Acta Psychologica 144 (2013) 361–372

Contents lists available at ScienceDirect

Acta Psychologica

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

The role of working memory in achievement goal pursuit

Rachel E. Avery [a,*], Luke D. Smillie [b], Jan W. de Fockert [c]

[a] University of Surrey, AD Building, Guildford, Surrey GU2 7XH, UK
[b] The University of Melbourne, Melbourne School of Psychological Sciences, Redmond Barry Building, VIC 3010, Australia
[c] Goldsmiths, University of London, Room 1.16 Ben Pimlott Building, Psychology Department, New Cross SE14 6NW, UK

ARTICLE INFO

Article history:
Received 13 December 2012
Received in revised form 11 July 2013
Accepted 15 July 2013
Available online 23 August 2013

PsycINFO classification:
2340 Cognitive Processes
2360 Motivation and Emotion
2343 Learning and Memory

Keywords:
Working memory
Motivational states
Achievement goal
Mastery-approach
Performance-approach

ABSTRACT

The present research examined the role of working memory in the pursuit of qualitatively different achievement goals. Pursuit of a mastery-approach goal entails a focus on developing self-referential competence while a performance-approach goal entails a focus on demonstrating normative competence. Across two experiments it was found that, when working memory is loaded, individuals pursuing a mastery-approach goal experienced larger performance decrements than individuals pursuing a performance-approach goal or those in a no-goal control. It was also found that reliance upon working memory intensive strategies (explicit strategies) was more evident for those in a mastery-approach condition, whereas reliance upon less working memory intensive strategies (implicit strategies) was more evident for those in the performance-approach condition. Results suggest that a motivated focus on developing self-referential skill relies heavily on working memory, facilitated by the use of deliberative, 'step-by-step' strategies during goal pursuit. Conversely, a focus on demonstrating normative skill depends less on working memory, facilitated by the use of more heuristic 'short-cut' strategies during goal pursuit. These findings show, for the first time, that working memory plays an important, but selective, role in achievement goal pursuit.

1. Introduction

Achievement goals concern the purpose of motivated behaviour in achievement settings, and are conceptualised in terms of a motivated focus on qualitatively different competence related outcomes (Dweck, 1986; Elliot, 1999, 2005; Nicholls, 1984). For instance, one might be motivated to develop self-referential competence (i.e., a *mastery-approach goal*), or to demonstrate normative competence (i.e., a *performance-approach goal*). An extensive literature shows that these goals differentially impact upon achievement outcomes in a range of settings (see Senko, Durik, & Harackiewicz, 2008; Senko, Hulleman, & Harackiewicz, 2011). Less is known, however, about *how* achievement goals might go about exerting an effect on such outcomes. In this paper, we investigate the way in which achievement goals might differentially engage working memory resources. Working memory (Baddeley, 2000; Baddeley & Hitch, 1974; Engle, 2002) plays a critical role in the goal-directed control of attention, by guiding, preserving and updating attention to goal-directed processes and information (Conway, Cowan, & Bunting, 2001; Hofmann, Schmeichel, Friese, & Baddeley, 2011; Lavie & de Fockert, 2005; Miller & Cohen, 2001). It therefore seems likely that working memory is critically involved in achievement goal pursuit. The aim of this paper is to understand how mastery-approach and performance-approach goals engage working memory resources, thereby shedding light on the cognitive processes that may underlie the effects that these goals have on achievement outcomes.

The distinction between mastery-approach goals (i.e., focus on developing skill) and performance-approach goals (i.e., focus on demonstrating skill) is a fundamental dichotomy in the achievement goal literature (Dweck, 1986). These achievement goal states can be elicited by simple cues or instructions, such as framing the purpose of a task as an opportunity to outperform others (performance-approach) or to learn something new (mastery-approach) (e.g., Elliot, Shell, Henry, & Maier, 2005) (see Elliot, 2005). Although beyond the scope of the present research, it is important to note that one can also be motivated to avoid demonstration of normative incompetence (*performance-avoid focus*) or to avoid deterioration of self-referential competence (*mastery-avoid focus*) (Elliot, 1999; Elliot & Church, 1997; Elliot & McGregor, 2001). The present research is designed to focus specifically on the role of working memory in mastery-approach and performance-approach goal pursuit.

