



The Process Definition of Creativity

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ABSTRACT

The “standard” definition of creativity as novel and useful describes creative products, but creativity is constituted by processes. This misalignment contributes to the oft-noted challenges of operationalizing creativity. Here, we distinguish creativity as a process from creativity as an attribute (i.e. “creative-ness”). Operating from *a priori* premises of creativity theory, we develop a process definition of creativity. Specifically, creativity is defined as internal attention constrained by a generative goal. This definition comprises three criteria: 1) attention is directed internally (toward mental representations); 2) attentional operations (e.g. search, manipulation) are constrained to fit parameters of a to-be-achieved goal state (whether or not a goal is actually achieved); and 3) the goal state is generative (not already precisely held in memory). We illustrate how these three definitional process elements align with insights yielded by creativity neuroscience, clarify ontological distinctions (e.g. from mind-wandering and retrieval), and relate the process definition to process-based models. The process definition provides minimal necessity and sufficiency criteria for whether a process should be considered creativity, but does not exclude the many other perceptual, emotional, etc. elements that can contribute to creativity processes. Researchers should specify whether they are studying creativity-as-process vs. “creative-ness,” and consider including process-focused assessments.

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Creativity has perhaps never been more universally espoused as a virtue across wide-ranging sectors of the academy, as well as in education, arts, and industry than it is at the present moment. The science of creativity is receiving increased investment, and creativity researchers are developing exciting new methods for both observation and enhancement of creative cognition. However, it is the most fundamental question about creativity – the definitional question – that has persistently clouded scientific progress. Both the timely and timeless importance of creativity make advancing the mechanistic understanding of creativity, especially as a process that can be taught and enhanced, a scientific priority. The answer to the question, “what is creativity?” should provide a meaningful framework for research aimed at understanding how creativity works. In plain terms, if we hope to effectively research and understand creativity as a process, we need to first define it as a process.

Building on the rich history of theoretical development in creativity, from Guilford (1950) to Stein (1953) to Hennessey and Amabile (2010) to Simonton (2012), Runco and Jaeger (2012) presented, “A Standard Definition of Creativity,” twelve years ago in CRJ, highlighting the criteria of originality and

effectiveness. This definition, henceforth referred to as “the product definition,” provides a concise description of the attributes that make for a successful creative product. Because the terms, novelty and usefulness, appear to be most frequently used in the literature to convey the product-focused definition of creativity that has emerged from historical and more recent theoretical developments, we will primarily use those terms here, though we note that other terms such as effectiveness, value, meaningfulness, etc. can be used instead with subtly different implications. The product definition has been extremely valuable for galvanizing the field around standards for assessing creative products. However, there remains a widely-appreciated need for greater theoretical specificity in operationalizing the construct of creativity (Kaufman & Glăveanu, 2021). As we will argue below, the lack of clarity may be due in large part to a linguistic ambiguity in the word, creativity, itself. A bit of linguistic bad luck has led to a general conflation of different constructs conveyed by different uses of the word that instead should be understood as having different definitions, including a conflation of creativity as the attribute of a product with creativity as a process. While creativity as the attribute of a product is defined

by the product definition, there is an increasingly pressing need – particularly with the growth of process-focused creativity research – for a process definition of creativity.

Of definitions and models

There are many excellent models of creativity that focus on process. Several are derived from Guilford's (1950, 1956) initial work rooted in the Structure of Intellect model, including later expansions (Mumford et al., 1991), suggested focuses (Reiter-Palmon & Robinson, 2009), and syntheses (Sawyer, 2012). There are also models that share commonalities with Guilford's core processes yet bring their own unique perspective (e.g., Benedek, Beaty, Schacter, & Kenett, 2023, Finke, Ward, & Smith, 1992, Simonton, 2011). By nature of being models, their focus is on how various aspects of creative processes work. They are intended to model the *how* of creative processes, rather than to define the *what* of creativity: their purpose is not to set out a minimal set of necessary and sufficient criteria for what constitutes creativity as process. Similarly, the design specs for a car are intended to indicate how the car works, but their intent is not to establish a standard for what is or is not a car. As an example, the recently-proposed MemiC model (Benedek, Beaty, Schacter, & Kenett, 2023) outlines multiple stages of episodic and semantic memory involvement in divergent creative ideation, including evaluation of the effectiveness of a potential product via episodic mental simulation, which the authors note has been associated with more successful products. The model thus elucidates mechanisms that support the production of successful creative ideas, with the intent to provide insight into the *how* of divergent creative ideation processes. The model does not, however, suggest that *only* processes that include a stage of effectiveness evaluation via episodic mental simulation, or processes that yield successful products, should be considered creativity. Rather, it delineates this effectiveness evaluation stage as a means of modeling how divergent ideas that are evaluated as being creative are often generated (this stage can support creative ideation without being a necessary component of any creative process). By contrast, definitions seek to distill the minimal set of criteria that constitute necessity and sufficiency. Whereas models of creativity can address the workings of a range of mechanisms that contribute to creativity in different forms and domains, definitions cannot address the full variety of what they are defining. The definition of a car or a flower will necessarily focus on the core definitive elements that are present across all cars or flowers (e.g., provides transportation, has petals, etc.),

and will not address many of the details and colorful variegation that characterize the range of cars and flowers.

The product definition distills two core criteria that are necessary and sufficient for a product to be considered creative. There are of course many attributes that a creative product might have that are not directly addressed by this necessarily minimal definition, and many models of how these two criteria are manifested (e.g., how a product can be made most useful, or how the usefulness of a novel product is appreciated over time), but those are not the domain of the definition itself.

Importantly, the product definition addresses the attributes of products; it does not provide a definition of what constitutes creativity as process. This is important because it leaves us without clear means to assess the creativity of processes themselves. In particular, what is lacking is a definition that provides a standard to assess whether a process constitutes creativity, and to inform related assessments of how creative a process is (along a continuum). In some instances, definitions need not be clearly relatable to empirical observations. In science, however, greater burden is placed on definitions, particularly definitions of processes, to provide the framework for interpreting data and for theory and model development. It is thus necessary to ensure that definitions in science can be meaningfully linked to observed data, including data about neurocognitive processes such as creativity.

Definitions are also important for developing coherent taxonomies in science. Science is built on taxonomic classifications of phenomena in the natural world, including ontological distinctions between the cognitive constructs of the human mind. Notwithstanding worthy philosophical questions about whether definitions can ever be universal at the extremes, or whether taxonomic distinctions can ever be absolute (Wittgenstein, 1922), good definitions should be general for all practical purposes, and taxonomies/ontologies in science should be sturdy enough – based on empirical observation and applicable to future empirical observation – to provide a field of inquiry with a stable and consistent structure. Here again, constructing a definition based on the intrinsic properties of creativity (as process), rather than extrinsic judgments of creations (as products) appears more likely to provide the requisite stability and relatability to empirical observation for distinguishing creativity from neighboring constructs.

Toward that objective, the present paper was developed as a component of ongoing efforts of The Society for The Neuroscience of Creativity via the SfNC Ontology Initiative (e.g., Kenett et al., 2020, Sagar,

Volle, Uddin, Chrysikou, & Green, 2021). This initiative seeks to engage theory alongside neural and cognitive data to achieve greater clarity in the ontology of creativity. A promising example is the proof-of-concept for a data-driven approach to test and improve the fit between creativity tasks and the constructs they are intended to measure based on the similarity/dissimilarity of neural activity across a set of tasks (Kenett et al., 2020). Ultimately, establishing a clear ontology of creativity will depend on clarifying definitions of creativity as well as relevant constructs and sub-constructs.

In the decade plus since the publication of “A Standard Definition,” the neuroscience of creativity has come into its own, highlighted by the application of advanced multivariate and network-neuroscience methods, as well as a range of noninvasive neuromodulation techniques, to elucidate and facilitate the interplay of neural systems that give rise to creative thought. As CRJ moves into a new era under the auspices of The Society for the Neuroscience of Creativity (Green, 2022), the time is right for a process definition of creativity that can be directly related to the science of understanding creativity as a neurocognitive process. Here, operating from first premises regarding necessity and sufficiency for creativity, we propose a general definition of creativity as a process construct that is aligned with key findings in the neuroscience of creativity, with the aim of establishing an updated standard for what constitutes creativity.

To be clear, we do not suppose that there is only one creative process. Indeed, it is likely that no two creative processes are ever the same. There are many facets that vary with respect to objectives, external influences, specific neurocognitive implementation, etc. Considerable research has identified distinct categories and forms of creativity (e.g., Baer, 2022, Dietrich, 2019, Simonton, 2022a, 2022b, Weisberg, 2014)). We consider several categories and forms of creativity below where we address taxonomy and the generality of our definition, but there are many more than we can consider here. Far from suggesting that all the many forms of creativity are the same, our goal is rather to identify a minimal set of core process elements that represent criteria of necessity and sufficiency across these many forms. Thus, as noted above, the process definition proposed here is intended to be general but it cannot capture the many vitally important aspects that distinguish different creative processes from each other.

While the neuroscience of creativity is growing rapidly, it is still a new field. We are only beginning to characterize the neural mechanisms that support creative thinking, and the generality of the mechanisms thus far identified remains largely to be proven. In this light,

it is worth clarifying that our aim here is not to *derive* a definition of creativity from the currently available neuroimaging data. Instead, the definition is derived from *a priori* premises of necessity and sufficiency for creativity. Nonetheless, the definition is aligned with empirical observations of creativity in the brain; that is, the definition is formulated and parsed such that the elements of theory map to key elements of the empirical evidence about creativity as a neural process. Our aim is a definition that can operate on both the theoretical and empirical levels. The definition we propose is thus explicitly deconstructed into constituent criteria, each reflecting 1) a bedrock element of creativity theory, and 2) a neurocognitive process element of creativity. Because each criterion of the definition maps to a neurocognitive component of creativity, the definition can be readily related to process models that specify neural and/or cognitive components of creativity, and to new cognitive and brain-based data being collected in relation to these cognitive components. The components of the definition also provide a basis for taxonomic distinctions between creativity and other related constructs based on which constructs include or exclude these components.

Relatedly, although the formulation of the present definition is aligned with a particular set of empirical findings that reflect key aggregations of the extant brain-based evidence, the intent of the definition is to be relatable to empirical data more generally. Because the present definition is not derived from empirical findings, its validity does not depend on the particular findings reviewed here. If, as is likely, future research leads to revisions of current brain-based characterizations of creativity, or expansion to artificial intelligence-based characterizations of creativity, the present definition provides a framework that can be related to the new data.

The product (“standard”) definition

As much as Guilford gets credit as a pioneer (and rightly so), his definition of creativity in his seminal 1950 paper was that “creativity refers to the abilities that are most characteristic of creative people” (p. 444). Obviously, he went into more detail (specifically, focusing on the importance and potential measurement of creativity), but there is a common element to Boring’s (1923) famous definition of intelligence as being whatever intelligence tests measure. Barron (1955) offers a bit more, calling originality the “capacity for producing adaptive responses which are unusual” (p. 484). What seems to be the first clearly articulated modern definition of creativity (also noted by Runco & Jaeger, 2012) is

Stein's (1953) offering that "[a] creative work is a novel work that is accepted as tenable or useful by a group in some point in time" (p. 311). Often the second component of tenable or useful is termed task-appropriate (Kaufman, 2016) or valuable (Hennessey & Amabile, 2010). Runco and Jaeger used the terms, "original" and "effective," to describe creative products. We have adopted "novel" and "useful" here to match the most frequently used terminology in the literature. While we do not necessarily consider those two terms to be more apt than others that have been suggested, these differences in terminology do not bear on the process vs. product distinction that is our primary focus here. There have been several additional components that have been proposed to be added to creativity's definition, ranging from surprising (Boden, 2004, Simonton, 2012) or unplanned (Amabile, 1996) to high quality (Sternberg et al., 2002) to authentic (Kharkhurin, 2014). However, these main two dimensions are the only consistent parts.

