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An integrative approach

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Distinct neurocognitive pathways underlying creativity: An integrative approach

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Abstract

By examining the shared neuro-cognitive correlates of curiosity and creativity, we better understand the brain basis of creativity. However, by only examining shared components, important neuro-cognitive correlates are overlooked. Here, we argue that any comprehensive brain model of creativity should consider multiple cognitive processes and, alongside the interplay between brain networks, also the neurochemistry and neural oscillations that underly creativity.

By integrating research on the shared cognitive and neural correlates of curiosity and creativity, Ivancovsky, Baror, and Bar offer insight into the brain origins of creativity. Yet, by only examining their shared components, important cognitive processes and brain correlates of creativity are overlooked. We argue here that true understanding of the brain basis of creativity should, alongside the interplay among brain networks, include multiple cognitive pathways to creativity and their underlying neurochemistry and neural oscillations.

Regarding cognitive pathways to creativity, there is robust evidence that creativity is a function of multiple independent cognitive processes (e.g., Benedek & Fink, 2019; Mumford, Reiter-Palmon, & Redmond, 1994; Nijstad, De Dreu, Rietzschel, & Baas, 2010; Zhang, Sjoerd, & Hommel, 2020). For example, original ideas emerge when someone flexibly explores and combines remote material from memory or the environment. This flexibility pathway to creative ideation involves using and switching between broad and inclusive cognitive categories, divergent thinking, and combining remote (rather than close) associations. However, equally original ideas can emerge when someone systematically explores a semantic category in depth. This persistence pathway to creative ideation results in original ideas only after more readily available ideas within a semantic category have been examined and discarded (Nijstad et al., 2010; Ward, 1994). The persistence pathway involves generating a large number of ideas within few semantic categories, and an incremental and systematic idea search, where original ideas emerge later in the process (De Dreu, Baas, & Nijstad, 2008).

That equally creative ideas can result from distinct cognitive processes matters because many individual differences and psychological states can be linked to creativity through one of these processes. Indeed, the flexibility pathway associates with curiosity, openness to experience, and novelty seeking (Gocłowska, Ritter, Elliot, & Baas, 2019; Ivancovsky et al.), but also with a happy mood (De Dreu et al., 2008), a focus on obtaining desirable outcomes (Baas, De Dreu, & Nijstad, 2011), and (trait) mindfulness (Baas, Nevicka, & Ten Velden, 2014; Lebuda, Zabelina, & Karwowski, 2016). Persistence, in contrast, links to working memory capacity (De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012), negative affective states like anxiety and anger (De Dreu et al., 2008) and threatening circumstances (Baas et al., 2011, 2019; Perchtold-Stefan, Papousek, Rominger, & Fink, 2022). This explains why curiosity for intense negative information (morbid curiosity) does not necessarily result in a large variety of creative ideas, but may specifically trigger novel ideas aimed at damaging others (Perchtold-Stefan et al., 2022). More generally, these findings question how the Novelty-seeking Model captures these different cognitive processes and morbid curiosity effects.

Like the Novelty-seeking Model, flexibility and persistence involve a complex interplay between brain networks, including the default mode network and the dopamine-innervated fronto-striatal circuitry (Beversdorf, 2019; Boot, Baas, van Gaal, Cools, & De Dreu, 2017a; De Dreu et al., 2014, 2024; Zhang et al., 2020). For instance, cognitive flexibility involves the default mode network and neural activity in the striatum, a brain region involved in reward processing, updating of goal representations, and shifting task strategies (Boot et al., 2017a; Gvirts et al., 2017; Kehagia, Murray, & Robbins, 2010). Cognitive persistence relies more on neural activity in the (dorsolateral and orbitofrontal) prefrontal cortex (Kane & Engle, 2002). This explains how differential neurochemical processes, including surges in dopamine, oxytocin, and norepinephrine may differentially affect cognitive flexibility and persistence, ultimately feeding into creative thinking and doing (Beversdorf, 2019; De Dreu, Nijstad, & Baas, 2024). These insights further provide a basis to understand the link between psychopathologies and creativity (Baas, Boot, Nijstad, & De Dreu, 2016), and to conceptualize how flexibility and persistence can be balanced in the brain to avoid distractibility and bizarre ideas on the one hand (too much flexibility) or rigidity on the other (too much persistence) (Boot et al., 2017a).

One promising avenue for understanding the brain basis of curiosity and creativity that is ignored in the Novelty-seeking Model is the role of neural oscillations that are captured by EEG. Compared to MRI, EEG delivers superior time-resolution to capture the fast neural events involved in creativity (e.g., insight; Kounios & Beeman, 2009). Numerous EEG studies have identified local and global alpha power as a robust correlate of creativity (Fink & Benedek, 2014; Perchtold-Stefan et al., 2022, 2023). Task-related changes in alpha power distinguish less and more creatively demanding tasks, less and more creative people, lower and higher creative performance, and less and more creative ideas within-person (Fink & Benedek, 2014; Stevens & Zabelina, 2019). Notably, creativity-related alpha increases reveal topographically distinct insights into the complexity of cognitive processes in creative ideation: Increases at frontal cortical sites have been linked to executive functioning, increases at (right) temporal sites to the connection of remote associations, and increases at (right) parietal sites to internally directed attention (Perchtold-Stefan, Rominger, Papousek, & Fink, 2023). These oscillatory alpha patterns of creativity are remarkably similar for different life domains, including playing soccer, creative emotion regulation, and musical improvisation (Fink & Benedek, 2019; Perchtold-Stefan et al., 2022). Also, neurostimulation of alpha power has yielded selective improvements in creativity, and trainings to boost creativity have simultaneously increased alpha power in the brain (Perchtold-Stefan et al., 2022; Stevens & Zabelina, 2019). Other EEG frequency bands were shown to modulate creativity as well (for delta, see Boot, Baas, Mulhfeld, De Dreu, & Van Gaal, 2017b), and interestingly, studies have also documented links of alpha/beta oscillations with curiosity and novelty seeking (Alicart, Cucurell, & Marco-Pallares, 2020; Käckenmester, Kroencke, & Wacker, 2018). In sum, including neural oscillations has tremendous potential for illuminating the complex and transient processes of creativity to reveal insights into the (neural) link between creativity and curiosity.

To conclude, understanding the shared neural basis for curiosity and creativity requires a good grasp of the neurobiology of each. Here, we focused on emerging work on the neurocognitive basis of creativity. We showed that multiple distinct neurobiological systems and cognitive processes operate that support creative outcomes, some of which may be at odds with curiosity. The same may be true for (morbid) curiosity. Regardless, it has become apparent that only a combination of (insights from) different neuroscience methods will ultimately reveal how creativity works in the brain.

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