Pursuit of these different approach-oriented achievement goals has been shown to produce differential outcomes, particularly in academic settings. For instance, performance-approach goals tend to predict actual academic performance, while mastery-approach goals tend to predict academic interest (Hulleman, Durik, Schweigert, & Harackiewicz, 2008). Relatively less research has examined the cognitive processes through

* Corresponding author. Tel.: +44 1483686862; fax: +44 1483689553.
E-mail addresses: r.e.avery@surrey.ac.uk (R.E. Avery), lsmillie@unimelb.edu.au (L.D. Smillie), j.de-fockert@gold.ac.uk (J.W. de Fockert).

0001-6918
http://dx.doi.org/10.1016/j.actpsy.2013.07.012

which these effects might operate. Mastery-approach goal states have been linked with deep processing tendencies and elaborative learning strategies, while performance-approach goal states have been associated with more surface-level task engagement and rote learning (Harackiewicz & Linnenbrink, 2005). Performance-approach goal pursuit has been found to strategically direct attention towards material essential for task performance (Elliot et al., 2005), and to foster cheating behaviour (Van Yperen, Hamstra, & Van der Klauw, 2011), compared to mastery-approach goal pursuit. In relation to memory performance, research has shown superior maintenance of memory strategies in recall tasks for mastery-approach, relative to performance-approach (Escribe & Huet, 2005). Researchers have also found enhanced recall for deeply processed information for mastery-approach, relative to performance-approach (Graham & Golan, 1991), however others have failed to replicate such findings (Barker, McInerney, & Dowson, 2002).

Despite these promising indications of the cognitive processes that might characterise achievement goal pursuit, few studies have considered the role of working memory. This is surprising as research informs us that working memory plays a major, though varied, role in a wide range of goal-directed behaviours (DeShon, Brown, & Greenis, 1996; Krawczyk & D'Esposito, 2011; Treisman & Doctor, 1987; Wegge, 2001; Worthy, Markman, & Maddox, 2009). In terms of achievement goals, Linnenbrink, Ryan, and Pintrich (1999) reported a positive association between working memory capacity scores (as measured by Reading Span, RSPAN; Daneman & Carpenter, 1980) and self-reported mastery-approach goals. More recently, Avery and Smillie (2013) examined the influence of experimentally manipulated mastery-approach and performance-approach goals on working memory under varying executive load, using a numerical N-Back task (Gevins & Cutillo, 1993). It was found that pursuit of a performance-approach goal resulted in poorer working memory processing than pursuit of a mastery-approach goal or no-goal control. Moreover, this achievement goal effect was restricted to the greatest executive load of the task relative to less demanding loads. This is consistent with research showing that achievement goals impact most upon performance in cognitively demanding conditions (Barker et al., 2002; Graham & Golan, 1991). Also relevant is a recent study by Crouzevialle and Butera (2012), who found that pursuit of performance-approach goals generated distractive concerns that depleted working memory resources relative to a no-instruction control group. These authors argue that allocation of such resources is divided among the storage, processing, and retrieval of task-relevant information, and, the activation of performance-approach goal concerns.

Thus, although some research has examined how working memory performance varies under different goal pursuit conditions, the role that working memory plays in the pursuit of mastery-approach and performance-approach goals remains unclear. That is, the extent to which mastery-approach and performance-approach goal pursuit might differentially engage working memory resources given task strategies employed, is yet to be investigated. Such investigation would be highly complementary to previous work described by offering some explanation for varying cognitive performance for these goal states (Bereby-Meyer & Kaplan, 2005; Escribe & Huet, 2005), especially when a task is executively demanding (Avery & Smillie, 2013; Graham & Golan, 1991). Furthermore, investigation of the role that working memory plays could offer some explanatory grounds for information processing patterns (Graham & Golan, 1991; Harackiewicz & Linnenbrink, 2005) observed for these goal states (i.e., can task strategy working memory resource requirements account for why deeper processing of material is more favourable with mastery-approach goal pursuit?). In exploring the working memory requirements of task strategies employed by these goal states, the current work offers much scope for developing theoretical understanding of how mastery-approach and performance-approach goal states actually go about exerting an effect on cognitive and ultimately academic performance.