It is important to note that Stein's (1953) original proposition, along with the many revisions, suggestions, nuances, and potential additional factors that have been suggested, remains firmly centered around the creative *product*. Yet Rhodes' (1961) classic Four P framework notes the importance not only of the Product but also of the Person (i.e., the creator), the Process of being creative, and the Press (i.e., the environment). Despite the existence of so much work on the creative process, there has not been a definition of creativity offered that takes a process perspective. It is commonplace for theories and studies focused on the creative process to nonetheless use the standard product-focused definition as a starting place (Boldt, 2019, Botella et al., 2013, Medeiros et al., 2018, Simonton, 2011); those that do not are most likely to simply not define creativity at all.

There are broader implications to the product focus if it comes in lieu of a process focus. Consider the distinction between everyday and eminent creativity, also known as little-c and Big-C. Kaufman and Beghetto (2009) expanded on this dichotomy to propose the Four C's. They begin with mini-c, or personal creativity, in creative actions are small but meaningful to the creator (even if not to others). Everyday, or little-c, creativity consists of the types of contributions that most people can make that are enjoyable by other people. If, after practice and improvement, a creator is able to make some type of impact on a domain (even low level; Sternberg et al., 2002), they can be considered to be Pro-c, or expert-level creativity. Finally, if a creative work or body of work lasts over time and generations and continues to have lasting impact, it can be Big-C, or genius-level creativity. It is natural to gravitate toward

Big-C or Pro-c for evidence of the importance or value of creativity, and such arguments tend to focus on the creative product, such as technological or economic advances (Florida, 2012, Simonton, 2018). However, there are countless benefits to be found in mini-c and little-c (Kaufman, 2018, 2023, Kaufman et al., 2022). These tend to be more process-focused, such as how creativity can boost one's personal mental health. If our core vocabulary and definitions are slanted toward the creative product, we risk over-valuing more exclusive conceptions of creativity at the expense of a more democratic, inclusive view.

Product or process?

As described above, the product definition is an excellent standard for assessing products. Assessing products has a great deal of pragmatic value, and the novel and useful criteria are particularly well-suited for relative assessments of product attributes (e.g., which of these products is more novel? Which is more useful?) because judgments of novelty and usefulness are generally relative rather than absolute or binary. But is a description of the attributes of creative products suitable as the basis for the scientific study of creativity?

Frequently – and problematically in our view – the product definition is phrased as a process definition; in particular, creativity is frequently defined as "a process that results in products that are novel and useful." Comparison to other domains of psychological science suggests that this product-based framing is an ill fit. For example, defining human development as "a process that results in adult humans" might be accurate in some oblique way, but it does very little to inform the research of developmental psychologists or biologists to understand how development works. Such a description does not specify the constituent process elements of development, and indeed the process of development need not reach adulthood/maturity in order to qualify as development.

Taking a nearer example, the definition of attention as a cognitive construct focuses on processes and states (e.g., selection, modulation, maintenance; Chun, Golomb, & Turk-Browne, 2011, Fan, McCandliss, Sommer, Raz, & Posner, 2002, Knudsen, 2007, Posner & Petersen, 1990, Posner, 1994), and is not framed in terms of any particular outcome or product. Attention qualifies as attention if it meets these standards, whether or not there is any product of the attentional process. Likewise, definitions of memory in psychology focus on processes (e.g., encoding, consolidation, storage, retrieval) (Craik & Jennings, 1992, Klein, 2015, Squire et al., 1993). These process-based definitions are aligned with,

and have in-turn been the basis of, considerable conceptual and empirical advances in the extensive fields of attention and memory research.

The science of creativity is smaller (though it is now growing rapidly), and generally younger than these other fields. Hewing to a description of products, rather than processes, may substantially impede the theoretical and empirical development of creativity research toward a more mature/adult form. Indeed, when the product definition is applied for assessment in creativity research, it is applied to assess products, not processes. This is not a trivial concern because, as noted above, scientific advancement requires empirically testable/falsifiable predictions, and the mapping from the product definition to the data that researchers collect on the cognitive and neural mechanisms of creativity often remains unclear.

The criteria of novelty and usefulness present additional challenges to the advancement of creativity research because they are largely based on external evaluation rather than inherent to a process (or even inherent to a product; Diedrich, Benedek, Jauk, & Neubauer, 2015). There is considerable ambiguity about what should constitute novelty or utility (e.g., Who should decide whether a product is novel or useful? How novel or useful should it be relative to other products in order to be creative? In what context?; Amabile, 1996, Kaufman & Baer, 2012). Plentiful examples from history and from everyday life illustrate the ambiguity of these judgments. Alfred Russel Wallace's development of a theory of evolution very similar to Darwin's theory is a well-known historical case (Gruber & Wallace, 1999). Should elements of Darwin's theory that overlap with Wallace's be considered less creative because one of these men conceived of the ideas just after the other one did? Analogous situations are common in everyday circumstances. If you are a math teacher and you have a student who finds a valid way to solve a problem that you did not teach them, this might rightly be considered creative. But is the solution less creative if another student generated that solution in an earlier class period? Or perhaps in a class you taught 10 years earlier? Some of the answers may depend on the scope of creativity; the construct of mini-c would suggest that if the solution is new to the creator, then it would still be considered creative (Beghetto & Kaufman, 2007). As one progresses up the Four C's, however, the novelty as perceived by the world becomes more and more crucial.

As noted earlier, translating empirical understanding of how creativity works into strategies that can meaningfully improve creative performance is a timely goal for the science of creativity. In addition to the

theoretical challenges of a product-based definition, conceptualizing creativity in terms of products may also limit the useful application of creativity research in both real-world and laboratory contexts. Put another way, focusing on the process of creativity (rather than defining creativity in terms of products) has several advantages, especially when considering the goal of fostering and enabling creativity. A focus on process, rather than product, is far better suited to educational contexts (Beghetto & Kaufman, 2014). You can teach the "how" of a process, but you cannot teach the "how" of a product. Math teachers don't focus on the answers to solved problems, they teach students the processes by which the problems can be solved – the particular numerical answer is useful for external evaluation purposes, but somewhat incidental to the actual learning of mathematics. Relatedly, in any learning context (educational, professional, or otherwise) a specification of process is crucial for effective practice. You can practice a process, but you cannot practice a product. The development of more direct interventions to support creative performance also relies on understanding the processes and subprocesses of creativity. This is the case for cognitive interventions that seek to scaffold elements of the creative process (Scott et al., 2004), and is perhaps most clearly the case for brain-based interventions. Intriguing advances have been made in the application of neuro-modulation techniques, including transcranial electrical stimulation and transcranial magnetic stimulation, to support creative cognition (Green et al., 2017, Kenett et al., 2021, Kleinmintz et al., 2018, Lifshitz-Ben-Basat & Mashal, 2021, Lucchiari et al., 2018, Weinberger, Cortes, et al., 2018, Weinberger, Green, & Chrysikou, 2017). By its nature, this work relies on first observing a creativity-related process in the brain and then leveraging the observations to target and titrate the intervention.

In view of the above considerations, while novel and useful appear to be apt descriptions of creative products, they do not suffice to characterize the process of creativity in a way that can effectively advance empirical creativity research. Extending this product-level description to define creativity as a process that results in products that are novel and useful leaves the actual process as essentially a black box. We thus argue for a distinct definition of creativity as a process, which can be used in the context of scientific inquiry separately from, or in conjunction with, the definition of creative products. Such a process definition can help to address several interpretative issues associated with the product-based definition, and would bring creativity research more closely in line with other areas of psychology and neuroscience in which process-based definitions have underlain

advancements. Focusing on process also provides a stronger foundation for the useful application of creativity research toward improving creative performance.

Creativity as process or creative-ness? Recognizing and overcoming creativity's linguistic bad luck

What has made the definition of creativity so elusive and unsatisfying? The cloudiness of creativity owes in part – likely in large part – to a generally unappreciated division in the usage of the word itself, an innocent but insidious linguistic duplicity. The word, creativity, has multiple usages that are actually importantly different in their meanings and implications. One usage of the word is adjectival; it *describes* something or someone that has creative attributes. For example, in the sentence, “Before we hire an engineer, we evaluate their creativity,” creativity is used in an adjectival sense to refer to an attribute of an agent (an inventor); and in the sentence, “The creativity of this invention is truly remarkable,” creativity is used in the adjectival sense to refer to an attribute of an output (invention). In adjectival usages, the “-ity” word ending yields a noun form of the adjective, “creative,” and retains the adjectival/descriptive sense. Perhaps the clearest way to explain this is that, in adjectival uses of creativity, the sense conveyed by the “-ity” word ending is the same as the sense conveyed by the more common word ending, “-ness,” as might be used to describe a person’s hopefulness, or an object’s heaviness. Thus, what is really meant by creativity in this usage is “creative-ness.”

The other sense of the word is nominal; it is used to *name* the process(es) that constitute creativity, as in the sentence, “Keeping an open mind can help creativity happen.” The construct conveyed by this nominal sense of creativity (i.e., creativity as process) is the primary focus of the definitional account we offer below. Of course, the root word of creativity is, “create.” Because create is a verb, the nominal sense of creativity can be considered an action noun (Merriam-Webster, [n.d](#)). Thus, when creativity is used in the nominal sense, the particular kind of thing that it names is not static (like non-action nouns such as stone or independence); it names an action (i.e., the process(es) of creativity). Another “-ity” word, “activity,” might provide a useful comparison. The nominal sense of activity as a name referring to dynamic movements, changes, or processes, rather than the adjectival sense referring to the attribute of a person’s level of active-ness, carries its verb root (i.e., act). This root makes it an action noun, such that it does not refer to

an ordinary kind of static thing; the thing it refers to is itself a dynamism.

Both the nominal and adjectival senses are correct and widely accepted uses of the word, creativity, but their meanings should not be conflated. Transcending this earthly discourse for a moment, we can consider the case yet of another “-ity” word, divinity, which, like creativity, has come to have a distribution of meanings that spans the nominal and the adjectival. It is possible to use the word, divinity, in the nominal sense to name a thing (i.e., a god). It is also possible to use divinity in the adjectival sense, i.e., to describe the “divine-ness” of a person, place, experience, etc. As above, both are correct uses of the word, but the two senses refer to two constructs that are quite different in meaning.

Because the different senses of the word, creativity, refer to different constructs, they require different definitions. The frustration our field has experienced in defining creativity has not come from lack of thought or imagination, but because, without distinguishing the different senses of the word, we’ve been trying to accomplish an inherently impossible task: fitting a single definition to fundamentally distinct constructs. Indeed, we think that our field has suffered a somewhat unlucky fate. If only the noun form of the adjective, creative, happened to end in “-ness” rather than “-ity” (if only creative-ness was an accepted word), then the nominal noun form of creativity would have to be more overtly/orthographically distinct from the noun form of the adjective. With better luck, we would have distinct words where instead we only have one. If we had distinct words instead of one shared word, then much handwringing over operationalization and confuddling of theory might have been avoided. But it is not so, and here we are, and the use of the word, creativity, in the common parlance is unlikely to change. This does not, however, mean that our field of research needs to be perpetually hamstrung by this ambiguity in our effort to develop a clearer and more maturely structured discipline.

