What are the critical ingredients of affective working memory training? - Comment on Engen and Kanske (2013)

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In this week's *Journal Club* Engen and Kanske (2013) set out to discuss the challenges of how we can improve complex higher-order mental processes such as emotion regulation. The authors do so compellingly by highlighting the promise of the affective and cognitive neurosciences in this endeavor, based in part on the findings from our recent study (Schweizer et al., 2013). where we show that the benefits of sustained (20 days for 20-30 minutes) training of *affective* working memory (WM) transferred to improvements in emotion regulation ability. These transfer effects were neurally associated with optimized recruitment of brain regions previously shown to be critical to emotion regulation (e.g., Wager et al., 2008), including the lateral and subgenual prefrontal cortices (Schweizer et al., 2013).

Engen and Kanske offer a provocative and scholarly discussion of how such post-training transfer affects might be achieved, positing a critical role for enhancements in the ability to maintain cognitive regulation over time. This begs an interesting question about whether the *affective* nature of the WM training employed in the Schweizer et al. (2013) study is a critical ingredient in the transfer to enhanced emotion regulation or whether emotionally-neutral WM training would have accrued comparable effects via putative gains in sustained cognitive regulation capacity. The second of these possibilities – the ability of neutral WM training regimes to generate ecologically meaningful transferable benefits - remains a topic of great contention within the cognitive neurosciences (for reviews arguing both sides see: Shipstead et al., 2010; Buschkuehl et al., 2011). For example, a recent randomized controlled trial by Redick et al. (2013)–

using an affectively neutral version of the dual *n*-back task administered in the Schweizer et al. (2013) study – failed to show any transfer effects of WM training on other higher-order cognitive processes.

Given this debate and before heralding the promises of extensive cognitive WM training regimes (Jaeggi et al., 2008), it seems critical that we broaden the discussion of the potential pathways through which affective WM training may have generated the far transfer effects found in our recent study. As noted, the first possible pathway is through the augmentation *per se* of some underlying cognitive capacity such as WM or sustained regulation that is shared between the training task and the target transfer task and that does not crucially depend on the affective nature of the task. There is some support for this possibility. An earlier study of affective WM training showed transferable benefits to an untrained neutral WM task (Schweizer et al., 2011). Furthermore, we know that emotion regulation capacity is greater in those with better WM capacity (Schmeichel et al., 2008; Schmeichel and Demaree, 2010). That said, Schweizer et al. (2011) also showed that successful transfer to improved performance on an affective target task – an emotional Stroop paradigm – was *only* obtained following affective WM training, with no such gains accruing after an emotionally neutral training regime. This suggests that the affective ingredient of WM training may be critical for transfer to other affective tasks. Unfortunately, the Schweizer et al. (2013) study did not include a neutral training comparison condition so it is unclear if the affective training component is mandatory to achieve transferable gains in emotion regulation.

Entertaining the premise that successful affective transfer effects do indeed critically depend on training WM within an affective context, does nevertheless raise a number of additional questions about the possible pathways through which training may work to improve emotion regulation. Firstly, what aspects of the emotion context are driving training effects? One possibility is that training may improve an individual's capacity to manipulate material in WM against a backdrop of elevated physiological arousal elicited by the nature of the training material (Eysenck et al., 2007; Derakshan and Eysenck, 2010). Mitigating against this possibility however are studies showing rapid habituation of physiological arousal (e.g., amygdala activation) to the kinds of emotional faces and words used in the affective WM training protocol (Breiter et al., 1996; Mackay et al., 2004). This suggests that the arousal experienced over the course of a training session is likely to be minimal. Consequently, participants would be left with limited opportunity to train the inhibition of arousal to emotional information. An alternative (or additional) possibility is that training may improve an individual's' ability to override the influence of task-independent goals and action tendencies set in train by the emotional nature of the training material (Moors et al., 2013). In terms of emotion regulation transfer, this hypothesis would suggest that affective WM training augments participants' ability to inhibit 'automatized' cognitive processes that amplify and shape the affective response to the aversive film content used in the emotion regulation task thus facilitating cognitive reappraisal of the film's content in the service of affective down-regulation.

A second question, regardless of which aspects of the emotion context are critical, concerns which components and/or processes of the affective dual *n*-back training used in Schweizer et al (2013) might this potentially critical affective context be influencing? There is no consensus on the precise task analysis of the dual *n*-back paradigm. However, processes of short-term memory storage, updating, selective attention, task switching and inhibition are all strong candidates (cf. Miyake et al., 2000). It is plausible that it is the operation of one, more or all of these different sub-components of WM in the context of affective material that is core to the successful transfer to emotion regulation. Future studies could include a portfolio of transfer tasks to differentiate these diverse mechanisms.

A third question concerns the role of task strategies. It is plausible that affective WM training encourages the acquisition of a task strategy that is also beneficial for emotion regulation, thus facilitating transfer between the two tasks. For example, explicitly discounting the importance of the emotive components of the stimulus material or selectively focusing on affectively neutral aspects of the task.

We have highlighted these questions about the nature of transfer effects for two reasons. First, to illustrate how little we currently understand about the nature of transfer effects following affective WM training and, secondly, to emphasize that the debate about how affective WM training may be operating is not synonymous with the debate about how (and indeed whether) emotionally neutral WM protocols exert their effects (Shipstead et al., 2010; Buschkuehl et al., 2011). Specifically, we have

hopefully illustrated that successful far transfer from affective training to an affective target process – emotion regulation – could potentially occur without any enhancement in the capacity of WM *per se* at all.

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