One way to address this question is to ask whether the availability of working memory resources has consequences for task performance depending on which achievement goal is being pursued. The current paper aims to address this novel and necessary question using dual task methodology, whereby a working memory load task is interleaved with a primary goal pursuit task. Dual task methodology involves performing two tasks simultaneously, or two interleaved tasks, with a distinction between a primary and a secondary task of interest. Performance decrements in the primary task can be attributed to the executive load of the secondary task. In the current work, two experiments are presented in which participants pursue either a mastery-approach or performance-approach goal under varying working memory load. Secondary working memory load will compete with the primary goal pursuit task for working memory resources to the extent that these are required for successful performance (Baddeley, 1986). Consequently, working memory load will affect task performance most strongly for the goal state in which working memory plays a greater role. In Experiment 1, given the discussed literature, the extent to which limited availability of working memory resources has more damaging consequences for primary task performance when pursuing a mastery-approach goal relative to a performance-approach goal is tested. In Experiment 2, task strategies employed by these goal states (under both low and high demanding task conditions) in accounting for differential working memory resources requirements is tested – specifically, whether the damaging consequences for primary task performance when pursuing a mastery-approach goal relative to a performance-approach goal is due to reliance upon more working memory intensive strategies.

2. Experiment 1

Games and puzzles offer a simple but effective way to examine goal-directed behaviour in the laboratory. Such tasks have been successfully employed to study, for instance, the role of working memory in chess performance (Robbins et al., 1995) and the impact of approach states on word-search puzzles and word matching games (Elliot & Harackiewicz, 1996; Senko & Harackiewicz, 2005; Steele-Johnson, Heintz, & Miller, 2008). For this study we constructed a word game based loosely on the *Parker Brothers* game Boggle™ as a primary achievement goal pursuit task. On each trial participants were presented with a 4×4 letter matrix and required to make as many words as possible. Working memory has been suggested to play a role in word formation games, allowing the retrieval of verbal information from long-term memory (Halpern & Wai, 2007).

The current word game was interleaved with a secondary task (low versus high load). If the primary achievement goal requires working memory resources, then game performance should decline at higher working memory load. Given that previous work has found a relationship between mastery-approach goals and increased working memory performance (Linnenbrink et al., 1999), and has also linked mastery-approach goals with cognitive styles that are suggestive of high working memory engagement (e.g., deep-processing learning strategies; Harackiewicz & Linnenbrink, 2005), we expected that working memory might play a greater role in the pursuit of mastery-approach goals, relative to the pursuit of performance-approach goals (i.e., a mastery-approach foci engages working memory resources more heavily during goal pursuit relative to a performance-approach foci). We therefore hypothesised that primary task performance would be most substantially disrupted by high secondary load when pursuing a mastery approach goal.

2.1. Method

2.1.1. Participants

Seventy-two[1] University of London undergraduates (47 females) from various disciplines took part and all were paid £5 for their participation. Age was recorded in five ranges (18–25; 26–35; 36–45; 46–55;

[1] One participant was removed from analyses due to exceptionally high word game performance, but this had no substantive effect on results.

56–65) with a modal range of 18–25 years accounting for 75.3% of the sample. Informed consent was obtained prior to participation.

2.1.2. Experimental task

Participants performed a primary achievement goal pursuit task interleaved with a secondary load task programmed using e-prime software (Schneider, Eschman, & Zuccolotto, 2002).

2.1.2.1. Primary task. The primary task was a word game whereby in each trial participants were presented with a 4×4 letter matrix (see Fig. 1) and required to type as many words as possible in 20 s under the single rule that words must be a minimum of 3 letters long. Each 16 letter matrix contained a minimum of 2 vowels and the remaining letters were any of the possible 21 consonants from the alphabet, with repetitions of the same letter in a single matrix permitted.