Recognizing that creativity has different usages, and that these different senses of creativity are actually different constructs, can substantially clarify the definitional effort, and the ontology of creativity by extension (see also Kenett et al., [2020](#)). Each construct can be defined individually (see [Figure 1](#)), without trying to accommodate an awkward fit to another construct. We think this effort might be helped by adopting terms that are overtly distinct: “creativity as process” for the nominal sense of creativity, and “creativity as attribute” (or “creative-ness”) for the adjectival sense of creativity. The present paper introduces a process definition of creativity. This definition applies to the

Distinguishing the Definitions of Creativity

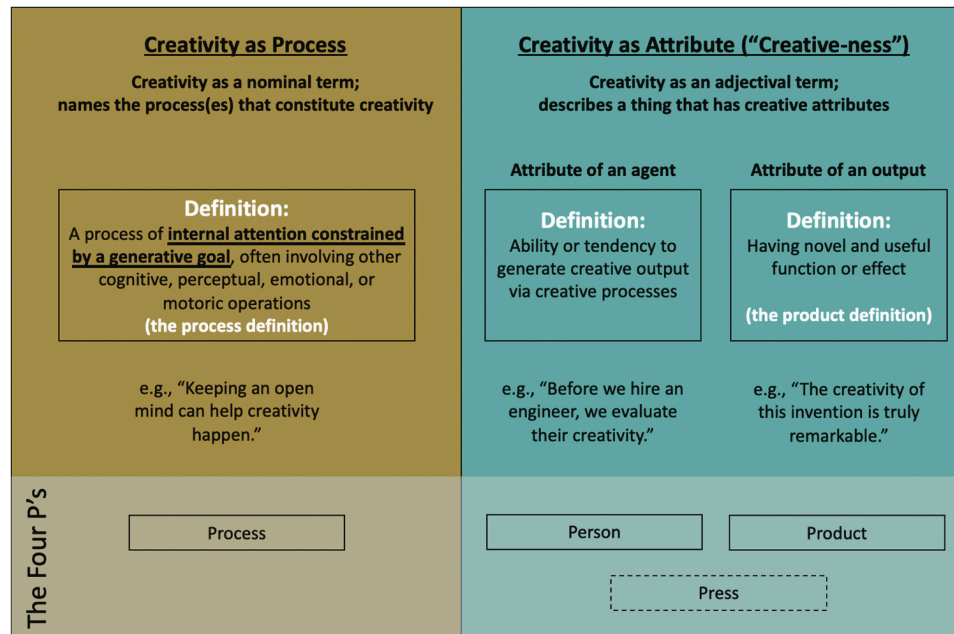


Figure 1. The word, creativity, is generally thought of as referring to a unitary construct that, although multifaceted, has a single definition. Instead, because of the particular linguistic construction of the word, creativity, it is actually used in substantively different ways that refer to different constructs. These different constructs require different definitions. In particular, the nominal construct of creativity as process, which is the focus of the process definition that we present here, should be definitionally distinguished from the adjectival construct of creativity as attribute ("creative-ness"). This distinction and the subsumed distinction between the process vs. product definitions are the primary foci of the present paper. We additionally offer a tentative definition of creativity as an attribute of an agent, situating this definition between the process and product definitions. As revisited briefly below, a person (or other agent) is considered creative based not only on their output but whether they generate that output via a process of actual creativity. While we think this positioning is generally aligned with the treatment of agentic creativity in the literature, an in-depth consideration of this definition is beyond the present scope – though such consideration would be a worthwhile undertaking. Distinguishing the different meanings of creativity provides a definitional framework for parsing the 4 P's (as shown in the lower panel of the figure), and can be similarly applied to other accounts of the components and facets of creative processes, products, persons, contexts, and more. Because the "Press" category of the 4 P's account is somewhat loosely specified, the dotted line indicates a tentative placement within the definitional taxonomy.

nominal sense of creativity as process. By contrast, the product definition of creativity applies to the adjectival sense of creativity as attribute (creative-ness), at least for the attributes of products.

Please parse the P's

As noted above, Rhodes' (1961) well-known account holds that there are 4 P's of creativity: Process, Product, Person, and Press, where Press is variously supplemented or substituted with other P's, including propulsion and public (Sternberg & Karami, 2022), phases (Cropley, 2015, Tan, 2015), perception (Kharkhurin & Yagolkovskiy, 2019), and persuasion (Simonton, 1988), not to mention Glăveanu's (2013) thorough reworking of the 4 P's into the 5 A's, integrating a sociocultural perspective. We posit that, while each of the P's is quite important, they would be best served by a clearer parsing. There is considerable ontological

hazard in the conceptualization of creativity as a conglomeration of all 4 (or maybe more) P's at once. Indeed, this conglomerized notion seems to be a direct consequence of the unfortunate ambiguity of the word, creativity (i.e., the use of the word in multiple senses that convey different meanings). It is this conglomerized ambiguity that, for example, leaves us futilely trying to apply the same definition to a product and a process. Forcing all 4 P's into one construct with one definition has muddled the definition and the operationalization of any of the P's. Rather than simply calling all 4 P's creativity, recognizing the distinction between the nominal construct of creativity (referring to the process construct) and the adjectival sense of creativity (referring to creative-ness), provides a clear basis for parsing the P's to enable clear understanding. As illustrated in Figure 1, the process P does not fall under the same construct as the other P's; it falls under the nominal construct of creativity as process, while the other P's fall

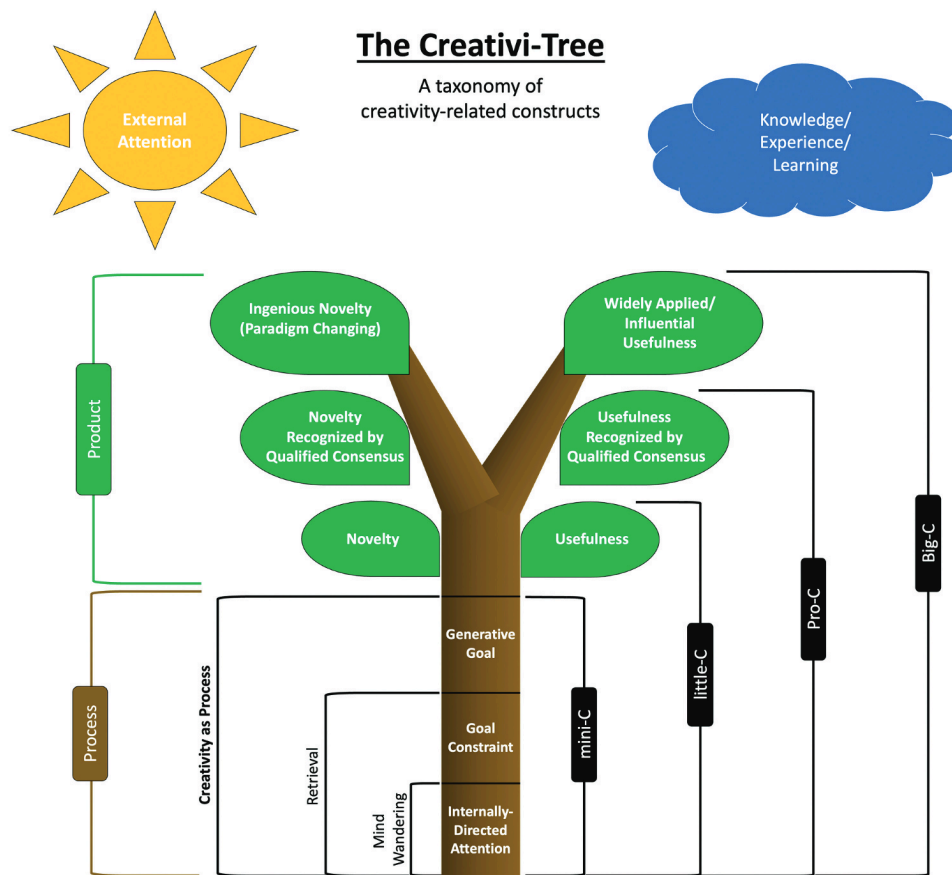


Figure 2. The Creativi-Tree illustrates how the three criteria of the process definition provide a basis for taxonomic distinctions between creativity and related constructs. These distinctions are also described in the text. **On the left side of the tree**, the brackets for each construct indicate the minimum set of creativity-related elements required to constitute that construct, but not always the maximum set of elements that the construct can encompass. For example, all the process constructs that comprise elements of the tree trunk can yield products listed among the branches of the tree. Also, whereas the tree includes elements relevant to creativity, constructs might also include some other elements not included in the tree. Mind-wandering, for example, is a complex construct, but here we indicate only the overlap of mind-wandering with the process elements of creativity (i.e., mind-wandering involves internally-directed attention, but is not goal-related so it does not involve the goal-related process elements, and thus does not meet the two goal-related criteria of the process definition). Retrieval involves internally-directed attention and goal state constraint, but the goal is to retrieve rather than to generate (so it does not meet the generative criterion). Colored brackets at the far left indicate the demarcation between process (including internally-directed attention and all goal-related elements), and product (including elements of product novelty and usefulness). **On the right side of the tree**, brackets for levels of creative eminence (mini-C, little-C, Pro-C, Big-C) indicate how these levels map onto the process and product elements that constitute the tree (as described below). **Above the tree**, the sun and rain cloud represent the elements of external attention/perception and knowledge/learning/experience that often support creativity – nourishing the tree in this metaphorical rendering.

under the adjectival construct of creativity as attribute. Further, although the present paper focuses on the process definition, it is interesting to at least briefly consider the different ways that the adjectival sense of creativity applies to Product, Person, and Press respectively. While both a product and a person can be described in terms of their creative-ness, the implications of these adjectival descriptions seem to be quite different. It might be, for example, that the adjectival creative-ness of a creative person actually corresponds to an attribute construct comprising qualities of ability or personality, which is somewhat distinct from the adjectival creative-

ness of a creative product (i.e., having novel and useful effect or function).

We mention the 4 P's account here because it is well known and provides an illustrative example of how clarifying definitional distinctions between the different constructs hidden within the word, creativity, can provide a basis for parsing the sometimes conglomerized accounts that arise when creativity is treated as a single over-arching construct. However, the 4 P's account is not entirely aligned or redundant with the distinct constructs of creativity we delineate here. The intent of the 4 P's is to position the P's relative to each other, rather

than to provide definitions (because it treats creativity as having a single multifaceted definition). By contrast, the present account has a definitional intent. Distinctions between the definitions of constructs are *a priori* distinctions of theory (i.e., what is the fundamental meaning of each construct of creativity?). By contrast, the 4 P's account makes *a posteriori* distinctions at the level of exemplars (what are primary contributors that we observe to be related to the ways creativity is often manifested and studied?). One way in which these different intents yield different kinds of insights is that *a priori* definitional distinctions allow for broader classifications (e.g., inclusive of non-person systems, such as animals, AI, group dynamics, etc.), whereas *a posteriori* accounts must be either subdivided or inexactly fitted for particular observed cases/exemplars (making the Press P especially difficult to conceptualize as a coherent category). Continuing to parse the P's, and appreciating that they are not all associated with one ambiguous construct of creativity, but with fundamentally distinct constructs that should be separately operationalized, seems an important next step in the maturity of creativity research as a scientific discipline.

