationist camp because it means that all brain circuits, in principle, produce ideational combinations from the information they normally handle. Novelty, then, is computed everywhere in the brain! This needs to fully sink in.

There is also good news. First, the brain is, of course, not an unconstrained generator of ideational combinations. At a minimum, we can assume that the more integrative the neural structure involved in the computation, the more combinational novelty might occur. Modern brain research conceptualizes cognitive function as a functional hierarchy with, roughly, inflexible brainstem circuits at the bottom and the cerebral cortex at the top. Structures such as the prefrontal cortex, then, are simply more likely to contribute to creative mentation but, to drive home the point one more time, the whole brain takes part in the fun. Second, the assumption that every neural circuit that computes specific information also produces novel combinations of that information means that creativity researchers can tap, once again, into the mountain of data available from mainstream cognitive neuroscience regarding where and how cognitive processes are implemented in the brain. So, for instance, if we are interested in creative imagery, we can make use of the extensive body of work on mental imagery in general. With this in hand, perhaps with a sort of contrastive analysis of some type, we can perhaps hope to isolate the elements that turn mental imagery into creative mental imagery.

Marching along, next up is outdated idea number 3: Creativity occurs in a state of defocused attention. Of course it does. But so it does in a state of focused attention, making this claim yet another brilliant example of the monolithic entity fallacy, the failure of seeing creativity in all the diversity of ways in which it can manifest itself. Here, again, researchers rushed to construct theories about the nature of the elephant of creativity after managing to grab only a piece of the trunk. Consider, for instance, the NASA space shuttle, an example of serious amounts of creativity mostly

occurring while engineers specifically focused on problems in need of creative solutions. Actually, this attentional drifting theory of creativity, as we might label it, also has several close relatives. For one, there is the odd fascination with altered states of consciousness, which are often associated with states of defocused attention—dreaming, daydreaming, drug-states, that sort of thing. But we are getting ahead of ourselves as this is part of outdated idea number 4. And then there is the low arousal theory, as if creative solutions cannot also arise in a state of high arousal—think Michael Jordan or speed chess, if you do need counterexamples. In either case, the trouble is, again, not with the ideas themselves, as critical links indeed exist there, but the lack of a discerned treatment when discussing them. It is yet another case of creativity researchers being lured into making glaring claims about the nature of creativity as a whole when all they have is one small piece of the gargantuan puzzle.

Despite the danger of beating a dead horse, the field of creativity must start wrapping its data in smaller packages and talk about them, not in terms of creativity per se and in so doing further fueling the already treacherously seductive misconception of creativity as a single, unified thing, but in terms of *types* or *processes* of creativity. So each time we read a sweeping assertion of this kind, say, creative insights are associated with states marked by a lack of attentional focus, the first question we should ask is: “What type of creative insights are we talking about?”, followed immediately by a second question: “To what forms of creative insights does this not apply?” Naturally, it would be preferable to avoid from the outset the slippery slope such global oversimplifications represent. By comparison, imagine cognitive psychologists discussing their experimental results in terms of what they mean to ‘thinking’ rather than in the context of, say, attention, working memory, retrieval processes, implicit learning, perceptual organization, categorization or some other specific process.

Consider, for instance, another, related curiosity that hints at how the field of creativity has, in the past 50 years, missed the forest for the trees. On the one hand, creative insights are associated in the minds of many researchers, to say nothing of the general public, with sudden realizations that occur—mystically, almost—in a state of aimless daydreaming. Indeed, anecdotal reports abound that describe the creative process as automatic and without attentional effort. From Kekulé’s daydream of whirling snakes forming a (benzene) ring to Coleridge’s poem *Kublai Khan*, among rather many others examples, such flashes of insights are the very cliché of creative genius. Yet, ironically, nearly all psychometric tests of creativity demand of the participant the opposite, the intentional focus on the task item at hand. Why, one must wonder, is there so little work addressing this obtrusive discrepancy? The reason, I submit, is part of the general malaise the field of creativity finds itself in, that is, people talk about the specific trees they see as if they are the only type of trees in the forest.

It is always risky to predict the future direction of a scientific discipline. The road ahead for creativity, though, so

much can perhaps safely be projected, will have to feature prominently studies on attention. It is easily conceivable that the issue of how attentional processes relate to creative thinking may even spawn an entire subfield of creativity research. There is a mountain of data on bottom-up and top-down processes of attention, and there is substantial empirical evidence to support the proposal that these two broad mechanisms of attention produce creative insights that are qualitatively different in type [7]. This also relates intimately to other points of contact between creativity and cognitive neuroscience, such as, for instance, implicit versus explicit or unconscious versus conscious information processing.