2.1.2.2. Secondary task. The primary word game was interleaved with a secondary task for digit order (see Fig. 2). At the start of each trial, prior to presentation of the word game, a memory set consisting of the digits 0–1–2–3–4 was presented (centered) for 1500 ms. For low secondary load trials, the memory set was always presented in a fixed order of 0–1–2–3–4. For high secondary load trials, the digit 0 always remained in the first position of the set but the order of the digits 1–4 was varied at random on each trial. Memory sets were followed by a 1500 ms interval in both low and high load conditions, which was then followed by presentation of the 20 second word game. Following the word game, a memory probe appeared and remained on screen until a response was made or 3000 ms had elapsed. The memory probe consisted of one digit with a question mark, equally likely to be either 0–3 in the low load condition or 0–4 in the high load condition. Participants were required to key-in the digit that followed the probe digit in the memory set they had seen prior to the word game for that trial. All of the positions in the memory set were equally likely to be probed across trials.

2.1.2.3. Primary and secondary task interleaved design. Following a practice tutorial, participants completed one primary task baseline block (12 trials) under low secondary load followed by four fully counterbalanced experimental blocks (2 blocks per secondary load, each containing 16 trials). Sixty-Four letter matrices were randomly generated for the total of 64 trials across the 4 main task blocks, with 16 letter matrices allocated to each block, all presented in a random order for each participant. Word game performance was calculated using a points-based system: 1 point for every 3 letter word or for the first 3 letters of words longer than 3 letters, and an additional 1 point for every letter after the third letter of words longer than 3 letters. Points were then summed for each letter matrix and these were then totalled per block.

Fig. 1. Experiment 1: Example letter matrix from primary word game.

Total word game performance, for low and for high secondary working memory load separately, were calculated by summing the total of the two block scores for each load. This created the key dependent variable; *Total Game Points (Low Load)*, *Total Game Points (High Load)*.

2.1.3. Manipulation of achievement goal states

Achievement goal state was manipulated between subjects. The word game was performed in one of three experimental conditions: mastery-approach goal (MAG), performance-approach goal (PAG) or no-goal (NG). Achievement goals were manipulated via instructions that framed the focal task in terms of an explicit target focused normative or self-referential goal. Although there are various achievement goal manipulation methodologies evident within the literature, the goal framing technique is consistent with the aforementioned definitions of MAG (focus on developing skill) and PAG (focus on demonstrating skill) (Elliot, 1999), has been shown to be effective in previous research and is highly consistent with previous literature examining the impact of motivational states on cognitive performance (Elliot et al., 2005; Escribe & Huet, 2005; Van Yperen, Elliot, & Anseel, 2009). In both the MAG and PAG condition participants were told prior to task engagement that they would receive points for words identified in the word game (as described earlier). Participants were told that the computer would automatically calculate scores throughout the task. Following a baseline block, participants in the MAG condition read the following set of instructions:

> *"Your round 1 score is X points. Your aim for this task is to develop your skill at performing the word game well. As such your goal for round 2 is to do better than your total round 1 score, which means getting more than X points in round 2. The computer will tell you at the end of round 2 whether you achieved above your previous round score."*

In contrast, following a baseline block those in the PAG condition read the following set of instructions:

> *"Your aim for this task is to demonstrate your skill at performing the word game well in comparison to other students who have taken part. The average total score of students who have taken part so far in round 2 is X points. Your goal for round 2 is to do better than this average student round 2 score, which means getting more than X points in round 2. The computer will tell you at the end of round 2 whether you achieved above the average student score for the round."*

These instructions to either perform better than one's own previous round score or than a normative score (for MAG and PAG respectively) were then repeated between each of the remaining 4 experimental blocks (i.e., after blocks 2, 3 and 4) with adjustments made to references to 'round X' and 'X points' accordingly. All participants in both goal conditions were presented with a standardised set of target scores based on pilot data.[2,3] Accordingly, all participants in the MAG and PAG conditions were provided with positive feedback at the end of each block (i.e., 'Yes, you scored better than your previous round score' or 'Yes, you scored better than the average student score for this round'). Participants in the NG condition received only standard task instructions, that is, no points system or target goals were provided.

