Psychological Medicine

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Cite this article: Savulich G, Ferry-Bolder E, Lim TV, Mak E, Ersche KD (2023). The 'Resilient Brain': challenging key characteristics associated with the concept of resilience. *Psychological Medicine* **53**, 6933–6936. https://doi.org/10.1017/S0033291722003907

Received: 14 July 2022
Revised: 24 November 2022
Accepted: 9 December 2022
First published online: 25 January 2023

Keywords:
brain reserve; coping; corpus callosum; emotion regulation; MRI; self-control; self-efficacy

Author for correspondence:
Karen D. Ersche, E-mail: ke220@cam.ac.uk

The 'Resilient Brain': challenging key characteristics associated with the concept of resilience

George Savulich[1], Eve Ferry-Bolder[1], Tsen Vei Lim[1], Elijah Mak[1] and Karen D. Ersche[1,2,3]

[1]Department of Psychiatry, University of Cambridge, Cambridge, UK; [2]Department of Systems Neuroscience, University Medical Centre Hamburg-Eppendorf, Hamburg, Germany and [3]Department of Addictive Behaviour and Addiction Medicine, Central Institute of Mental Health, University of Heidelberg, Mannheim, Germany

Correspondence

Resilience is a psychological construct broadly defined as positive adaptation in response to adversity (Fletcher & Sarkar, 2013). Resilient people do not despair or distract themselves from difficulties, but instead face them head-on. What makes some individuals more resilient than others is thought to rely on psychological mechanisms such as abilities to cognitively and emotionally cope with negative emotions. The corpus callosum provides interhemispheric connections, specifically to cognitive pathways, which allow for faster processing and reflection and has been identified as a key neural substrate of resilience (Edwards, Sherr, Barkovich, & Richards, 2014; Etkin, Egner, & Kalisch, 2011). Galinowski et al. (2015) have shown greater anatomical connectivity within the anterior body of the corpus callosum in resilient adolescents with high exposure to lifetime stress compared with non-resilient adolescents exposed to the same level of stress and healthy control adolescents from the same community. Converging neuroimaging evidence has further shown reduced volume of the corpus callosum in stress-related and major psychiatric disorders such as depression and treatment-resistant schizophrenia (Sun, Maller, Daskalakis, Furtado, & Fitzgerald, 2009). These studies highlight an association between resilience and structural integrity of the corpus callosum, with particular emphasis on the cognitive resources it subserves (Galinowski et al., 2015). Other characteristics typically used in the conceptualization of resilience are extraversion, openness to experience, self-efficacy and agreeability (Fletcher & Sarkar, 2013; Galinowski et al., 2015). However, protective factors are largely built on the assumption that resilient individuals actively work through the problems they face (Luthar, 2006; Luthar & Cicchetti, 2000; Luthar, Cicchetti, & Becker, 2000). Here, we call into question this widely held assertion by presenting a case of a fully functioning middle-aged man, T.C., who is not only unaware of his congenital absence of the corpus callosum, but also refutes key traits that are commonly associated with the concept of resilience.

When enrolled to a neuroimaging study, T.C. showed characteristics typical of a healthy volunteer. He was well-educated and had a normal IQ, stable employment, no childhood adversity and good mental and physical health (online Supplementary Table S1). However, structural magnetic resonance imaging of his brain revealed total agenesis of the corpus callosum (AgCC), a rare birth defect, characterized by a partial or complete absence of the bundle of fibres that connects both cerebral hemispheres (Fig. 1a, b). Less than seven in 1000 people are thought to be affected by this condition, most of whom are diagnosed early in life due to experiences of severe developmental disabilities, seizure disorders, cognitive deficits and social difficulties despite otherwise normal intelligence (Paul et al., 2007; Siffredi et al., 2018). Nonetheless, T.C. remained asymptomatic and was leading, by several measures, a healthy and successful life.

T.C.'s case is remarkable, particularly when considering his cognitive and emotional profile with respect to the AgCC and malformation of the basal ganglia and other grey matter structures (Fig. 1a, b). T.C.'s performance on working memory and attentional-set shifting tasks fell within normal range (online Supplementary Table S1), but his self-control, as indexed by the Stop-Signal Reaction Time (SSRT) during stop-signal task performance, was above the average of his 55 healthy peers participating in the same study (Fig. 1c). Given that the ability to suppress unwanted or inappropriate thoughts and actions is critical for adaptive behaviour (Verbruggen et al., 2019), good self-control may be one higher-order executive function that is particularly important for helping vulnerable individuals overcome their difficulties. For example, trauma-exposed individuals who successfully control their negative memories by over-activating top-down inhibitory control networks do not develop post-traumatic stress disorder (Mary et al., 2020). Likewise, at-risk individuals, who despite a family history of drug addiction do not succumb to addiction themselves, also over-activate the prefrontal inhibitory network when controlling their thoughts and behaviour (Ersche et al., 2020; Morein-Zamir,