To this end, it is vital that researchers clarify their own representations of the constructs they are actually studying, particularly whether they are studying the nominal or adjectival construct of creativity. It is of course possible to study both of these constructs, just as one can study both affect and personality, but they are not the same thing. Keeping them separate in our own minds as we approach our experimental questions is essential for valid, meaningful operationalization and inference. Relatedly, achieving greater theoretical and empirical clarity in the field will require researchers to specify what we mean by "creativity" in our scholarly publications and presentations. Just as it is important to specify whether one is studying divergence or convergence (or a combination of the two), it is important to indicate whether one is studying the process of creativity or the creative-ness of objects, persons, etc. Interestingly, the convergence vs. divergence distinction appears to be largely orthogonal to the distinction between creativity as process and creativity as attribute.

The data: Empirical insights from the cognitive and brain-based study of creativity

Creativity has a long history of being conceptualized as a confluence of cognitive processes (Finke, Ward, & Smith, 1992). More recently, empirical research has provided support for this view, pointing to the interaction of memory, attention, and cognitive control (Benedek & Fink, 2019; Krieger-Redwood et al., 2022).

Evidence from a growing body of individual differences research indicates positive correlations between creative thinking and cognitive control abilities, such as verbal fluency (Gerver, Griffin, Dennis, & Beaty, 2022) and fluid intelligence (Gerwig et al., 2021). This evidence is consistent with a role for executive influences, such as goal maintenance, in guiding and constraining the generative process to meet specific creative goals. In a study of verbal fluency, for example, Silvia et al. (2013) reported a large correlation between verbal fluency and performance on the alternative uses of objects task (AUT; both fluency and rated originality of ideas; cf. Avitia & Kaufman, 2014), suggesting that the ability to strategically search memory, in a goal-directed fashion, is important for creative thinking (Schneider & McGrew, 2018). Likewise, fluid intelligence (Gf) was found to support goal maintenance during creative thinking: Gf predicted AUT performance when participants were explicitly instructed to "think creatively" (Nusbaum, Silvia, & Beaty, 2014). In this case, participants had to maintain the goal of coming up with creative ideas when searching memory for alternate uses, and not simply retrieve known uses. Other work has shown that Gf correlates with people's ability to use cognitive strategies when thinking creatively (Nusbaum & Silvia, 2011), further supporting the relevance of goal maintenance in creative thinking.

Cognitive and brain-based studies of creativity have also focused on the role of attention, particularly *internally-directed attention* (Fink & Benedek, 2014). In contrast to external attention – which requires focusing attention outwardly to stimuli in the environment – creative thinking is characterized by a distinct state of internal attention, in which cognitive processes are "shielded" from sensory input. Perhaps the most compelling evidence for the contribution of internal attention to creative thinking comes from studies using electroencephalography (EEG). Benedek and colleagues have consistently shown that when participations engage in creative idea generation, the brain exhibits increased alpha power, an EEG waveform that has been linked to internal attention (Cooper, Croft, Dominey, Burgess, & Gruzelier, 2003). In one experiment, for example, EEG alpha was found to be higher when participants had to maintain the task stimulus (e.g., an AUT object cue) in the "mind's eye" when thinking creatively (requiring internal attention), compared to when the stimulus remained on a screen (requiring external attention; Benedek et al., 2014). EEG alpha was particularly pronounced in the right anterior inferior parietal cortex, a region previously associated with internal attention (Ray & Cole,

1985). In a follow-up functional magnetic resonance imaging (fMRI) study, using the same experimental paradigm, Benedek and colleagues again implicated the right parietal cortex in internal attention during creative thinking (Benedek et al., 2016). Internal attention (compared to external attention) was also associated with reduced activity of the occipital cortex, as well as increased functional connectivity between occipital cortex and the right parietal cortex. The authors suggested that deactivation of occipital cortex reflected reduced sensory input during internally-directed attention, while occipital-parietal connectivity may relate to suppression of sensory input by the parietal cortex to shield ongoing internal processes.

fMRI studies have provided additional insights into the neural correlates of creative idea generation. One insight has been to distinguish the creative thought process from non-creative processes (e.g., memory retrieval). Early studies contrasted tasks that involve creative thinking of object uses (AUT) vs. tasks that simply require thinking about or listing the characteristics of objects (e.g., object characteristics task), finding stronger activity for creative thinking within frontal, parietal, and temporal regions (e.g., Fink et al., 2009). Subsequent work aimed to further distinguish creative thinking from memory retrieval, since old ideas can be sometimes retrieved from memory, even when participants are asked to think of creative ideas (Gilhooly, Fioratou, Anthony, & Wynn, 2007). For example, Benedek et al. (2014) asked participants to freely generate alternative uses for objects during fMRI; their ideas were recorded, and after the scan, they were asked to identify whether each use was either *old* (something they had seen or thought of before) or *new* (something they came up with for the first time). Compared to recalling old ideas from memory, generating new ideas was associated with activation in the left anterior inferior parietal lobe – a region associated with cognitive control and high-level integration of multimodal information. Subsequently, Benedek et al. (2018) extended this work by distinguishing creative thinking from two types of memory retrieval with respect to the AUT: recalling common object uses (from semantic memory) and recalling original object uses (from episodic memory; i.e., atypical uses that people had thought of or seen before). In addition to replicating the left parietal finding from Benedek et al. (2014), the authors found common engagement – for generating new ideas and recalling original uses from episodic memory – of the parahippocampal gyrus and medial prefrontal cortex, areas that contribute to episodic retrieval and prospection. These findings help to dissociate the creative

thought process from related but distinct cognitive processes, such as memory retrieval.

Benedek and Fink's (2019) neurocognitive framework of creative cognition posits that the generation of creative ideas is marked by goal-directed memory processes, including searching, retrieving, integrating, and simulating information. These processes are sustained by internally-directed attention and can be contrasted with cognitive activities that lack goal-directedness, demand continuous external attention, or involve minimal constructive memory processes, such as mind-wandering or mental arithmetic. This framework provides insights into the cognitive mechanisms that are likely to underlie creative thinking (see also Benedek, Beaty, Schacter, & Kenett, 2023).

In recent years, creativity neuroscience has seen an increasing focus on large-scale functional brain networks or “functional connectivity.” In contrast to conventional/univariate activation studies, which identify activity patterns of brain regions in isolation, network neuroscience examines the coordinated activity of multiple regions across the brain. Two brain networks that have been consistently associated with creative thinking are the default (mode) network (DN) and the fronto-parietal control network (FPCN; also known as the executive control network; for reviews, see Beaty, Benedek, Silvia, & Schacter, 2016, Beaty, Kenett, Hass, & Schacter, 2022). The DN consists of cortical midline regions, including the posterior cingulate cortex and medial prefrontal cortex, as well as lateral temporal and parietal regions, including the angular gyri and middle temporal gyri, in addition to subcortical regions within the medial temporal lobe (e.g., hippocampus). The DN is strongly activated “at rest”—i.e., in the absence of external task engagement – and during many other cognitive states, particularly when cognition and attention are internally focused, such as mind-wandering, episodic memory retrieval, and future simulation, among others. The FPCN consists of lateral prefrontal regions (e.g., dorsolateral prefrontal cortex) and anterior inferior parietal regions (e.g., intraparietal sulcus). The FPCN activates during tasks that require cognitive control, such as response inhibition, task switching, and goal maintenance. Note that the key nodes of these two networks are largely overlapping with the findings of the early studies comparing AUT to control tasks focused on characteristics/description.

Functional connectivity between the DN and FPCN is one of the most robust neural signatures of creativity. DN-FPCN connectivity has been reported across diverse tasks and creative domains, from divergent thinking (Beaty, Kenett, Hass, & Schacter, 2015, Beaty, Thakral, Madore, Benedek, & Schacter, 2018,

Beaty, Cortes, Zeitlen, Weinberger, & Green, 2021) to artistic drawing (Ellamil, Dobson, Beeman, & Christoff, 2012) to musical improvisation (Pinho et al. 2014). For example, Ellamil and colleagues reported stronger functional connectivity between DN and FPCN when visual artists were evaluating ideas for a book cover, compared to when they were initially brainstorming cover ideas. Likewise, Liu et al. (2015) found increased DN-FPCN coordination when poets were creatively revising poems, compared to an earlier brainstorming phase. Regarding divergent thinking, Beaty, Thakral, Madore, Benedek, & Schacter (2018) found that people with stronger functional connections between DN and FPCN regions tended to produce more original ideas on the AUT. Together, these findings indicate that DN and FPCN support creative thinking across domains.

Yet DN and FPCN do not always work in concert. Indeed, neuroscientists initially discovered that the DN and FPCN typically worked in opposition: when one network activated, the other network deactivated (Fox et al., 2005). From a cognitive perspective, this antagonistic relationship aligns with their seemingly opposing roles in cognition. On the one hand, the DN is often active when attention is focused inwardly; on the other hand, the FPCN tends to activate when attention is focused externally. Recently, Dixon and colleagues reported different connectivity profiles for *subnetworks* within the larger FPCN (Dixon et al., 2018). One FPCN subnetwork, FPCNa, showed a positive correlation with DN at rest and during various tasks; another FPCN subnetwork, FPCNb, however, showed the characteristic “anticorrelation” with DN.

How might these subnetworks operate during creative thinking? We aimed to address this question in a recent reanalysis of a large sample of participants who were scanned during the AUT (Beaty, Cortes, Zeitlen, Weinberger, & Green, 2021). We replicated the findings of Dixon et al. (2018), finding negative connectivity between FPCNb and DN at rest. Interestingly, however, this connectivity profile reversed, from negative to positive, when participants were thinking creatively. Moreover, the strength of FPCNb-DN connectivity positively correlated with performance on the divergent thinking task (i.e., the originality of ideas). To our knowledge, this study was the first to report a behavioral benefit (enhanced creative ability) to FPCNb-DN cooperation, pointing to a unique neurocognitive state invoked by creative thinking. Ovando-Tellez et al. (2022) recently examined the relation of whole-brain functional network connectivity to different

stages of creative search processes. This work found that creative search is related to attention and FPCN networks, suggesting goal-directedness. In addition, switching between different topics was related to DN-FPCN coupling.

Aligning theory with data: The process definition of creativity

Observing how the brain carries out cognitive operations can empirically inform and constrain theory about those cognitive operations. This is among the most valuable contributions of cognitive neuroscience to the psychological sciences, and the inferences that neural observations allow have become increasingly meaningful as cognitive neuroscience has matured both in methodological sophistication and in scale of aggregation across studies. The above-reviewed insights into the function and connectivity of neural systems during creative thinking point to ways in which fundamental elements of creativity theory can be translated to specific neural processes that implement creativity.