[2] Target scores were identical in order to 1) ensure that only the framing of the target scores differed across goal conditions, 2) prevent block by block feedback variability within and between conditions thus ensuring consistency in terms of approaching a positive improvement outcome focus, and 3) prevent numerical targets becoming more salient than the framing of the achievement goals.

[3] Although the difficulty of letter matrices was not manipulated but kept constant, improving on the practice block was deemed moderately challenging. Regardless of goal condition, for those who did block 1 (following a practice block) under low secondary load, 50% actually achieved the standardised target goal assigned. If we consider this by condition, similar results are achieved with 46% in the no goal control, 55% in the mastery-approach condition and 53% in the performance-approach condition actually achieving the standardised target goal assigned in block 1 post the practice round.

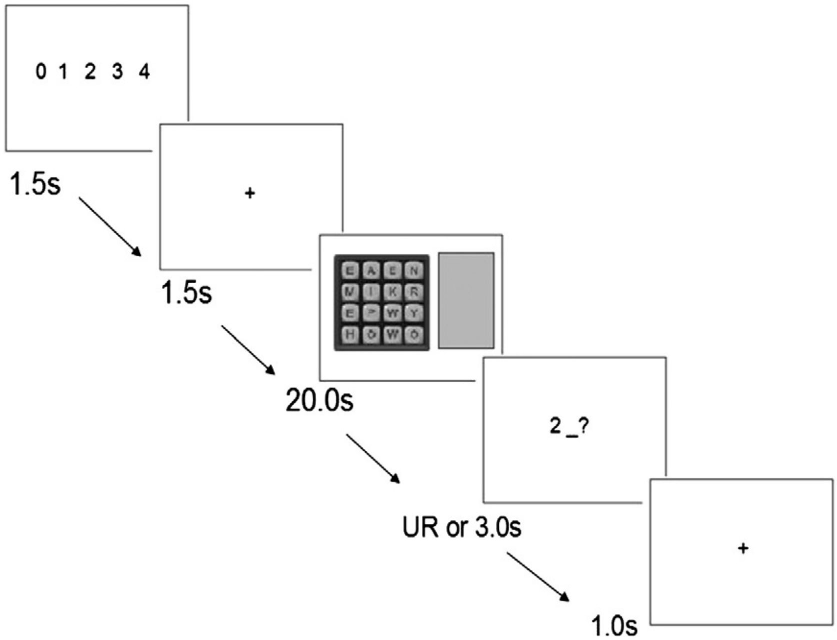

Fig. 2. Experiment 1: Example task trial (low load condition).

2.1.4. Psychometric measures

2.1.4.1. Working memory capacity. The Operation Span (OSPAN) task (Turner & Engle, 1989) was used to confirm that experimental groups did not vary in terms of working memory capacity. Working memory capacity represents individual differences in the limit of information that can be maintained and manipulated in working memory. Participants view operation strings one at a time and are required to read each string out loud (e.g., "Is $(9 \div 3) - 2 = 2$? AUNT"). The participant states the mathematical string, followed by verification of the answer (i.e., "yes" or "no"), followed in turn by the word (i.e., "aunt"). Operation strings ranged from sets of two to five (three of each set presented randomly) and once the end of each set was reached participants were required to recall the sequence of words stated. OSPAN scores ranged from 0 to 42, calculated by summing the total number of recalled words across the twelve sets.