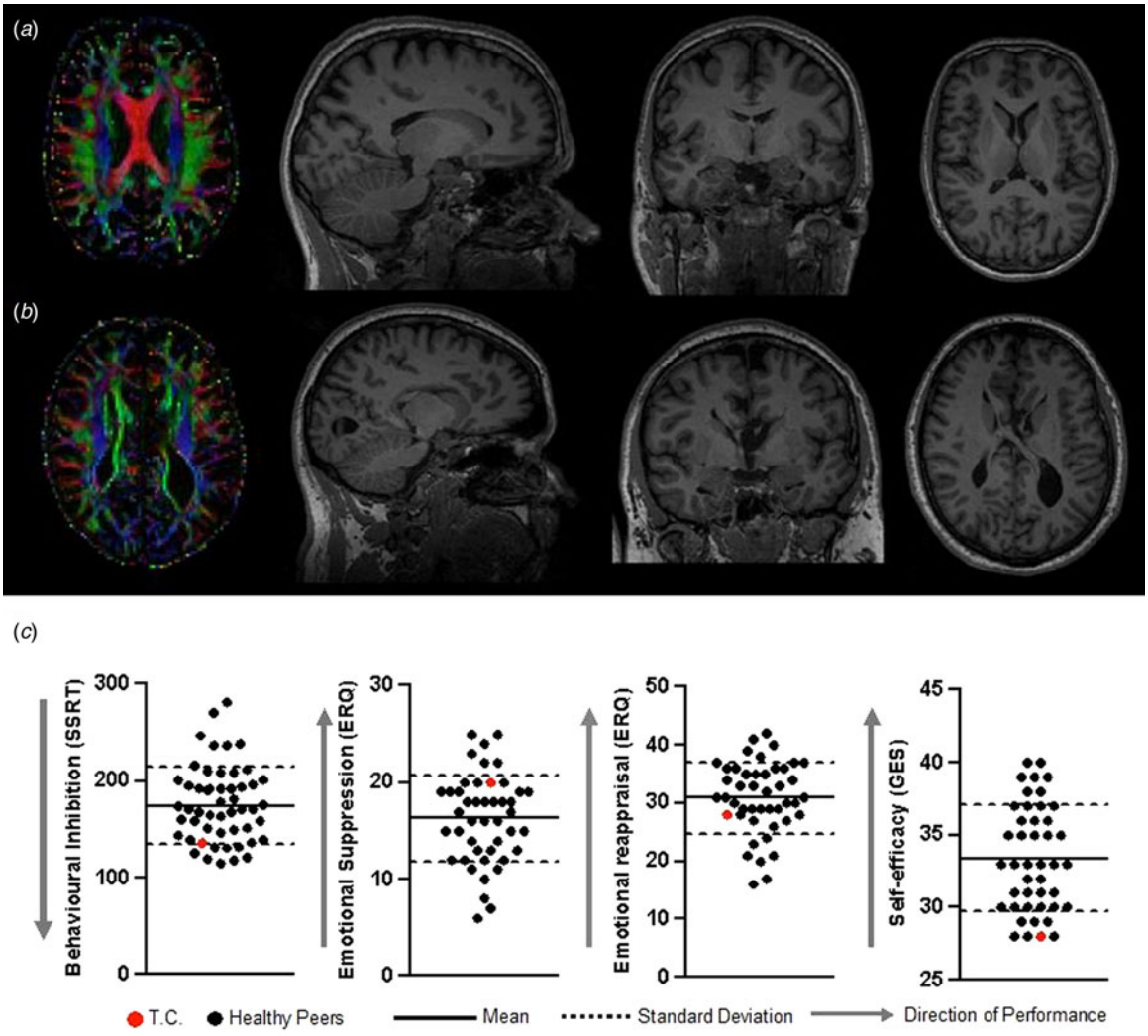

Fig. 1. (a) White matter structure of the healthy brain of a 44-year-old man showing the corpus callosum (red) connecting both hemispheres, and the related grey matter structure of the same brain in sagittal, coronal, and transaxial planes. (b) White matter structure of T.C.'s brain, who is also 44 years old, which shows the absence of the corpus callosum and malformations of grey matter structure. (c) Charts showing responses of 55 healthy control volunteers (black dots) and T.C. (red dot) on self-report scales measuring behavioural inhibition, emotion regulation (i.e. emotional suppression and reappraisal) and self-efficacy.

Simon Jones, Bullmore, Robbins, & Ersche, 2013; Smith, Jones, Bullmore, Robbins, & Ersche, 2013). These studies suggest that executive top-down control is a critical ingredient for resilience, rather than efficient cognitive and emotional processing abilities, which have been previously linked to the corpus callosum.

Interestingly, T.C.'s self-control not only manifested behaviourally during stop-signal task performance, but also on responses to questionnaire measures indicating relatively high levels of anger, perfectionism and obsessive-compulsive traits. He often became angry with himself, self-blamed for mistakes and suppressed rather than reappraised negative emotions (Fig. 1c). These attributes are largely not in keeping with those previously reported in resilient individuals (Galinowski et al., 2015). To our surprise, T.C. reported below average levels of self-efficacy and sense of coherence, which are widely regarded to enable individuals to 'bounce back' or recover from stress. By contrast, his superior self-control may instead confer resilience through increased top-down control of the prefrontal cortex in the absence or abnormal transmission of bi-hemispheric cortical projections from the corpus callosum, which might also prevent the prefrontal-limbic pathway from getting over-activated during high levels of arousal. It is thus conceivable that he has acquired other coping skills or possesses less favourable personality traits at subclinical levels, which may facilitate 'bouncing back' more adaptively in the context of adversity (e.g. using anger for motivation to do better next time). It is worth noting that T.C.'s stable family environment, social support network, degree-level education, employment/socioeconomic status and lack of mental health problems are among several protective factors that may have supported his good cognitive functioning and wellbeing.