Informed by these data, but starting from a *a priori* premises, we propose a process definition of creativity as *internal attention constrained by a generative goal*. This definition combines three core elements of evidence-aligned theory: 1) that attention is directed internally (i.e., toward mental representations in memory; as distinct from external/perceptual attention); 2) that attentional operations (e.g., search, manipulation of representations in memory) are constrained to fit parameters of a to-be-achieved goal state (whether or not a goal is actually achieved); and 3) that the goal state of the creative process is generative (a representation not already precisely held in memory; as distinct from rote retrieval of extant representations). This is intended as a general definition of creativity. The aim is to provide a general process-based standard for what creativity is, distinct from but relatable to more specific models of how creative processes, or specific facets of creative processes, work. In other words, we posit that satisfaction of these three criteria is necessary and sufficient for creativity. Below, we lay out the theoretical considerations underlying each of these criteria, and explicate the alignment of these considerations with the above-reviewed brain-based data. We note that, as indicated in the above criteria, the attentional processes we specify are attentional interactions with memory, thus, the definition does not de-emphasize memory by emphasizing attention. As discussed below, creativity can manifest in a wide variety of ways, and many forms of creativity involve other processes elements in addition to the minimal definitive criterion elements we delineate. Thus, the

process definition can be more completely worded as follows: any process that includes *internal attention constrained by a generative goal*, often involving other cognitive, perceptual, emotional, or motoric operations.

Internally-directed attention

The first criterion, that attention is directed internally, distinguishes creativity from perceptual processes that are characterized by attention to external stimuli. Observing the outside world can often support and inspire creativity. However, even in such cases, attention to external stimuli would not be a sufficient basis for creativity. Simply seeing a beautiful scene in nature, or even photographing it – as an aerial drone might do – is not sufficient for creativity. Internal attentional processes are required, which act on the information that is represented internally (often on the basis of external perception as well as strong internal influences on perceptual processing; Baluch & Itti, 2011, Gilbert & Li, 2013, Gilbert & Sigman, 2007). When a person engages in creativity, they are directly operating on their internal representation of the outside world (not the external stimuli themselves). Further, it is not always evident whether or how the representations that are the substrates of creativity relate to any particular external stimuli. Certainly, such relationships to the external world need not be on the immediate timescale of external attention, and even a person who has no capacity to attend external stimuli can presumably still think creatively. Thus, while attention to the outside world can rightly be considered an antecedent stage of many creative processes, it is not a part of all creative processes (at least not in any direct or proximate way). We therefore posit that internal attention is a necessary condition for creativity, whereas external attention often contributes, but is not a necessary condition. Put another way, this criterion reflects the theoretical consideration that creativity requires origination (i.e., that a person – or other system – can only be considered a creator if creativity happens within that system). This criterion is aligned with the above-noted empirical data indicating that creative thinking is associated with higher spectral power of EEG alpha, which appears to mark internally-directed attention (Agnoli, Zanon, Mastria, Avenanti, & Corazza, 2020, Benedek, Bergner, Könen, Fink, & Neubauer, 2011, Benedek, Schickel, Jauk, Fink, & Neubauer, 2014, Fink & Benedek, 2014, Klimesch, 2012, Kounios & Beeman, 2014), and with the evidence that visual processing and attention to external stimuli is dampened during creative thinking (Benedek, 2018, Benedek et al., 2016).

Goal constraint

The second criterion, that attention is constrained by parameters of a goal state, reflects the theoretical consideration that creativity is a meaning-based process (i.e., that internally-directed attention has a meaningful/nonrandom basis for generating and selecting representations). Here, the term “goal” does not imply a goal that is an overt, consciously accessible representations. While overt goals are represented in many explicitly targeted creative processes, it is also often the case that the goal(s) of a creative process are not consciously accessible, at least not fully accessible during the process. In our view, the goal state of creativity can include the range of conscious, unconscious, and even self-surprising end states to which creative processes lead. Parameters of a goal state can include any attributes of representations that are preferable to the individual in the process of generating and selecting candidate representations. For example, an individual might prefer representations of things that are beige, nonsensical, slippery, beautiful, named Gary, analogous to the changing of the seasons, surprising, sweet-tasting, etc. Importantly, the presence of goal state parameters does not imply that there is a definite or fully-specified goal state that is guiding attentional processes in creativity. Indeed, if the goal was already fully represented, then the process would not actually be creative (see the below discussion of the generative criterion). Likewise, as noted above, a process that does not result in the achievement of a goal (e.g., if no representation is generated that fits the goal state parameters) can still be considered creativity so long as goal state parameters constrained attention within the process.

Fitting the parameters of a goal provides 1) a framework for meaningful generation (a creative process is meaningful to the creator in relation to the parameters of the goal state; fitting the parameters of a goal state constitutes the meaningfulness of the process); and 2) a basis on which the attentional deployment in a creative process can be completed (i.e., can result in a created outcome). A substantial body of evidence has demonstrated the role of constraint in supporting creative ideation (Diaz, Nelson, Beaujean, Green, & Scullin, *in press*, Medeiros et al., 2014, Tromp & Sternberg, 2022, Yang et al., 2022); in our view, fitting the parameters of a goal state constitute the most basic form of constraint in creative processes. In the absence of such constraint, the deployment of internally-directed attention/ideation would be a means without an end (a search and/or selection and/or manipulation process with no goal

state). Ideation that lacks the meaningful frame of goal state parameters, or that is end-less (without a goal end state) may characterize the intrusive thoughts and disordered, uncontrollable associations that present in pathologies such as schizophrenia (Spitzer, 1997).

In all cases of creativity in which the process actually results in a product, a meaningful selection of a product must occur (where meaning reflects the fitting of the end-state parameters). However, as we have just noted, the presence of goal state parameters does not require that we deliberately set out to find a particular representation when we deploy our internally-directed attention. Indeed, the presence of goal state parameters does not imply that we are always aware of what our parameters are, that we are aware that we have parameters at all, or even that parametric constraints influence our internal attention before the final stages of a creative process. Sometimes we are mind-wandering with minimal constraint, and simply happen upon a mental representation that we only then identify as meaningful with respect to some set of end-state parameters. In these instances, goal state parameters constrain/bias the selection of particular internal representations at the final stages of an attentional deployment. The mental representations of the end-state parameters are present, even if they are not being actively considered during the mind-wandering attentional deployment. In other words, end-state parameters are still a necessary element of the creative process, even if they are primarily relevant to the attentional selection that completes the process, rather than to directing attention throughout the process.

A related point, which is addressed in greater depth below, concerns the taxonomic relationship between mind-wandering and creativity. Like attention to external stimuli, mind-wandering is sometimes part of creative processes, and studies have focused on this connection (Baird et al., 2012, Gable, Hopper, & Schooler, 2019). However, mind-wandering alone (if goal state constraints are never imposed) is neither necessary nor sufficient for creativity (Murray et al., 2021). Moreover, it is not sufficient that a person who engages in mind-wandering also maintains some superposed goal state(s) if the constraints of that goal state never intersect with the mind-wandering. Mind-wandering is only considered part of creativity in cases where a candidate representation is identified such that *attention is deployed* to determine the fit of that representation to the constraints of a goal state.

Of course, there are other times when the deployment of internally-directed attention is much more deliberate and we do set out to find a particular kind of representation (e.g., a solution to a design problem,

or a joke to tell at a retirement party). In these cases, the process can be characterized by meaningful constraints on the implementation of idea generation, whether or not the process actually results in an identifiable product. These constraints might reflect goals (explicit goal states) that constrain/bias the direction(s) in which attention is deployed within the vast “semantic space” of internal representation, making the attentional deployment far more targeted and efficient. These constraints might also reflect particular ideational strategies, such as analogy, which requires fitting the constraints of relational structures and roles to achieve valid creative mappings between source and target concepts (Falkenhainer, Forbus, & Gentner, 1986, Green, Fugelsang, Kraemer, & Dunbar, 2008, Green et al., 2014, Lu et al., 2012).

There are thus two general types of process that meet this second criterion of goal constraint: 1) Processes that involve the evaluation of candidate representations to fit the parameters of a goal state (e.g., when mind-wandering results in representations that are candidates to fit a superposed goal); 2) Processes that involve constraints on attentional search or other attentional deployment strategies that reflect the parameters of a goal state (e.g., when an individual is deliberately trying to think of a creative solution to a particular problem). Note that neither type of process has to actually result in the selection of a mental representation in order to meet this criterion. Note also that the second type of process, but not the first, meets the goal constraint criterion even if no specific representation is even evaluated as a fit for a goal state. Finally, note that many creative processes – perhaps most – are of both types (e.g., a deliberate search that involves the evaluation of several candidate representations).

The criterion of goal constraint is aligned with the evidence concerning FPCN and its connectivity with DMN during creative cognition (Beaty, Benedek, Silvia, & Schacter, 2016, Beaty, Cortes, Zeitlen, Weinberger, & Green, 2021). The evidence linking FPCN (including FPCNb) to creative performance strengthens empirical support for theories that emphasize goal state constraints (particularly constraints of overt goals). Across multiple domains, FPCN connectivity appears to bias the function of other neural systems toward goals or expectations (Zanto & Gazzaley, 2013). As noted above, FPCN and DMN appear to generally work in opposition, and this accords with cognitive theory suggesting that dampening internally-directed attention is advantageous for maintaining focus during goal-directed cognition. Thus, the evidence that, during creativity, the connectivity of FPCN (including FPCNb) to DMN reverses (i.e., becomes positive rather

than negative) aligns with a theoretical framework in which creativity involves a somewhat exceptional cooperation between internally directed attentional resources and application of goal-related biases to internally-directed attention.

Generative goal

The third criterion of the process definition is that creativity is generative (i.e., that the to-be-achieved goal state is a representation not already held in memory). This criterion is included to distinguish creativity from internally directed attention with the non-generative goal of retrieving, without alteration, mnemonic representations that are already present before engaging in the process of creativity. For example, a reasonable case could be made that a simple search of declarative memory (e.g., to recall the answer to a Trivial Pursuit question) might fit the other two criteria of the process definition, but this would not fit the generative criterion because it would be retrieval, rather than generation. Of course, much of creative ideation relies on retrieving representations from memory (Beaty, Thakral, Madore, Benedek, & Schacter, 2018, Gilhooly, Fioratou, Anthony, & Wynn, 2007, van Genugten et al., 2021), but retrieval alone does not suffice; a goal state of generating some change with respect to the retrieved representations is required for creativity (e.g., Benedek, Beaty, Schacter, & Kenett, 2023). Generative goal states can take many forms, including modification or manipulation of representations, combination or association of representations, integration or synthesis of representations, and extension of representations to contexts or uses other than the one in which the representation was acquired. Any form of generation is sufficient to satisfy the generative criterion, and multiple forms of generation can be components of a superordinate goal state within the same creative process in independent or interacting ways.

We have taken care here to refer to attention without exclusively referring to attentional search. Attention can be deployed not only in ways that search existing representations, but also in ways that implement and/or interact with traditional “working memory” resources to actively operate on mental representations. Indeed, attention and working memory are highly overlapping constructs (Awh & Jonides, 2001, Awh, Vogel, & Oh, 2006, Gazzaley & Nobre, 2012, Oberauer, 2019), and some have argued that they are not meaningfully distinct (Engle, 2002, Gazzaley & Nobre, 2012). In order to create, it is not enough to search, it is also necessary to generate. The generative criterion of the process definition reflects this requirement.

