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Why do high working memory individuals choke? An examination of choking under pressure effects in math from a self-improvement perspective☆

Annique Smeding [a],*, Céline Darnon [b,c], Nico W. Van Yperen [d]

[a] University of Savoie, France
[b] Clermont University, France
[c] French University Institute, France
[d] University of Groningen, The Netherlands

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ABSTRACT

Choking under pressure (CUP) research shows that individuals working on higher-order cognitive tasks do not benefit from higher working memory (WM) capacity under pressure. This CUP effect, or reduced WM/performance link, entails that high working memory individuals (high WMs) perform at about the same level as low WMs. However, it still is an open question which specific components create a high pressure situation. We hypothesized that CUP effects should occur in situations where high WMs are faced with a self-improvement goal, particularly when they do not have much room to improve their performance any further. Study 1 demonstrated that the positive WM/math performance link was reduced in the mere presence of a self-improvement goal. Study 2 further showed that the WM/math performance link was only reduced when self-improvement instructions emphasized that there was not much room left for improvement. Discussion focuses on implications for both CUP and achievement goal research.

1. Introduction

Working Memory (WM) is an executive resource used to perform higher-order cognitive tasks, which can be conceived of, in line with Baddeley and Hitch's (1974) framework, as a "limited-resource system with storage and processing capabilities" (Kane, Conway, Hambrick, & Engle, 2007, p. 21). WM is positively related to fluid intelligence (Unsworth & Engle, 2005), mathematical problem solving (see Ashcraft & Kirk, 2001; Raghubar, Barnes, & Hecht, 2010, for reviews; see also Uittenhove & Lemaire, 2013), and academic achievement more generally (Alloway & Alloway, 2010). Consequently, the positive WM/performance link should be quite robust for higher-order cognitive tasks, as such tasks require rule and goal maintenance for successful completion, which are mental operations at which high WM individuals are better than their low WM counterparts. The former will therefore usually perform better than the latter on tasks such as matrix reasoning if fluid intelligence is assessed (e.g., Unsworth & Engle, 2005), or number operations if mathematical competence is of interest (e.g., Alloway & Alloway, 2010; Bull & Scerif, 2001).

However, choking under pressure research (CUP; Beilock, Kulp, Holt, & Carr, 2004) shows that in high-pressure situations, individuals working on higher-order cognitive tasks do not benefit from higher WM capacity, leading high WMs to perform at about the same level as their low WM counterparts and resulting in a reduced WM/performance link (Beilock & Carr, 2005). Phrased differently, in high-pressure situations, a reduced WM/performance link indicates that high WM individuals choke under pressure. A similar, high WMs-specific effect of testing situations has also been observed using a dual-task paradigm: Adding a secondary task (i.e., making the task more complex) hampered high WMs' performance while that of low WMs was unaffected (Kane & Engle, 2000; Rosen & Engle, 1997). Together, these findings suggest that situational features have the potential to prevent high WMs from using all of their available cognitive resources. This explains why their performance suffers (i.e., why they choke under pressure), but not that of low WMs who use less complex solving strategies to begin with (hence reducing the influence of contextual factors on performance).

Although the cognitive mechanisms behind CUP start to be rather well understood (e.g., Beilock & DeCaro, 2007; Beilock et al., 2004; DeCaro, Thomas, Albert, & Beilock, 2011), it remains less clear which specific components create a high pressure situation, and accordingly,

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* Corresponding author at: LIPPC2S, Université de Savoie, BP 1104, F-73011 Chambéry cedex, France.

E-mail address: annique.smeding@univ-savoie.fr (A. Smeding).

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affect performance on higher-order cognitive tasks. Indeed, pressure has typically been induced through a combination of elements: (i) a self-improvement goal, (ii) a performance-contingent monetary reward coupled with team effort, and (iii) being videotaped (Beilock & Carr, 2005; Beilock & DeCaro, 2007; Beilock et al., 2004). Recent findings suggest that being videotaped may be the pressure component that harms performance on tasks that do not require WM for successful execution (DeCaro et al., 2011), but no research has investigated whether one of the other two components may be specifically involved in CUP effects on tasks that do require WM for successful completion. Because we suspected the self-improvement goal to be the key factor, particularly when there is not much room left for self-improvement, the aim of the present research was to examine whether this particular goal may have different consequences for high and low WMs.

Indeed, there is a logical principle stating that the lower one's initial performance level, the more room there is for further improvement and vice versa (Critcher & Rosenzweig, in press). That is, when working on a task, low performers have the latitude to improve their level of task mastery and performance, whereas similar improvements by high performers will be more difficult to achieve given their high performance level. Arguably, the less room for improvement, the more pressure is put on the individual when pursuing a self-improvement goal. Hence, on higher-order cognitive tasks – tasks on which high-WMs have an advantage under standard instructions – under self-improvement instructions, high WMs will have only limited room for improvement, resulting in higher pressure and suboptimal performance. Conversely, low WMs will have more room for improvement, resulting in less pressure. If high WMs' performance is reduced and that of low WMs remains stable, the WM/performance link is also reduced, which indicates a CUP effect.