2.1.4.2. State anxiety. As noted by Avery and Smillie (2013), it is plausible that the pursuit of some achievement goals may impact upon state anxiety (e.g., being prompted to continually outperform others may elicit heightened anxiety), compared, for instance, to a no goal control group. Also, given the known negative impact of anxiety on working memory performance (Ashcraft & Kirk, 2001; Ikeda, Iwanaga, & Seiwa, 1996; MacLeod & Donnellan, 1993), this may create interpretative ambiguities in the present study. Therefore, to guard against competing explanations (e.g., that the differential role of working memory in achievement goal pursuit is attributable to differences in experienced state anxiety between conditions), we examine any impact our achievement goal manipulation might have on state anxiety. State anxiety was assessed using a 5-item measure drawn from Ryan, Koestner, and Deci's Intrinsic Motivation Inventory (1991). All items ($\alpha = .86$) were adapted to the task at hand, for example, "*I was anxious whilst doing this activity*", became, "*I was anxious whilst doing this memory and word task*".

2.1.5. Manipulation checks

2.1.5.1. Task purpose. To confirm that participants understood the goal-related aim of the task, at the end of the experiment participants were asked to tick from a list provided, what the purpose of the task they had just completed was. Options included '*to provide me with the opportunity to develop my skill at performing the word game well*' (MAG), '*to provide me with the opportunity to demonstrate my skill at performing the word game well in comparison to other students who had taken part*' (PAG), and additionally, '*I don't remember the purpose of the task*', and, '*the purpose of the task was not made clear to me*' to capture any misunderstanding.

2.1.5.2. Goal assigned. To confirm that participants understood the specific target goal assigned to them they were also asked to identify the target goal they were assigned, by ticking one option from a list of goals, including, '*to do better than my previous score for each round*' (MAG), and '*to do better than the average student score for each round*' (PAG), and additionally, '*I was assigned no target goals*' *and* '*I did not understand the goals assigned to me*'.

2.1.5.3. Motivational state. In order to assess whether the goal manipulations had the desired effects on achievement motivation, a measure of goal state was also taken. State adapted forms of the mastery-approach and performance-approach scales from Horvath, Scheu, and DeShon's (2001) Global Goal Orientation measure were utilised. The mastery-approach scale ($\alpha = .85$) consists of 4 items such as '*The opportunity to learn new things on the task was important to me*'. The performance-approach scale ($\alpha = .92$) consists of 4 items such as '*It was important to me that I performed better than other students taking part on the task*'.

2.1.5.4. Goal commitment. While we expect participants in the MAG and PAG conditions to differ with respect to their motivational focus on developing versus demonstrating competence, we do not expect them to differ in their commitment to their assigned goal. Thus, a five-item measure of goal commitment was also included ($\alpha = .80$) to assess adherence to the target goals set within the MAG and PAG conditions. Items were taken from the Hollenbeck, Williams, and Klein (1989) Goal Commitment scale (e.g. *I was strongly committed to pursuing the goals assigned*).

2.1.6. Procedure

Participants were tested individually in a sound proof laboratory. Written consent was obtained and demographic items were completed first. Participants then completed the OSPAN assessment, after which they were given a 5 minute break (but remained in the testing room). They then completed a practice tutorial to ensure familiarisation with the task, followed by a baseline task block. Participants were then randomly assigned to different achievement goal conditions before completing the four main experimental blocks. After completing the experimental blocks participants completed (in counterbalanced order) the manipulation check questionnaires assessing task purpose, goal assigned, motivational state, state anxiety and goal commitment. (Those in the control group did not complete the task purpose, goal assigned or goal commitment manipulation check.) Testing sessions lasted approximately 90 min.