We end this demolition project with outdated idea number 4: Altered states of consciousness facilitate creativity. Evidence for this unqualified claim is easy enough to find in the literature. For starters, drugs—alcohol and opium, in particular—have a long standing reputation of fostering creative inspiration [8]. And then there are—how can we forget—the mind spectaculars generated by hallucinogens and psychedelics. The mistaken view that the hallucination zone is just oozing with untapped creative potential [9] is all the more seductive as it meshes so well with the view, equally mistaken to be sure, that these chemical nirvanas are somehow mind-expanding [10]. One also does not have to search long to find reports of enhanced creativity in other altered states—daydreaming, dreaming, meditation, long-duration exercise and so on [11]. And, to complete the list, the link of creativity with mental illness—bipolar disorder, autism and schizophrenia, mostly [12,13]—also fits this category of misbegotten ideas because these conditions do qualify, albeit not in the traditional sense, as alterations to consciousness.

A few probing questions quickly expose where, exactly, things go wrong here. How many creative ideas occur in the default mode of consciousness? Or, how often do people enter altered states and come out with nothing but neurological junk? What is the incidence and prevalence, compared to the general population, of creative achievement for people suffering from mental illness? In other words, given the astronomical number of cases where the opposite is true, the statement identified above—altered states of consciousness facilitate creativity—unqualified like this, is wrong outright. The question then becomes, given that most researchers are undoubtedly aware of this, why do they continue to discuss their ideas and theories as if creativity is one, big, holistic thing? Mental illness does not have a link with creativity; it has a link with a specific kind of creativity—if that. Drugs do not bring out the muse; they might—under certain circumstances and in rare cases, apparently—disinhibit specific types of cognitive processes that perhaps enable a specific type of insight. Why, for instance, are there virtually no reports of scientists and engineers benefiting from alcohol and opium? It is always artists—mostly writers, actually. Yet there is hardly anything in the literature indicating why this might be so, a question which, if pursued, would not only force researchers to realize the limited scope of their individ-

ual studies but would also bring about a better understanding of what might be going on here. It is obvious at this point, I hope, that insisting on a more differentiated treatment is not a trivial matter. The fact that investigators continue to present their data as if it has relevance to the whole of creativity shows just how difficult it is to go all the way with the notion that creativity is composed of a plethora of very different processes. But if we do not relinquish the implicit bias towards thinking of creativity as a monolithic entity and start in earnest walking down this path, the field of creativity will develop neither the necessary theoretical understanding nor the methodological know-how to search for the underlying mechanisms, cognitive or neural, that enable human beings to think so creatively.

### 3. Conclusion

In the hope of carving out a niche for the field of creativity, researchers have advanced a number of ideas designed, for the most part, to delineate creativity from ‘ordinary’ cognition. Creative thinking is obviously special in some way and there must be something that makes it so. All in all, those proposed demarcation lines have largely turned out to be theoretical non-starters. Contrasted with their opposites, creativity cannot be identified with divergent thinking, right brains, defocused attention, altered states of consciousness, or half a dozen other, equally arbitrary markers, as they also underpin noncreative thinking. Although widely recognized as not selective for creativity, it didn’t follow, as it should have, that these partitions be either rejected and replaced by new ones or deepened to see what, exactly, is creative about them. Instead, like a bad meme out of hell, they have happily self-replicated and spread widely throughout the field of creativity even while cognitive psychology and neuroscience were in the midst of developing a solid grasp of higher mental processes, the very processes that could serve as useful starting points for the mechanics of creativity.

The main aim of this article was to disabuse anyone of the residual validity of these outdated ideas. This, it seems to me, is an essential step. For, new paths are seldom taken when the comforting, old paths still appear as viable alternatives. The promise for the field of creativity is great; but so are the pitfalls. Luckily, the bits and pieces to establish an experimental, laboratory-based research program geared towards finding mechanistic explanations for creative mentation are already all around us. The advances in cognitive neuroscience in just the past two decades that are relevant to creativity have been breathtaking and they have brought unprecedented understanding and predictive power about how the mind works. What we need to do now is to ground creativity research in this extensive knowledge base of cognitive and neural processes, while at the same time guard against the haphazard borrowing of concepts from cognitive neuroscience that will do nothing but generate the next round of pernicious fallacies that are then equally difficult to demolish.

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