

Thinking too much: self-generated thought as the engine of neuroticism

Adam M. Perkins¹, Danilo Arnone¹, Jonathan Smallwood², and Dean Mobbs³

¹Department of Psychological Medicine, King's College London, London, SE5 8AZ, UK

²Department of Psychology/York Neuroimaging Centre, University of York, Heslington, York, YO10 5DD, UK

³Department of Psychology, Columbia University, New York, NY 10027, USA

Neuroticism is a dimension of personality that captures trait individual differences in the tendency to experience negative thoughts and feelings. Established theories explain neuroticism in terms of threat sensitivity, but have limited heuristic value since they cannot account for features of neuroticism that are unrelated to threat, such as creativity and negative psychological states experienced in benign, threat-free environments. We address this issue by proposing that neuroticism stems from trait individual differences in activity in brain circuits that govern the nature of self-generated thought (SGT). We argue our theory explains not only the association of neuroticism with threat sensitivity but also the prominence within the neurotic mind of representations of information that are unrelated to the way the world is right now, such as creativity and nonsituational 'angst'.

The challenge of explaining neuroticism

The personality dimension of neuroticism captures trait individual differences in proneness to negative psychological states of all types. High scorers on neuroticism are especially vulnerable to psychiatric illness and also tend to perform poorly in dangerous jobs, yet are typically more creative than average individuals. Despite its important effects on the human experience, currently we lack a mechanistic neurocognitive account that can explain both the costs and benefits of high scores on neuroticism.

In this opinion article, we propose that the cost and benefits of neuroticism are surface manifestations of a tendency to engage in negatively hued SGT [1]. SGT reflects the capacity for cognition to represent information without an obvious link to the current environment, such as those thoughts that occur during mind wandering or daydreaming. However, these SGT processes are not wholly fanciful, but instead are typically based on prior experience and are especially important in contexts where episodic memory and/or semantic knowledge are needed to make sense of the world. Therefore, the process of self-generation can be conceptualised as a mechanism that allows a stimulus to convey a meaning that goes beyond that prescribed by its veridical features. Viewed from an

individual differences perspective, the capacity to think beyond the current situation explains the vulnerability that neurotic individuals have for negative thoughts and feelings of an apparently abstract nature. Furthermore, we now have evidence as to where SGTs come from, since neuroimaging research has identified that the same brain network (the default mode network) is implicated in the episodic memory and semantic processing that occurs during states of spontaneous thought. The simplest and most elegant explanation is therefore that we use the same process to perform all of these different mental computations and that the tendency to apply these particular brain systems to generate negative thoughts and feelings will be reflected in high scores on measures of neuroticism.

Viewed as a whole, these analyses provide a plausible mechanistic account for the fact that neurotic individuals often experience negative affect even when their environment is benign. Moreover, since SGT is also linked to beneficial outcomes, such as creativity and a patient, long-term style of decision-making, it entails a similar mix of costs and benefits to the neurotic personality profile. Finally, both neuroticism and SGT have been linked to changes in activity in the medial prefrontal cortex, including those examples of SGT that are accompanied by a negative ruminative emotional tone. Altogether, these similarities suggest to us that individual differences in proneness to particular elements of SGT are the root cause (the 'engine') of neuroticism.

What is neuroticism?

Neuroticism indexes individual differences in proneness to negative thoughts and emotions of all types [2]. It is reliably measured by self-report questionnaires and features in all major descriptive models of personality [3–6]. Neuroticism significantly increases susceptibility to psychiatric illness [7–11] and also modulates risk-related behaviour. For example, high scorers on neuroticism take fewer risks when making investments, an effect that is genetically based [12]. Likewise, neuroticism affects performance in occupations that entail physical danger: low scores on neuroticism are associated with superior performance among bomb-disposal operatives [13]. Similarly, volunteers for military pilot training on average score significantly lower on neuroticism than the general public and those trainees that graduate typically score even lower on neuroticism than their already low-scoring

Corresponding author: Perkins, A.M. (adam.perkins@kcl.ac.uk).

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peers who fail training [14]. This association appears to stem from the more dangerous nature of military aviation rather than the psychomotor demands of flying aircraft *per se*, because amateur civilian pilots score close to the population average on neuroticism [15]. Other personality constructs also influence performance in military aviation, especially extraversion [15], but recent meta-analytic research comparing the incremental effect of different personality constructs on military aviation success shows that neuroticism exerts the strongest influence [16].