The cooperation between FPCN and DMN is consistent with this generative criterion. Such cooperation need not only reflect goal-based constraints on attentional search, it is equally consistent with the interaction of internally-directed attention with traditional working memory resources in FPCN. We note that FPCNb includes dorsal areas of lateral PFC that are robustly implicated in manipulation of mental representations (Dixon et al., 2018). Notably, this generative criterion is also consistent with evidence that DMN activity during creative ideation emerges for creativity tasks over-and-above nongenerative control tasks that involve simple descriptions of objects (e.g., Fink et al., 2009), and over-and-above an internally-directed attention task devised to minimize the generativity requirement (Benedek et al., 2016).;

The way in which attentional resources are deployed is likely to depend on the particular generative goal state. For manipulation and integration, the role of working memory operations is perhaps most evident. Altering and integrating representations in working memory has been well studied (D’Esposito, Postle, Ballard, & Lease, 1999, Masse et al., 2019). Mental rotation of objects, and relational integration in analogy are prominent examples (Bunge, Helskog, & Wendelken, 2009, Cortes et al., 2023, Green, 2018, Green, Fugelsang, Kraemer, Shamosh, & Dunbar, 2006, Green, Kraemer, Fugelsang, Gray, & Dunbar, 2012, Holyoak & Monti, 2021, Milivojevic et al., 2009, Zacks, 2008). For extension of a representation to a context or use, the role of attentional search is more evident, whereas the role of working memory is more subtle. Working memory is likely to support the maintenance of context or use parameters as components of the goal state parameters, at least for deliberate forms of extension ideation. In both deliberate and mind-wandering (or spontaneous) ideation, once a candidate representation is identified, working memory resources might support adaptations or simulations to fit that candidate representation to a target use, or test the aptness of the candidate representation in a target context. Note that attention is similarly deployed when creativity takes the form of evaluating or selecting among products that others have produced.

We readily acknowledge that the interaction between traditional attentional processes, such as search, and traditional working memory processes, such as manipulation, remains loosely specified both in our description and in the extant literature and, again, this interaction is likely to vary complexly depending on the generative goal state parameters. Clarifying this complexity is perhaps the most timely priority for cognitive and brain-based research in creativity, and for

models of creativity as a process. Such models might operate most fruitfully within constrained subsets of creative processes (e.g., integration of representations based on deliberate attentional deployment, or extension of representations to uses based on mind-wandering attentional deployment), rather than generalizing across the spectra of creative processes. As noted above, our charter here is not to construct a specified process model, but to provide a broader definitional structure that can serve to frame empirical and modeling work.

Relationship of the process definition to the product definition

There are some elements of the process definition proposed here that relate to elements of the product (“standard”) definition, and other elements that do not. We note that the generative criterion (i.e., ideating something not already represented in memory) implies a form of novelty, but is substantially distinct from the use of novelty in the product definition. Here, we specify a frame of reference bounded by the mental representations present within the individual. If an individual does not already hold a representation, then ideating that representation is generative, whether or not it can be considered novel in any context beyond the individual. And, again, this criterion is process-based, rather than product-based; there is no requirement that the outcome is novel (even to the individual), or even, in a strict sense, that there is an identifiable outcome of the process at all, so long as parameters of a generative goal state constrain the creative process. Relating this again to the discussion of deliberate vs. mind-wandering-based creativity, deliberate deployment of internally directed attention with the constraints of generative goal state parameters is always creativity, regardless of whether there is an outcome. By contrast, in order to be considered creativity, mind-wandering requires at least the identification of a candidate representation and the deployment of attention to determine the fit of that representation to the parameters of a generative goal state.

As regards the “useful” criterion of the product definition, the presently proposed definition makes no direct reference to usefulness. Usefulness, in the product definition, is frequently tied to the value or appropriateness externally ascribed to a product, especially for the application of the product to some external circumstance or problem. Because the presently proposed definition is process-based, it does not set any requirements for the value of a product. It is worth noting that the usefulness criterion is itself robustly

contested among contemporary creativity theorists, some of whom feel that only novelty is necessary for creativity, even for product-focused assessment. Accounts that employ the term “task-appropriate” over “useful” or “valuable” (e.g., Kaufman, 2016) implicitly argue that although creativity cannot be random or chaotic, the questions of “use” or “value” are fully context-dependent. Indeed, the concept of *mini-c* (Beghetto & Kaufman, 2007, Kaufman & Beghetto, 2009) includes the idea that such creativity need only be original and useful/valuable to the creator, as opposed to any potential audience.

While the process definition does not require usefulness in a conventional sense, it retains what is perhaps most useful about usefulness. The usefulness criterion is generally taken to distinguish creativity from ideation that is unrelated to any internally meaningful purpose (e.g., as a means without an end in pathological thought patterns). The present definition retains this distinction by requiring that internally-directed attention is constrained by the parameters of a generative goal state. Ideation entirely unconstrained by a goal would not meet this standard.

Indeed, a fuller consideration suggests that the very presence of goal state parameters implies at least some degree of affordance. That is, for any goal state parameter that an individual prefers, generation that achieves that goal would necessarily be affordant to the individual in some way. Note that affordances can be of any kind (aesthetic, practical, destructive, fun, etc.), such that the term, “useful,” would be at best an awkward fit (e.g., Gibson, 1977, Glăveanu, 2013, Glăveanu, 2016). At the most basic level, the achievement of a generative goal state (or even an individual goal state parameter) is itself affordant to the individual, even if what is ideated remains entirely internal and no externally evaluable product is ever rendered (e.g., Matheson & Kenett, 2020, 2021).

The fitting of internally-represented goal state parameters might be interpreted as a special, internally-focused case of “appropriateness,” which is also sometimes used in the place of the usefulness criterion (Cropley & Cropley, 2008, Hennessey & Amabile, 2010). However, note again that, because the presently proposed definition is process-based, it only requires that goal state parameters constrain the deployment of internally-directed attention. Thus, it does not strictly require that a goal (or even the fitting of a goal state parameter) is actually achieved even internally. That is, it does not require that the product is actually appropriate (or affordant) even to the individual, and indeed does not require that a product is actually generated.

The generative and end-state constraint criteria of the process definition thus depart from the novel and useful criteria of the product definition in several ways. The criterion of internally-directed attention is perhaps most evidently distinct. There does not appear to be any relationship between internally-directed attention and the product criteria of novelty and usefulness.

Applying the process definition to process models of creativity

Most process-based models of creativity share four core stages in common (Guilford, 1950, 1956, Sawyer, 2012). The first stage in most models is problem-finding, in which the creator determines the actual problem that needs to be solved. In real life, problems tend to be ill-defined so this stage is essential (Abdulla, Paek, Cramond, & Runco, 2020). This stage can encompass thinking of different ways to restate the problem (Reiter-Palmon, 2017) and considering potential constraints that will be encountered along the way (Medeiros et al., 2018). The second stage, divergent thinking, is when many different possible solutions are considered (Runco & Acar, 2019). After ideas have been generated, convergent thinking occurs, in which the creator tries to evaluate and determine the best possible idea to pursue (Cropley, 2006). Finally, the creator aims to validate the solution. Of course, most creative process models are focused on problem-solving, which is a more focused and direct approach to being creative. Ideas that come from daydreaming, fantasy, play, or mind-wandering (e.g., Smallwood & Schooler, 2015) may emerge initially from less overt or intentional deployments of internally-directed attention.

How does the process definition inform the broad model of the creative process? For one, each stage of the creative process leans on different components of the definition. Problem-finding has several different possible components, depending on the particular problem. Sometimes identifying constraints is a key part (e.g., Damadzic, Winchester, Medeiros, & Griffith, 2022), in which case goal constraint would be dominant. Other times, searching for relevant information is essential (e.g., Harms, Reiter-Palmon, & Derrick, 2020); if such a search is focused initially on one's own memory or acquired knowledge, then internally-directed attention would be the most relevant (it would still play a role when processing and considering the new information, even if the creator's initial search was focused on an external information source). Some of the other aspects of problem-finding, which would likely draw on both internally-directed attention and generative elements, include considering the parameters of the problem,

restating it, attempting to give it structure, identifying resources, and generally working to figure out the exact problem that needs to be solved (Reiter-Palmon & Robinson, 2009).

During divergent thinking, the creator generates many different ideas and potential solutions. It is during this stage when generativity (as opposed to recall) becomes especially salient. The Cattell-Horn-Carroll (CHC) model of intelligence (Schneider & McGrew, 2018), which is the model that underlies most IQ tests (Kaufman and Beghetto, 2009), initially placed creativity under the *Glr* long-term storage and retrieval) factor. This was subsequently split into *Gl* (learning efficiency) and *Gr* (retrieval fluency), with creativity closely tied to *Gr* (A. S. Kaufman et al., 2019). Among widely-used measures, *Gl* is commonly assessed; only the Woodcock-Johnson IV includes *Gr* (Schrack & Wendling, 2018). Although both divergent production (Beaty, Silvia, Nusbaum, Jauk, & Benedek, 2014) and rated creativity (Avitia & Kaufman, 2014) do correlate with this ability, the process definition highlights how creativity encompasses much more than simply being able to quickly retrieve information. One must be seeking to generate new ideas, such that access to knowledge or past experience is necessary but not sufficient for creative thought.

Both convergent thinking and solution validation lean heavily on the ability to constrain attention to fit goal state parameters (in this case, evaluating and selecting one's best idea and then testing it) and on thinking, reflecting, and other dimensions of internally-focused attention. For example, Smith et al. (2013) conducted a variation of the remote association task – the typical task assessing convergent thinking (Mednick, 1962) in which they asked participants to undergo the remote association task, while speaking aloud their guesses to the solution during each trial. Based on participants' guesses, the authors modeled the search processes involved in this task. The model indicated that convergent thinking in the remote associates task involved two stages: An initial divergent stage, where participants generate alternative solutions to the task; and then a second, convergent stage that involves solution matching and evaluation (Smith et al., 2013).

Three process-oriented theories that merit further discussion are the Genevieve model (Finke, Ward, & Smith, 1992), the Blind Variation and Selective Retention (BVSR) theory (Simonton, 2011), and the MemiC model. Although all three have a commonality in having one process or stage devoted to producing ideas and another centered on some aspect of evaluation, convergence, or selection, these theories are also distinct. The Genevieve model focuses on how

creators conceive of preinventive structures, or the initial mental representations of what will become fully formed ideas. Creators generate these preinventive structures and then explore and interpret them within the context of potential constraints. Finke, Ward, and Smith (1992) offer several examples of cognitive processes that lend themselves to analysis via the process definition. For example, one generative process is retrieval, which the authors suggest is a basic component and may occur automatically. It is possible that some retrieval processes that do lead to creative actions may not yet be fully distinguishable from non-creative retrieval. It is the next steps, such as associating the retrieved ideas with related ideas, that might actually qualify the process to be considered creativity. Subsequent generative processes, which can include synthesizing different parts and transforming them to be different and more applicable to the problem in question, may be more clearly creative (and, indeed, rely heavily on internal processing and constrained attention), as are analogical transfer and categorical reduction. Many of the exploratory processes (which include attribute finding, conceptual interpretation, functional inference, contextual shifting, hypothesis testing, and limitation searching) particularly rely on being able to constrain one's attention.

The BVSR theory was articulated by Campbell (1960) but advocated and expanded by Simonton (1999, 2011, 2015, 2022a). Taking an evolutionary perspective on creativity, BVSR suggests that creative ideas are generated blindly, without the creator necessarily knowing their level of utility. On this account, if a creator fully knows beforehand whether an idea is useful then the process is sighted – and not creative – because such a response is either dependent on prior knowledge or relying on a clear algorithm (e.g., Amabile, 1996). Because a creator putting forth a blind idea does not know whether it will be effective, there is a chance that it will not work; as a result, such blind ideas come with high levels of risk. In addition, a creator may think they know an idea's usefulness but be wrong about their knowledge (i.e., having low metacognitive accuracy about their creative process; Kaufman & Beghetto, 2013). When a creator tries an idea that they incorrectly believe will not be useful, they may end up with a discovery that is considered to be serendipitous. Some variants on ideas, in extreme cases, may be generated by pure chance (which would be blind by their very nature). The ideas that are selected to be pursued (or retained), however, are the ones that are, presumably, tested and valuable. In this circumstance, the blind variations emphasize internally-directed attention and

generativity, although it is important to note that external tinkering is also allowed in this stage (Kantorovich, 1993). The selective retentions, meanwhile, likely would emphasize attentional constraints. A brain-based framework developed by Jung, Mead, Carrasco, and Flores (2013) suggests aspects of the neural implementation of BVSR that are consistent with the elements of internally-directed attention (including DMN involvement) and attentional constraint (including prefrontal involvement) that we have outlined in alignment with the process definition.