In addition, research in the area of achievement goals has shown that self-improvement goals – hereafter referred to as a mastery goals[1] – lead to better performance than other achievement goals (i.e., performance goals or avoidance goals) or no goal (for a recent meta-analysis, see Van Yperen, Blaga, & Postmes, 2015; see also Dompnier, Darnon, & Butera, 2009; Hulleman, Schrager, Bodmann, & Harackiewicz, 2010; Poortvliet & Darnon, 2010; Senko, Hulleman, & Harackiewicz, 2011; Van Yperen, Blaga, & Postmes, 2014). However, there are situations where this is not the case, for example, when there are external pressures or constraints such as the anticipation of external feedback on one's task performance or a strict time limit to perform the task (Van Yperen et al., 2015). Similarly, Avery, Smillie, and de Fockert (2013) showed that under secondary task load, mastery goal participants suffered a more severe performance decrement on the primary task than performance goal participants. This is because the former used more complex and WM intensive solving strategies, which undermined performance when load increased. Other research suggests that mastery goals hinder performance improvement in instances of success feedback (i.e., your score on this task is 95% correct; Cianci, Schaubroeck, & McGill, 2010), and that because low achievers have more to learn than high achievers, the former, but not the latter, benefit from mastery goals (Butler, 1993). Also, whereas mastery goals foster inter-individual cooperation when there is room for performance improvement (i.e., for low-ranked individuals), this is not so when there is hardly any room for improvement (i.e., for high-ranked individuals; Poortvliet, Janssen, Van Yperen, & Van de Vliert, 2009). Past research thus suggests that some of the typical benefits associated with mastery goals (i.e., cooperation and learning) are jeopardized when mastery goal individuals do not have much room for improvement.

Following this line of reasoning, CUP effects should occur in situations where high WMs working on a higher-order cognitive task are faced with a mastery goal. That is, the WM/performance link should be reduced due to high WMs' reduced performance levels whereas low WMs – who have more room for improvement – were expected to maintain their performance levels. In Study 1, we tested this hypothesis in two phases. In the first phase, we did not implement other components of the pressure scenario (i.e., reward and team effort, being videotaped). This allowed testing for the sheer effect of mastery goals without the possible confounding effect of the other pressure-inducing components. Specifically, in the first phase, we compared the effects of a situationally induced mastery goal with two control conditions: (Kane & Engle, 2000) a performance goal control condition to test whether the effect can be explained by a mastery goal rather than another type of achievement goal, and (Murayama & Elliot, 2011) a no-goal control condition. Our mastery goal manipulation closely paralleled Beilock and Carr's (2005) self-improvement goal manipulation. That is, we recommended participants to improve their performance relative to the preceding trials. In the performance goal control condition, we recommended the participants to adopt a performance-approach goal (henceforth referred to as a performance goal), that is, the goal to perform better than the other participants (Crouzevialle & Butera, 2013; Elliot, 2005). In the no goal control condition, no achievement goal was induced. This control condition plays a crucial role as it provides an anchor of what would be the typical WM/math performance link (i.e., how low and high WMs typically perform) in the absence of any goal. Hereafter, we will refer to this first phase as to the goal only scenario.

In the second phase, hereafter labeled CUP scenario, we also distinguished between a mastery goal, a performance goal control condition, and a no goal control condition, but we added all the situational components typically used in CUP research (see above). This resulted in a mastery goal condition similar to the high pressure condition in the Beilock and Carr (2005) study, and a performance goal control condition, which only differed from the high pressure condition in the Beilock and Carr (2005) study in terms of goal type. The no goal control condition was the same as in the first phase.

This two-phase design allowed testing whether high WMs' CUP occurs – and the WM/performance link is reduced – in the mastery goal condition of both goal only and CUP scenarios, that is, in the mere presence of the self-improvement requirement. In contrast, in either control condition, we expected to observe the typical positive WM/performance link. Thus, in Study 1, we tested whether a mastery goal, but no other situational components or another type of achievement goal, specifically accounted for the reduced WM/performance link.

In Study 2, we manipulated mastery goal individuals' room for improvement in order to test the mechanism hypothesized to account for high WMs' CUP (Spencer, Zanna, & Fong, 2005). More precisely, in two CUP scenario experimental conditions, we tested whether a mastery goal would lead to a reduced WM/performance link when participants are explicitly informed that they do not have much room for improvement, but not when informed that they do have substantial room for improvement. Also, in an additional no goal control condition, we expected to observe the typical WM/math performance link.

2. Study 1

2.1. Method

2.1.1. Participants and design

Participants (tested individually) were 139 female French undergraduate students from various academic disciplines ($M_{Age} = 21$ years, $SD = 2.71$). Data from one participant were removed because the computer failed to record her WM score and from another because of both an uncommon studentized deleted residual and an extreme Cook's distance value (Judd & McClelland, 1989). It is important to emphasize that extreme values on studentized deleted residuals and Cook's distances are problematic in regression analysis because they have the potential to drastically increase residuals or bias parameter estimates, and therefore to increase the model's error. In accordance with Judd

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[1] Precisely, we are referring to a mastery-approach goal, as it is the approach component that has been emphasized in typical pressure scenarios.