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# A bio-psycho-behavioral model of creativity

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In this article, a model of creativity is proposed that seeks to integrate concepts and findings from different lines of creativity research. The model aims to provide an understanding of interindividual differences in real-life creative behavior by considering central psychological constructs, their mutual relationships, and their respective neurobiological bases. It is argued that openness to experience, cognitive creative potential (divergent thinking ability), and intelligence constitute core variables relevant to real-life creativity across domains. Interindividual differences in these variables are thought to arise from variation in the dopaminergic system, the default mode, and the executive control network. The model may guide future research in that it provides an integrative framework for the study of human creativity at multiple levels of analysis.

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## A bio-psycho-behavioral model of creativity

Creativity and creative individuals are of inherent fascination. Each of us has a unique and personal understanding of what they might consider creative, and so we all come up with different concepts when asked 'what do you associate with *creativity*?'. These associations range from adjectives referring to ideas or products (such as 'original' or 'innovative') to characteristics of people's personality ('open-minded', 'spontaneous'), intellectual ability ('clever', 'gifted'), or motivation ('enthusiastic'). Also, associations to creativity encompass traits that point to mental disorder ('schizotypal') or spontaneous thought ('being kissed by the muse'). All of these concepts have been subject to the empirical study of creativity, an all of them can be related to some aspect of the complex phenomenon.

In this article, a model is proposed that seeks to integrate concepts and findings from different fields of creativity research. Building upon prior work on the prediction of real-life creative behavior across various domains of creative endeavor [1], the model presented here extends this work to three levels of analysis: (I) neurobiological systems that are thought to underlie (II) individual differences in creativity-related psychological personality and ability dimensions, and lastly (III) real-life creative behavior (see Figure 1). The hierarchical structure indicates that variables at higher levels build upon those on lower levels.

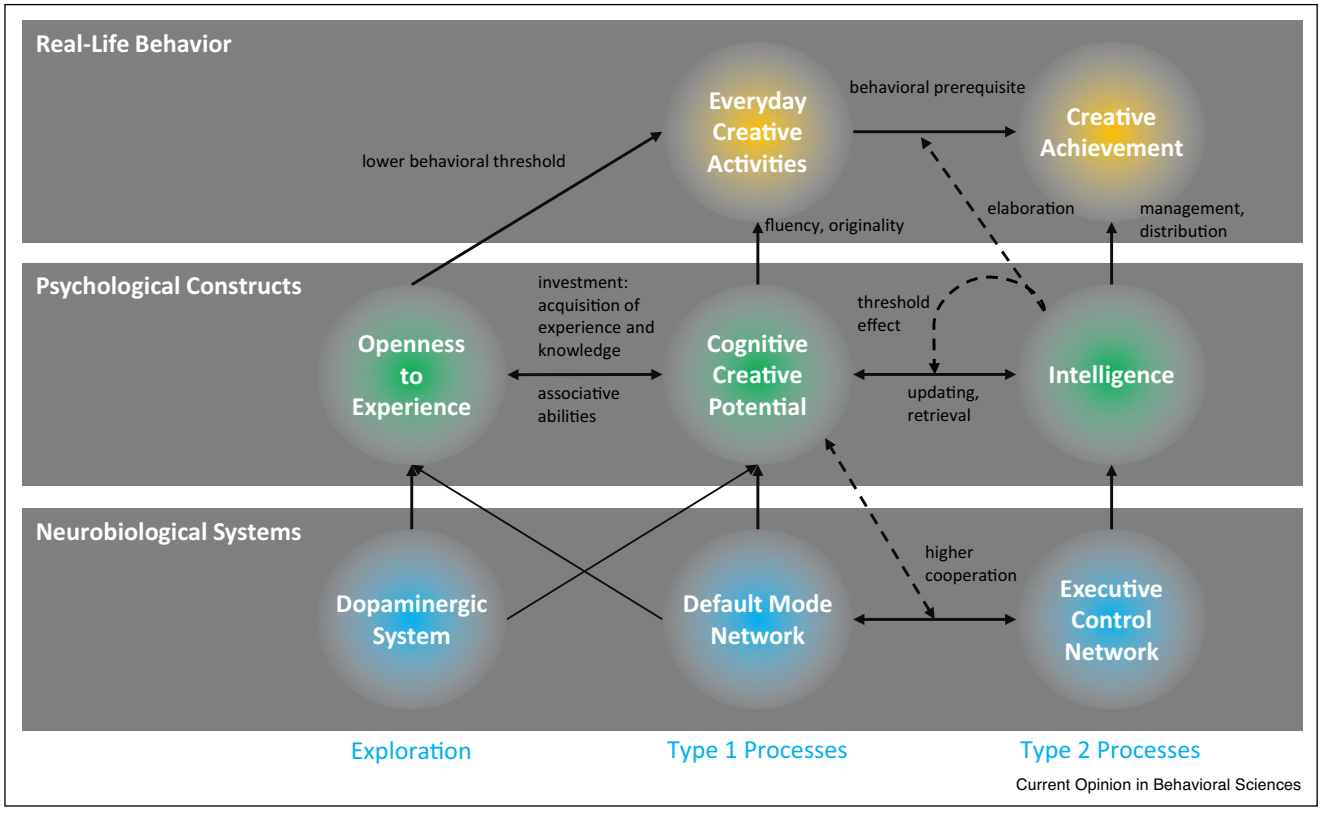
The overall aim of the model is to provide a framework for understanding interindividual differences in real-life creative behavior (top level). To this end, everyday creative activities are distinguished from socially acknowledged creative achievement [2••]. In light of the many domains of creative endeavor [3], the model adopts a *domain-general* view, which means that domain-specific factors are not highlighted. In the following, I will present evidence from studies that address individual differences on at least one of the levels included in the model. I will start with the middle level of psychological constructs, turn the discussion of their respective neurobiological systems, and finally to an integrative discussion of real-life creative behavior.