Building on the above-described models of creativity, and on the extensive empirical cognitive and neuroscientific research conducted on the role of memory in the creative process over the past few decades, Benedek, Beaty, Schacter, and Kenett (2023) recently proposed an updated model for the role of memory in divergent ideation (MemIC). This model highlights the role of different types of memory systems – focusing on semantic and episodic memory – at different stages of the creative process. The authors propose greater nuance in the stages of ideation, arguing for two stages during idea generation – search and connection – and two stages during idea evaluation – evaluating novelty and evaluating effectiveness (Benedek, Beaty, Schacter, & Kenett, 2023). Relevant to the process definition of creativity, the MemiC model highlights general aspects of divergent creative ideation that include controlled memory retrieval processes as well as constructive memory processes (Benedek, Beaty, Schacter, & Kenett, 2023).

In each of the above cases, the process definition can be used as a framework for modeling creative processes. As noted above, these models seek to elucidate the ways that mechanisms of creativity work, and especially how the most novel and useful ideas are generated. They do not seek to present a definition of creativity (i.e., to establish minimal necessity and sufficiency criteria).

Applying the process definition to develop a taxonomy of creativity-related constructs

Levels of creativity

How are the levels of creative eminence reflected in the Creativi-Tree (Figure 2)? The initial level of mini-c would be achieved when the creator has either reached or realized the generative goal state. This moment of insight, understanding, or mental exploration can move on toward having the goals of novelty and usefulness. At the mini-c level, an explicit usefulness goal may be as simple as the creator wanting to successfully amuse

themselves, or ponder an interesting notion; usefulness does not necessarily mean a tangible product or even a shared thought (Beghetto & Kaufman, 2007). Part of the process of striving toward novelty and usefulness at higher *c*-levels would be to share initial thoughts and early experiments with other people; therefore, the process will likely result in some sort of product, and this point could be considered to be little-*c*. At this level, an audience might initially only be one's family or friends; even as someone at little-*c* continues to grow and develop, their audience may remain the local community. The recognition of novelty and usefulness may well be in relation to what is expected; in other words, few people would mistake a local diner or community theater performance for a Michelin-starred restaurant or Broadway. Its novelty and usefulness would be recognized, but there would likely not be strong agreement and such recognition may not come from an audience with the experience or knowledge to discriminate high and low quality. Simonton (2004b) notes that when considering the hierarchy of sciences (i.e., what makes one science more prestigious or elite than another), one important marker is whether there tends to be higher levels of consensus in peer (i.e., expert) evaluation of contributions. Similarly, one distinction between little-*c* and higher levels of creativity is that nearly any consensus of a product's novelty or usefulness (regardless of the domain) would likely come from non-experts at the little-*c* level. In other words, someone who cooks for their family and friends would be less likely to have the chance to cook for the best chefs in the world. As the product is refined and, often, modified to reflect the input of many others, it moves toward having a consensus of qualified people (in some cases, experts) who may agree that it is at a level of ingenious novelty and at a level of widely accepted/influential usefulness. Such a contribution would be considered Pro-*c*, with the potential to persist over generations and continue to be appreciated until it might reach Big-*C*. Thus, whereas mini-*C* encompasses the minimally definitional process elements that define creativity, little-*C*, Pro-*c*, and Big-*C* are demarcated primarily by the extent of influence of the products that creativity yields.

Divergence and convergence

Measures of creative thinking are often divided into the categories of divergent and convergent. Broadly, open-ended measures in which many possible answers are valid fall into the divergent category, while the convergence category applies to measures in which a limited number of possible answers (usually just one answer) is correct. Much of the work we have

described above, especially work related to the AUT, is typically placed in the divergent category. Without question the most frequently used convergent measure in the creativity literature is the remote associates task (Bowden & Jung-Beeman, 2003, Wu et al., 2020). A typical implementation of this task presents three prompt words (e.g., crab, pine, sauce), and participants respond with a word that is an associate of all three prompts (i.e., apple). The relationship of this task and other similar convergent tasks to creativity has often been debated (Lee et al., 2014, Lee & Theriault, 2013). We, and many others, have argued that divergence and convergence are not cleanly separable (Cortes, Weinberger, Daker, & Green, 2019, Cropley, 2006, Goldschmidt, 2016) and that they are best conceptualized as integrated, rather than distinct. Regardless of whether or how one seeks to distinguish divergence and convergence, we argue that the criterion of generativity should supersede this distinction. Traditional measures of both "divergent" and "convergent" creativity easily meet the standards of internally-directed attention and goal constraint. The extent to which they are generative is not always as clear.

In a divergent measure, like the AUT, simply retrieving a standard use for an object (e.g., retrieving the use of a brick to build a wall) is not generative in the sense that this representation was likely already present in the precondition. The AUT and other similar tasks reflect this consideration in their scoring, which typically favors responses that are nonstandard. However, it is possible that even responses that are nonstandard (e.g., using a brick as a pet) might already be represented by the participant in the precondition. Applying the process definition, the cognition underlying AUT responses should only be considered creative to the extent that participants are seeking to generate representations not present in the precondition (i.e., not already held in memory). As with all behavioral measures, the internal process of the participant cannot be fully inferred based on their responses but, as discussed further below, implementing process-focused elements of divergent measures (e.g., debrief questions) has considerable potential to inform the extent to which responses were retrieved vs. generated and indeed can directly query participants' strategy (retrieval vs. generation).

In a convergent measure, like the remote associates test, the place of generativity is somewhat less clear. In order for an item to be solvable, the correct answer must be a word that the participant already knows. Similarly, each of the individual associations to the respective prompt words also generally need to be already known to the participant. Thus, applying the process definition of creativity, the cognition underlying responses to the

remote associates test should be considered creativity to the extent that the goal of linking a word to all the prompt words is considered generative. It is likely that, in most cases, the word is not already represented as having all of those multiple associations simultaneously. This could therefore be considered generation in the form of extension to a context (the context of multiple simultaneous associations) other than the context(s) in which the response word was acquired.

Mental simulation/prospection

Mental simulation refers to envisioning characteristics of an event that is imagined rather than simply remembered. Mental simulation can be the basis of far-fetched fantasies that are not tethered to events in the real world, but it can also be applied to planning real-world events that simply have not yet occurred. These activities may range from spontaneous daydreams or musings to extremely deliberate thoughts or fantasies (Barnett & Kaufman, 2020). Applying the process definition, many instances of the more fantastic kind of mental simulation would readily qualify as creativity so long as they involve fitting the goal state of generating items, events, contexts, and combination of items and events with contexts that were not represented in the precondition (note that this criterion can be met irrespective of any discernable product arising from mental simulation; the definition applies to the process). Prospective mental simulation for the purpose of planning could plausibly also be considered a form of creativity if the intent is to mentally situate items and events in a future context because the association of those items and events with that context would not have been represented in the precondition (Matheson & Kenett, 2020). This is subtly, but importantly, distinct from the goal of purely retrieving past events and their contexts (such retrieval would lack the generation of event-context combinations). While this kind of prospection would qualify as creativity in a minimal sense according to the process definition, most such cases would not be considered highly creative because they are far more retrieval-based than generative (as noted below, the generativity of a process should be understood along a continuum).

Accidental creativity/serendipity

Sometimes creative products result from accidental circumstances. If a clumsy chemist trips on a shoelace and a test tube falls into a vat resulting in the accidental creation of a compound that a clever colleague subsequently recognizes could be used as an effective sunscreen, the creation of the new sunscreen could be

described as “accidental creativity.” However, as has been argued previously (Ross & Vallée, 2020, Simonton, 2004a), the actual creativity in these instances is not in the occurrence of the accidents themselves, but in the recognition of how the accidental creation (the compound) could be further developed or applied to problems or contexts other than those in which it first arises. Accordingly, the process definition of creativity does not describe the accident itself. Tripping on a shoelace is not a creative process. Instead, the process definition applies to how an individual may operate on their mental representation of the compound in ways that support the generation of a representation of the compound as sunscreen. Indeed, examples such as this one help to emphasize the distinction between creative products and creative process. If the process of creativity was simply defined with respect to the product (i.e., a process that results in the creation of something novel and useful), then the clumsy chemist’s tripping on a shoelace would qualify as creativity (this was the process by which the novel and useful something was created), whereas the mental operations of the clever chemist are not clearly represented in this product definition. In other words, just as it is possible to have a creative process without a creative product, it is possible to have a creative product without a creative process (Simonton, 2022c). Again, this points to a fundamental error in applying the product definition to the process of creativity.

Generality of the process definition

Here, we have primarily framed the process definition in terms of creative ideation and problem solving, however it is not our intent to indicate that the definition is limited to these forms of creativity. Rather, it is our view that the definitional framework described here applies broadly across different domains in which creativity manifests; that creativity in any domain involves the three fundamental elements we have posited. A close consideration of each creative domain is beyond the scope of this paper, but a brief consideration of artistic domains of creativity that are often – whether rightly or not – considered less “cognitive” than the kind of creativity that has been our primary focus here may still be informative. Taking music or dance (composition or improvisation) as examples, these forms of creativity appear to require the deployment of internally-directed attention (to mental representations of sounds or movements) under the constraint of goal state parameters. Because dance is perhaps at the extreme end of action-oriented, ostensibly “non-

cognitive” creativity, let’s consider that example a bit further. Even as a dancer improvises movements in the moment, abstractions of potential movements are being represented in the dancer’s brain (largely in superior parietal cortex; Grafton, Hazeltine, & Ivry, 1998, Hardwick et al., 2018, Héту et al., 2013, Johnson, 2000), as are neural representations of the dancer’s own body position (Pellijeff et al., 2006). The dancer’s mental operations with respect to these representations are at the core of their creativity. Certainly, some bodies enact mental representations of movements more fluidly or athletically than others, but being a better dancer purely on the basis of execution does not make one a more *creative* dancer. Imagine a dancer with prosthetic limbs that translate signals from motor cortex into movements (such prostheses have been developed; Collinger et al., 2013). Would a dancer with a more expensive set of prostheses that can translate the neural signals more fluidly be more creative in any meaningful sense? Should a dancer who becomes paralyzed or loses their limbs be considered less creative? As we have noted above for other elements that often contribute to creative processes (e.g., external attention, prior learning), actions often play a role in the creative process, especially in artistic domains, but it is the mental process described by the process definition – rather than the actions themselves – that are necessary and sufficient for creativity even in these domains. Consistent with prior examples described above, if some of the moves are truly improvised in the sense of being originated in the moment, then the generation of the mental representations of those moves would be more creative than representations of previously-learned moves that an experienced dancer might simply recall from memory – although such recall can be a component of creativity if there is also a generative element, such as generating a representation of the remembered moves in relation to a previously unassociated sequence or context.