The neurobiological and psychosocial underpinnings of resilience and their interactions with environmental factors remain poorly understood (Malhi, Das, Bell, Mattingly, & Mannie, 2019). The case of T.C. further supports recent studies highlighting the role of top-down inhibitory control in resilient individuals (e.g. Ersche et al., 2012, 2020). This does not, however, rule out the potential moderating role of other psychological and personality factors not measured in the present study (e.g. early adaptive

https://doi.org/10.1017/S0033291722003907 Published online by Cambridge University Press

schemas, defence mechanisms and locus of control). Clearly, good self-control is likely to foster positive outcomes, but psychological constructs of resilience do *not* typically include self-control in its conceptualization, instead emphasizing that awareness of adversity is essential for positive adaptation. Early adverse experiences such as poverty and childhood trauma are environmental stressors associated with greater risk of psychopathology (McLaughlin, Sheridan, & Lambert, 2014). But what about those individuals who demonstrate resilience *without* knowledge of their condition or prior experience of an external stressor? As T.C. was completely unaware of his disability, his superior self-control would not be recognized as a source of resilience. We speculate that such explicit awareness is not integral to the concept of resilience and that recruitment of compensatory brain mechanisms may increase self-control, even in individuals not reporting high levels of self-efficacy or other traits commonly associated with resilience. By restricting positive adaptation to awareness of one's adversity, then the ability to cope with psychological stress or hardship excludes unknown physiological conditions including abnormalities in brain structure, function or connectivity. It also excludes those individuals who do not know the root of their problems (e.g. where adversity has been normalized) or cannot remember a previous stressful or traumatic event. Current questionnaire measures of resilience may thus not fully capture its multidimensions and instead attempt to identify personal characteristics or coping styles that have been associated with successful adaption to adverse experiences rather than the quality of resilience itself. Greater consideration should therefore be given to individual differences in response to adversity depending on its type, timing, intensity and duration, as these can differently affect the stress-response system (Malhi et al., 2019). Furthermore, traits which are rarely identified as protective and usually pathologized, such as anger and perfectionism, may in fact enable some people to succeed.

Inhibitory control impairments have been well-documented in several psychiatric disorders including drug addiction, attention-deficit hyperactivity disorder and obsessive-compulsive disorder (Ersche, 2020). Although the case of T.C. exemplifies the potential relationship between self-control and resilience, a systematic review of the available empirical evidence is still warranted. In the absence of psychopathology, emotion regulation strategies, which are typically viewed as maladaptive (e.g. self-blame; emotional suppression; obsessive-compulsive traits), may reflect more extreme levels of inhibitory control, which in turn serve as coping mechanisms for adaptive behaviour. Future studies may want to investigate inhibitory control in the context of negative emotions and heightened sensitivity to stress to elucidate mechanisms by which some individuals demonstrate resilience despite seemingly negative attributes (i.e. below average level of self-efficacy in the presence of strong self-control). The ability to stop a prepotent response once initiated may be another executive function that is enhanced, rather than impaired, by adversity (Malhi et al., 2019). A broader framework of resilience is therefore required, which does not restrict its definition to exposure to a known stressor and takes into account alternative pathways to positive adaptation. Incorporating self-control in the conceptualization of resilience could inform novel strategies for more targeted interventions and prevent poor mental health outcomes in at-risk individuals. How cognitive, psychosocial, environmental and epigenetic components of resilience are influenced by neurobiological mechanisms remains a key avenue of research (Eaton, Cornwell, Hamilton-Giachritsis, & Fairchild, 2022; Malhi et al., 2019). Clarifying the relationship between self-control and resilience would thus help us better understand those individuals still demonstrating resilience even in direct contrast with what the current framework predicts.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291722003907

Acknowledgements. We thank all of our volunteers for their contribution to the present study and our colleagues at the Wolfson Brain Imaging Centre for their support. We also thank Rachel Lee for presenting this case at the 34th European College of Neuropsychopharmacology in Lisbon (Portugal) in October 2021.

Financial support. The study was funded by a grant from the Medical Research Council (MR/J012084/1) and financially supported by the NIHR Cambridge Biomedical Research Centre. T. V. L. was a recipient of the Angharad Dodds John Bursary in Mental Health and Neuropsychiatry. E. M. was supported by an Alzheimer's Society Junior Research Fellowship (443 AS JF 18017). K. D. E. is the recipient of an Alexander von Humboldt Senior Fellowship (Grant No. GBR 1202805 HFST-E) and receives editorial honoraria from Karger Publisher.

Conflict of Interest. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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