Given that high scorers on neuroticism have difficulty coping with dangerous jobs, it might seem reasonable to explain neuroticism as stemming from a magnified perception of threat; indeed, this hypothesis is a leading causal explanation for neuroticism [17]. However, high scorers on neuroticism are not only highly sensitive to threat but also prone to experiencing negative psychological states in the absence of a current threat stimulus, as demonstrated by the content of neuroticism items in the well-established Eysenck Personality Questionnaire (e.g., ‘Do you ever feel ‘just miserable’ for no reason?’; ‘Are you often troubled about feelings of guilt?’; ‘Do you worry about awful things that might happen?’; ‘Have you ever wished that you were dead?’; ‘Do you worry too long after an embarrassing experience?’) [2]. The content of these items suggests that a cardinal aspect of neuroticism is the tendency to self-generate negative affect, a tendency that casts doubt upon theories that explain neuroticism wholly in terms of threat sensitivity, because these theories can only explain a heightened response to a threat stimulus that is currently present. Instead, our SGT-based theory of neuroticism has the advantage of encompassing threat sensitivity, since it is plausible that a tendency to self-generate negative affect would be a distraction when attempting to defuse a bomb, yet it also explains the proclivity for rumination and abstract ‘angst’ in threat-free situations that is such a prominent feature of the neurotic mind.

Links between neuroticism and creativity

If it is true that the root cause of neuroticism lies in the tendency to self-generate negatively hued thoughts and feelings, then it is plausible that high scorers on neuroticism should, on average, be more creative problem-solvers than low scorers, because they will tend to dwell on problems to a greater degree than low scorers. This is an important point because a key feature of creative thought is the ability to generate solutions to problems that are distinct from the traditional way the problem is solved [18]. This hypothesis is supported by the stereotype of the brooding, tortured, genius, as well as a variety of empirical evidence. For example, depressive states may facilitate the analysis of complex problems [19]. Additionally, there is evidence that high scorers on neuroticism tend to be more creative than low scorers: a study of 257 professional painters and sculptors living in Germany found that the male artists were significantly more neurotic than the male nonartists [20]. Similarly, individuals working in creative roles in the advertising industry tend to score significantly higher on neuroticism than employees in noncreative roles [21].

These associations between neuroticism and creativity are backed up by epidemiological research showing that

creative professionals have a higher than average risk of both psychiatric illness and suicide [22]. Viewed as a whole, these findings are consistent with the notion that a hyperactive imagination is the root cause of neuroticism, but they do not demonstrate that this is the case.

A clue as to the solution of this problem can be found in the words of Isaac Newton, who viewed his creativity as a product of intense, prolonged rumination: ‘I keep the subject constantly before me, and wait till the first dawns open slowly, by little and little, into a full and clear light.’ [23]. Newton also exhibited signs of being highly neurotic, such as brooding over past mistakes and worrying obsessively about scientific precedence, all of which culminated in a nervous breakdown during the summer and autumn of 1693 [24]. This breakdown could have been a coincidence but, viewed in the light of studies linking neuroticism and creativity, it seems more plausible that the proclivity for prolonged, self-generated rumination that underpinned Newton’s creativity was also responsible for his neurotic symptoms and, ultimately, the collapse of his mental health. In line with this notion, experimental findings show that associations between neuroticism and creativity stem from the problem-solving benefits of rumination-related processes, such as worrying. For example, experimentally induced worry increased creativity in high scorers on neuroticism [25].

Towards a mechanistic explanation for neuroticism

The two features of the neurotic brain (affective states that are independent of the environment and novel and original solutions to abstract problems) can both be simply accounted for by a mechanism that allows thoughts and feelings to represent states that are unrelated to immediate sensory input, a phenomenon known as SGT (Box 1) [18]. SGT is common across cultures [18] and is fundamentally prospective in orientation [26]. It has been argued that SGT is adaptive because it allows individuals the

Box 1. SGT

The content of consciousness does not always directly reflect the events taking place in the immediate environment. Building on work showing that episodic and semantic knowledge is a constructive process, it is hypothesised that states such as mind-wandering or daydreaming are consequences of a similar mechanism(s) that allows us to represent thoughts and feelings that are not present in the immediate environment. One term that captures both the independence of these experiences from the events in the environment as well as their active representational nature, is SGT [1].

- SGT refers to the nature of the process through which an experience is produced; it does not refer to whether an experience is related to an ongoing task. Certain tasks, such as reading, require an individual to elaborate on stimulus input. For example, when reading a detective novel, it is necessary to use a model of the narrative to make inferences about who committed a crime [45]. The extent to which an experience is related to a task depends on whether the process of self-generation is coupled or decoupled from task-relevant events in the environment.

- SGTs do not imply that an experience is intentional. Self-generation is a process that describes how conscious experiences represent information we can not see and/or results from an intrinsic stimulus. It does not describe whether the experiences are intentional. In the same way that a dishwasher can be programmed to initiate a self-cleaning routine without prescribing intention, SGT can be both deliberate and nondeliberate [46].

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