As noted above, the proposed definition of creativity derives from *a priori* premises of necessity and sufficiency for creativity. It is thus not only intended to be general with respect to various forms and expressions of creativity, but also with respect to various mechanisms by which creativity may be implemented. While the alignments of the proposed process definition with empirical data on the neural bases of creativity are informative, the definition does not rely on these findings, and can accommodate new evidence that is virtually certain to arise about how brains instantiate creativity. For example, if we find that internally directed attention is actually implemented differently from

the way neuroscience currently characterizes it, the definitional framework we propose would nonetheless accommodate the new data under the criterion of internally-directed attention.

The recent advances in computational creativity via machine-learning models such as ChatGPT, present an interesting challenge for the terminology used to define creativity. For example, whereas the search and manipulation processes that are applied in computational instantiations of creativity are conceptually aligned with the intent of the word “attention” in our definition, it remains to be seen how well the word, attention, will be understood to apply to AI. It is possible that a somewhat wordier description such as, “search and manipulation operations,” should eventually be substituted to make the definition more general for humans and AI.

Applying the process definition: Interpretation and assessment

The process definition provides a framework for determining the extent to which a process constitutes creativity. Further, it provides a framework for the interpretation of cognitive and brain-based data related to creativity. For example, while cognitive and neural findings that indicate internal vs. external attention, or that indicate generation vs. retrieval, cannot be meaningfully interpreted with respect to a product criterion such as “novel,” such findings can be readily interpreted with respect to the process criteria we have proposed here. Such interpretive clarity is helpful for evaluating not only processes in a pure sense but, by extension, evaluating tasks and individuals.

The process definition can be applied to evaluate tasks, paradigms, etc. that are intended to elicit creativity. A task that elicits processes that do not meet the criteria of internally-directed attention, generation (rather than retrieval), and goal state constraints on attention would be a poorer measure of creativity than a task that elicits processes that satisfy these three process definition criteria.

Although it defines the process itself, rather than defining an agent (e.g., person, animal, machine), the process definition also applies to assessing the creative ability of individuals. This is because the assessment of how creative an individual is depends not only on what they produce, but on the process they use to produce it. If an individual produces ideas that are judged to be highly novel and useful but is observed to rely primarily on retrieval rather than generation, that individual should be evaluated as less creative than a person whose responses might be less novel but are based on

generation. Simply recalling memorized information is not a highly creative ability. Likewise, if an individual is observed to generate without goal state constraint on attention, as may occur in individuals with Schizophrenia, they should be evaluated as less creative than an individual who exhibits a creative process that meets the goal constraint criterion (see, e.g., Acar, Chen, & Cayirdag, 2018). Importantly, evaluations of individuals need not only focus on creativity as a trait. Understanding the dynamics of creativity as a state, within an individual across time, is a priority for creativity research (Cortes, Daker, Colaizzi, Peña, & Green, *in press*, Green, 2016, Nusbaum et al., 2014, Weinberger et al. 2016), and the process definition can be equally well-applied to evaluate the creativity of an individual's process at different times and under different conditions.

An important point to emphasize is that the process definition, and the generative criterion in particular, provides a basis for assessing processes along a continuum of creativity. If the observation of process (e.g., via neuroimaging or a think-aloud paradigm) indicates greater reliance on retrieval than generation, that process may be considered less creative than one for which the data indicate greater reliance on generation than retrieval (an earlier example was raised when considering prospection that is only minimally generative). Notably, the more generative process should be considered the more creative process, even if the products of the more retrieval-based process are externally evaluated as more novel and/or useful. Indeed, valuation of the generative basis of creative ideas is consistent with Mednick's classic conceptualization of the associative generation of creative ideas (Beaty & Kenett, 2023, Kenett & Faust, 2019, Mednick, 1962).

It is thus our hope that establishing a process definition of creativity supports a shift toward greater consideration of process in creativity assessment. At the behavioral level, multiple approaches have been developed to assess process, including think-aloud paradigms (Boldt, 2019), self-report measures (Pringle & Sowden, 2017), thought visualization/diagramming techniques, and tracking of gamified creativity performance (Rafner 2021, Rafner et al. 2022). Integrating such approaches with the definitional framework proposed here has potential to yield a next generation of creativity assessment that focuses on 1) the extent to which an individual's creative processes exhibit the defining characteristics of creativity as a process (especially generativity), and 2) the particular ways in which those characteristics manifest across individuals, tasks, domains, and contexts.

Integrating process-based assessment to improve standard product-based assessment

The process definition is not intended as a rubric for direct assessment of externally observable creative production, just as the product definition is not well-fitted to measurements of processes. That said, there is considerable potential for the process definition to inform and enable more effective assessments of creative production. In general, the underlying purpose of assessing creative production in creativity research is not to evaluate the products themselves, but to assess the creative performance/ability of individuals. Thus, introducing means of assaying the process that individuals use (the processes that yield the products) can enrich the assessment.

In standard versions of the AUT – likely the most widely used creativity measure – it is not possible for external evaluators to know the extent to which any particular response given by a participant was generated in that moment or whether it was wholly or largely retrieved from a previous experience or exposure (the assessors are simply observers of externally presented responses). This points again to the distinction between process and product. Creativity assessments generally operate on the assumption that this distinction can be ignored. Instead, efforts to assess the process behind the product could inform standard assessments of creativity. The work by Benedek and colleagues (Benedek et al., 2014, Benedek et al., 2018) that we have noted above shows how this can be accomplished in relatively simple ways. In addition to collecting alternative use responses on the AUT, these researchers directly queried participants as to whether their responses were recalled from prior experience or generated in the moment. Other studies have examined the so-called “serial order effect” in creative thinking tasks – an effect whereby ideas tend to become more original over the course of idea generation – finding that people typically begin by recalling common ideas from memory before eventually generating new ideas (Beaty, Kenett, Hass, & Schacter, 2022, Beaty & Silvia, 2012, Gilhooly, Fioratou, Anthony, & Wynn, 2007, Hass, 2017).

This kind of process-level assessment (generative vs. recalled) aligns with the generative criterion of the process definition, and has the potential to provide a valuable addition to traditional product-based metrics (e.g., as a weighting variable for originality scores in the AUT). Querying the extent to which a response was remembered (including in neuroimaging contexts) has been used to great effect in the memory literature (e.g., in “Remember/Know” paradigms; Dunn, 2004). Process-level assessments of creativity could plausibly be integrated as weighting variables in combination

with standard product-level assessments, or responses judged to result from processes that do not sufficiently meet the criteria of the process definition might simply not be scored. Ultimately, the novelty or usefulness of a product is only relevant to evaluating an individual's creativity, and can thus only be taken as construct-valid assessment criteria, if the product actually reflects a creative process. Assessment of generativity in the AUT and similar paradigms can be readily extended to include non-binary (e.g., Likert scale-based) self-ratings of generativity vs. recall involved in a producing responses. Evaluation of generativity can also likely be informed by considering the distinctness of responses from each other (e.g., if a person produces uses for multiple objects as food for various fictional characters, later response might be largely recalled from previous responses rather than newly generated). Indeed, provision of at least some insight into generativity vs. recall is one reason why it is considered preferable to have creative works evaluated by raters with a degree of expertise in the domain (i.e., Amabile, 1996, Kaufman & Baer, 2012). If a rater does not have sufficient knowledge and experience, then they may not recognize copied responses that are merely retrieval (such as copying a plot or image a participant may have seen and is remembering).

While assessment of generativity, as in the above examples, may prove particularly valuable, assessments of attentional deployment with respect to goal state constraints are also likely to afford insights. For example, differences in the deployment of broader or narrower attentional searches, or differences in the extent to which individuals tend to manipulate individual representations/concepts as opposed to seeking to integrate multiple representations, may be informative. In addition to behavioral indices, integrating neuroimaging of creative processes could further – and qualitatively – enrich the assessment of creative processes by investigating 1) the extent to which individuals exhibit characteristics of neural function that align with the defining characteristics of creativity as a process (as described above), and 2) differences in activity and connectivity associated with these characteristic neural operations across individuals, tasks, and contexts. Combining assessment of products with cognitive and brain-based assessment of process, within the structure of the definitional framework proposed here, has potential to advance longstanding efforts to identify particular features of creative processes that yield the most successful outcomes for particular individuals in particular contexts. Process-level insights also have substantial value to inform education and training with the goal of fostering effective creative processes.

Conclusions and recommendations

We propose a definition of creativity as a process, distinct from the “standard” product definition of creativity. This distinction derives from recognizing that the word, creativity, actually refers to fundamentally different constructs: the nominal construct of creativity as a process; and the adjectival/descriptive construct of creativity as an attribute (creative-ness). Aligning empirical evidence on the neurocognition of creativity with *a priori* considerations of creativity theory points to a process definition of creativity as internally-directed attention constrained by a generative goal. We propose that, if this definition is met, a process can be rightly considered *creativity* based on its intrinsic characteristics even if the product is not externally judged to be particularly *novel or useful*. Indeed, even if no product results from the process, the process itself can still be considered creativity if it meets these criteria.

Why does the definition matter? As a field, creativity research has long acknowledged that we need greater theoretical specificity in order to make more meaningful empirical advances. Indeed, this call for greater theoretical clarity has become a nearly ubiquitous refrain in our journals and at our conferences. As noted above, the SfNC Ontology Initiative, is an effort to address this need, including the development of the process definition proposed here. To the extent that creativity theory is currently unclear, clarifying the boundaries/distinctions of our theoretical understanding will necessarily require some revisions of common narratives regarding how we define creativity. As noted above, while it is important to study process, products, persons, contexts, etc., and while the word, creativity, can be used for each of these study targets, this does not mean that they should all be considered components of a single construct. If creativity is defined as so many things, then it is hard for those inside or outside of the field to move beyond the criticisms and confusions of theoretical muddling (e.g., attempting to define processes using terms that describe products). To make the meaning of creativity research clearer to those inside and outside the field, it is incumbent on creativity researchers to be as clear as possible in thinking and publishing about creativity. In order to be clear in communicating our research, and to identify points of conceptual overlap and distinctness between studies, we recommend that, when researchers use the word, creativity, they specify whether they are studying creativity as process or creativity as attribute. Indeed, researchers should classify the particular creativity-related construct they are

studying along as many dimensions as possible. Ideally, the field might develop a minimal set of classifications (e.g., as required keywords or as an “ontology statement”) that can provide greater taxonomic clarity across published works.

As we have described above, the process definition provides a framework for interpreting the findings of cognitive and brain-based creativity research (for which the data are inherently about process), for unifying process models of creativity, for taxonomic organization of creativity-related constructs and phenomena, and for assessing the creativity of processes, tasks, and individuals (by distinguishing definitional criteria for creative processes from definitional criteria for creative products). The process definition also provides a means by which current approaches for assessing products can be enriched by considering the extent to which those products are truly the result of a creative processes. In each of these ways, the process definition helps to address gaps or confusion at the theory level that have hindered advancement in creativity research. Regarding assessment in particular, it is our recommendation that, whenever possible, researchers who are collecting data on product-based assessments also collect at least one measure of process. This might be as simple as asking participants whether (or to what extent) their responses were generated or recalled (as demonstrated by Benedek et al., 2014, Benedek, 2018), or as extensive as including think-aloud data collection (Boldt, 2019) or gamified paradigms designed to track process-level variables (Rafner et al., 2022). Assaying the creativity of the process would substantially bolster the construct validity of creativity research.

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