Journal of Applied Research in Memory and Cognition 5 (2016) 470–477

Contents lists available at ScienceDirect

Journal of Applied Research in Memory and Cognition

journal homepage: www.elsevier.com/locate/jarmac

A Closer Look at Who "Chokes Under Pressure"☆,☆

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Previous research has shown that the higher one's working memory capacity, the more likely his/her performance is to be negatively impacted by performance pressure. In the current research we examined potential explanations for this finding by assessing the relation between pressure-induced performance deficits (i.e. "choking under pressure") in math-based problem solving and individual differences in both working memory (as assessed via complex span tasks) and attentional control (as assessed via two measures from an Eriksen Flanker task). We find higher working memory only relates to "choking under pressure" when individuals were low in attentional control. These results further elucidate the mechanism by which high-pressure scenarios can lead to errors in performance and carry implications for developing effective intervention strategies to prevent poor performance in high-stakes situations.

Keywords: Working memory, Pressure, Attentional control

Not all errors are created equal. Repercussions from miscalculating a tip at dinner may be somewhat trivial, but miscalculations in a testing situation such as the ACT or GRE can be much more costly. The outcomes of high-pressure situations such as standardized testing can have a significant impact on one's academic future and career. One large factor contributing to performance in these cognitively-demanding situations is our working memory, a limited-capacity executive resource used for the immediate storage, integration and manipulation of information (Miyake & Shah, 1999). As working memory works to maintain task-relevant information, it intrinsically plays a role in resisting against information that could interfere with task performance (Kane & Engle, 2000). Relatively higher levels of working memory are associated with a number of desirable outcomes, including greater mathematics performance (Raghubar, Barnes, & Hecht, 2010) and even higher levels of general academic achievement (Alloway & Alloway, 2010).

Although an increased working memory capacity is generally associated with positive outcomes, the advantage that those higher in working memory have over those lower in working memory are not always seen. For instance, research by Kane and Engle (2000) measured susceptibility to interference during a word recall task between those low in working memory and those high in working memory. When participants' performed only a word recall task, those with a higher working memory showed a markedly lower number of task interferences compared to lower working memory individuals. However, when participants engaged in a second, attention-dividing task while performing the word recall task, participants exhibited the same number of task interferences regardless of their level of working memory. A similar pattern has been shown in high-pressure performance situations. Relative to low-pressure situations, individuals placed in high-pressure situations often show performance decrements, a phenomenon known as 'choking under pressure' (Baumeister,

☆ Author Note.

☆ Please note that this paper was handled by the current editorial team of JARMAC.

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1984; Wine, 1971). In math problem solving, individual differences in working memory moderates this effect, such that those highest in working memory actually show the largest cognitive deficits as a result of pressure (Beilock & Carr, 2005; Gimmig, Huguet, Caverni, & Cury, 2006).

In one of the first demonstrations of the moderating role of working memory on choking under pressure, both low and high working memory participants were subjected to a high-pressure scenario involving peer pressure, monetary incentives and social evaluation. Before experiencing pressure, individuals higher in working memory showed significantly higher cognitive performance than those lower in working memory. However after experiencing pressure, cognitive performance for those higher in working memory decreases to a similar level as their low working memory counterparts. Further research suggests that this increase in error by those relatively higher in working memory is due to the working memory resources that these individuals normally rely on being compromised by thoughts or anxieties related to task performance (Beilock, Rydell, & McConnell, 2007; DeCaro, Rotar, Kendra, & Beilock, 2010; Schmader and Johns, 2003; Wang & Shah, 2014).

Although previous research shows that as working memory increases, susceptibility to performance decreases in acute high-pressure situations, it is important to point out that the effects of these results do not suggest that all individuals higher in working memory choke under pressure. When studies such as Beilock and Carr's (2005) account for cognitive performance with an interaction of working memory and pressure, the effect sizes are not extremely high (e.g. $\eta^2 = .06$). This suggests that factors other than working memory account for additional variance in cognitive performance under high-pressure conditions. Better understanding who is susceptible to pressure-induced cognitive deficits will not only shed light on the mechanisms by which performance pressure impacts skill execution, but also inform the best interventions to ensure optimal performance when it matters most.

One way to understand variation in choking under pressure as a function of working memory is to dissect how researchers have chosen to characterize working memory in the first place. As previously mentioned, working memory is commonly cited as a singular cognitive construct measuring the relative ability to store task-relevant information and inhibit against task-irrelevant information. However, recent evidence suggests that standard indices of working memory reflect an inter-relationship of primary memory, secondary memory and attentional control for storage and maintenance of task information (Shipstead, Lindsey, Marshall, & Engle, 2014). By comparing over 20 separate measures of executive functioning, Shipstead and colleagues (2014) found that commonly used complex span working memory tasks (e.g. an Operation Span task) do relate to measures of attentional control (e.g. an arrow-based flankers task), as attentional control likely acts as a way to maintain information that has transitioned from primary to secondary memory.

We hypothesize that variability in attentional control may alter the amount of interfering information allowed into working memory storage, thus affecting the degree to which working memory resources are compromised during a high-pressure task. For instance, a relatively higher degree of attentional control may prevent task-irrelevant information from co-opting working memory resources, and in turn eliminate a relationship between working memory and pressure-induced performance deficits. In effect, using solely complex span measures of working memory to predict who will choke in high-pressure scenarios may mean we are missing explainable differences that attentional control can provide. Therefore, in the current work we attempt to replicate Beilock and Carr's (2005) choking under pressure finding by showing that higher levels of working memory relate to larger deficits in cognitive performance due to pressure, while we additionally collect measures of attentional control. The goal is to determine if both working memory capacity and attentional control interact to determine who is susceptible to choking under pressure.

We chose an arrow-based flankers task to measure attentional control. Although previous studies have shown a relationship between working memory capacity and measures of attention recorded from flanker tasks (Heitz & Engle, 2007; Redick & Engle, 2006), flanker tasks used have varied greatly, and separating what specific functions of attention these RT measures represent is problematic. Therefore, we used two separate RT measures from our flanker task to index attentional control and test if either measure of attention altered the relationship of working memory and choking under pressure. First, we used a comparison of response times (RTs) on trials with interfering information (incongruent) to RTs on trials without interfering information (congruent; i.e. the Flanker Effect; Sanders & Lamers, 2002). Although greater differences in this "inhibition" measure have been related lower working memory in the past (see Redick & Engle, 2006), RT difference scores can be incredibly unreliable (Lord, 1963). Therefore, we also analyzed flanker RTs across all trials (congruent + incongruent). We reason that if participants are matched on flanker accuracy, then lower overall RTs indicate a relatively increased ability to sustain attention to the task at hand throughout the course of the flanker task.

We first looked to test if higher working memory scores related to higher attentional control as indexed by either of our flanker RT measures (Kane & Engle, 2000; Redick & Engle, 2006). More importantly, however, we hypothesized that the relationship between working memory and cognitive performance under pressure would be altered by levels of attentional control, as indexed by either of our flanker RT measures. Overall, the decrease in cognitive performance due to pressure should grow larger as working memory increases, replicating the research of Beilock and Carr (2005). However, attentional control may alter this relationship. When attentional control is lower, higher working memory should predict decreases in performance due to pressure. Task-irrelevant information stemming from our pressure manipulation is likely to be allowed into working memory, in turn decreasing cognitive performance those higher in working memory. When attentional control is higher, the relation between working memory and performance under pressure may not be as robust, as higher attentional control should prevent pressure-induced worries from co-opting working memory resources.