## Psychological constructs

### Personality constructs: openness to experience

At the level of psychological constructs, personality and ability predictors of creative behavior can generally be distinguished. Arguably, the one personality trait that is most consistently associated with different indicators of creativity is openness to experience [4, for second order meta-analysis, see 5]. Open people characterize themselves as curious and imaginative, which intuitively appears as a good basis for creativity. But which are the mechanisms by which openness fosters creativity? There are at least two possible pathways: First, openness is thought to *lower the behavioral threshold* for the engagement in creative everyday activities [6]. This effect is proposed to relate to exploration behavior driven by dopaminergic activity (see below). Second, openness fosters the acquisition of experience and knowledge (crystallized intelligence) over time [7]. This makes openness an *investment trait* for creativity [8]. Open people not only possess a rich basis of knowledge, but also have a more interconnected semantic memory structure [9], on the basis of which cognitive creative potential (in terms of divergent thinking ability; see below) can operate to produce novel ideas [10,11]. These two pathways may explain the effect of openness on the exertion of creative

**Figure 1**




Bio-psycho-behavioral model of creativity. Solid lines indicate causal and correlational effects; dashed lines indicate moderator effects.

activities and the association between openness and cognitive creative potential.

Current models of openness differentiate two or three aspects between the overall openness factor and its facets [12•,13]. The openness aspect (cognitive engagement with perception, fantasy, aesthetics, and emotion) is more closely related to creative accomplishments in the arts, whereas the intellect aspect (cognitive engagement with abstract and semantic information) is more related to creativity in the sciences [14•]. The third recently proposed aspect, open-mindedness (nontraditionalism, variety-seeking, diversity [12•]) has not yet been studied in relation to creativity in its present form. It might be hypothesized that this aspect is a domain-general promoter of creativity, as it was for instance found that multicultural experiences enhance creative cognition [15]. Within the model proposed here, open-mindedness might be most closely associated with lowering the behavioral threshold for creative activities.

### Ability constructs: cognitive creative potential and intelligence

At the heart of individual differences in creativity stands cognitive creative potential in terms of divergent thinking ability, the ability to produce novel and useful ideas [16]. Cognitive creative potential predicts real-life creative activity, and indirectly (via creative activity) also creative achievement [1]. Among cognitive creative potential, qualitative (ideational originality) and quantitative (ideational fluency) indicators of cognitive creative potential can be discerned. Ideational originality is closely tied to intelligence (with latent correlations around 0.5; for an overview see [17]), while fluency is not [18]. The shared variance among intelligence and ideational originality is substantially due to executive functioning, particularly updating ability [19]. Also, retrieval ability is related to both, ideational originality and intelligence, which supports the executive account of cognitive creative potential [20].

Though general intelligence is highly related to qualitative indicators of cognitive creative potential, there is robust evidence showing that the relationship is nonlinear in the way that a certain level of intelligence forms a necessary but not sufficient condition for ideational originality (known as the *threshold hypothesis* [21,22,23•]). This means that as soon as an above-average IQ threshold is reached, cognitive creative potential is no longer dependent upon intelligence. An intriguing question for future