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***The link between anxiety and cognitive performance: What we know a decade on***

*Elizabeth J. Edwards & Mark S. Edwards (York St John University)*

A decade ago, Eysenck and colleagues (2007) proposed attentional control theory (ACT) as a framework to explain the relationship between individual differences in anxiety (i.e., trait anxiety and situational or state anxiety) and cognitive performance (i.e., effectiveness or accuracy, and efficiency or the ratio of accuracy to RT). Since then, ACT has gained momentum in its ability to explain the allocation of cognitive resources in the presence of threat (whether the threat is external e.g., a stressful situation or threat-related stimuli, or internal e.g., worrisome thoughts). The theory suggests that highly anxious individuals preferentially direct their attention to task-irrelevant, worrisome thoughts, resulting in poor performance on cognitive tasks. Specifically, ACT proposes that anxiety (the multiplicative result of trait anxiety and situational stress) is more likely to impair processing efficiency, rather than performance effectiveness, on tasks involving the shifting, inhibition and updating functions of the central executive (Miyake et al., 2000). There is now a growing body of work supporting ACT.

Our research has focussed on exploring the characteristics that moderate the anxiety-cognition link. We tested the hypothetical assumptions of the later iterations of ACT (Derakshan & Eysenck, 2009; Eysenck & Derakshan, 2011), namely, that high-anxious individuals recruit additional resources in the form of mental effort and/or motivation to prevent performance shortfalls. We ran a series of quasi-experiments measuring trait anxiety and mental effort, and manipulating situational stress using ego-threat instructions. In one study using a shifting task that required individuals to switch back and forth between changing task requirements (i.e., Wisconsin card sorting task), we found that effort buffered the relationship between anxiety and shifting efficiency, but not effectiveness (Edwards,

Edwards, & Lyvers, 2015). In other work we employed an inhibition task which required individuals to deliberately inhibit a dominant response (i.e., Go-No-Go task), and found effort moderated the relationship between anxiety and both inhibitory effectiveness and efficiency (Edwards, Edwards, & Lyvers, 2017). We concluded that on shifting and inhibition tasks, our data was consistent with the efficiency-cost described by ACT, specifically, that higher trait anxiety and higher effort predicted poorer processing efficiency (i.e., longer RTs to attain a given performance). In another study (Edwards, Edwards, & Lyvers, 2016a) we used an updating task, requiring individuals to monitor and manipulate relevant information in working memory (i.e., reading span task). We found that anxiety and updating performance varied with motivational effort, but not exactly as predicted by ACT. In accord with ACT, there was no relationship between anxiety and updating effectiveness (accuracy on reading span trials). However, contrary to ACT, highly anxious individuals who reported higher motivation were more efficient (accuracy divided by RT) on the task. Our updating data, therefore, demonstrated that motivational effort facilitated efficiency on a reading span task. Taken together, the results from our work examining performance on shifting, inhibition and updating tasks broadly indicate that mental effort and/or motivation are key moderators in the link between anxiety and cognition. Furthermore, it is plausible that this relationship manifests as an efficiency-deficit on tasks utilising attentional control (e.g., shifting, inhibition), and an efficiency-boost on tasks that include both attention and memory processes (e.g., updating).

The efficiency-cost described by ACT, nonetheless, is not yet fully understood (see Berggren, & Derakshan, 2013). We are currently exploring whether anxious individuals rely on alternative cognitive resources to avoid performance deficits, that is, other than recruitment of additional motivational or mental effort. Preliminary work has suggested that performance in the presence of anxiety may vary with working memory capacity (Edwards,

Moore, Champion, & Edwards, 2015), and cognitive load (Edwards, Edwards, & Lyvers, 2016b). Investigations seeking to clarify the nature of these, and other possibilities, are being undertaken at present. In 2017 we relocated our laboratory to York St John University, and have retained our collaborative links with researchers at Bond University. Across both labs our work continues to seek clarity on the processes that underpin the relationship between anxiety and performance using both simple and complex (higher order) cognitive tasks, and translating our methodology to other populations.

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