2.2. Results and discussion

2.2.1. Manipulation checks

Chi-square tests confirmed that participants' post-task reported purpose, $\chi^2 = 35.28$, $df = 3$, $p < .001$, and assigned goal, $\chi^2 = 39.66$, $df = 3$, $p < .001$, were consistent with their experimental condition. There were no significant differences in reported goal commitment between the participants in the MAG ($M = 19.9$, $SD = 2.8$) and PAG ($M = 20.0$, $SD = 4.4$) condition ($p = .909$), with both group commitment means indicating strong commitment to goals assigned. Goal State checks revealed significant differences in reported state mastery-approach, $F(2,69) = 3.97$, $p = .023$, and reported state performance-approach, $F(2,69) = 3.88$, $p = .025$, across groups. Participants in the MAG condition scored the highest in state mastery-approach ($M = 14.96$, $SD = 2.85$) in comparison to those in the PAG ($M = 12.61$, $SD = 4.0$), $t(46) = 2.35$, $p = .023$, and those in the NG control ($M = 12.42$, $SD = 3.63$) condition, $t(47) = 2.74$, $p = .009$. Participants in the PAG condition scored higher in state performance-approach ($M = 12.83$, $SD = 5.10$) than those in the MAG ($M = 9.96$, $SD = 4.27$), $t(46) = 2.11$, $p = .040$, and NG control ($M = 9.42$, $SD = 4.10$) condition, $t(45) = 2.53$, p = .015. These manipulation check results clearly confirm effective inducement of target goal states.

2.2.2. Preliminary analyses

Descriptive statistics for Experiment 1 variables by goal condition are presented in Table 1. No effect of gender, age or block load order on word game performance was found (all p's > .70), and no group differences on word game points during the baseline block were identified, $F < 1$, *ns*, indicating that experimental groups did not significantly differ in terms of word game performance prior to goal inducement. Further analyses revealed that groups did not significantly differ on working memory capacity ($p = .87$) (*Ms*: MAG = 31.42, PAG = 31.82, NG = 30.83) or state-anxiety ($p = .12$) (*Ms*: MAG = 16.6, PAG = 18.3, NG = 20.8).

For all participants, mean reaction times (RT, in milliseconds) to memory probes were significantly slower under high secondary load ($M = 1649$, $SD = 256.3$) than under low secondary load ($M = 1075$, $SD = 156.2$), $F(1,71) = 509.92$, $p < .001$. Additionally, memory probe accuracy was higher with low secondary load ($M = 30.6$, $SD = 1.7$) than with high secondary load ($M = 17.9$, $SD = 6.8$), $F(1,71) = 244.05$, $p < .001$. This indicates that the manipulation of working memory load was effective. No experimental group differences in mean RT to probes under low secondary load were found ($p = .67$). However, under high secondary load groups significantly differed on correct probe RT, $F(2,69) = 6.69$, $p = .002$. There were no significant differences in correct probe RT between the MAG and PAG conditions ($p = .13$), however, participants in the NG control ($M = 1519$, $SD = 213.5$) responded significantly faster to memory probes under high secondary load than those in both the MAG condition ($M = 1661$, $SD = 266.9$), $t(47) = 2.06$, $p = .045$, and PAG condition ($M = 1771$, $SD = 228.5$), $t(45) = 3.925$, $p < .001$. Similarly, there were no group differences in probe accuracy under low secondary load ($p = .13$), but there were significant differences under high secondary load, $F(2,69) = 6.62$, $p = .002$. The MAG and PAG condition did not differ in terms of probe accuracy ($p = .73$), suggesting there to be no differences in attentional bias between achievement goal conditions. However, those in the NG control ($M = 21.7$, $SD = 6.0$) had a significantly higher probe accuracy under high secondary load than those in the MAG ($M = 15.6$, $SD = 6.8$), $t(47) = 3.32$, $p = .002$, and PAG ($M = 16.3$, $SD = 6.2$) conditions, $t(45) = 3.02$, $p = .004$. This potentially indicates that inducement into an achievement goal consumed some resources that would have otherwise been devoted to the secondary load task. The finding that performance on the secondary load task was the same in MAG and PAG groups is important, as it rules out the possibility that any group differences in performance on the word game as a function of load being explained in terms of differences in prioritisation of the load task and word game task.

Table 1
Experiment 1: means and standard deviations for variables by goal condition.

	Mastery-approach		Performance-approach		No-goal control	
	M	*SD*	*M*	*SD*	*M*	*SD*
State mastery-approach	14.96	2.85	12.61	4.02	12.42	3.63
State performance-approach	9.96	4.26	12.83	5.10	9.42	4.09
Working memory capacity	31.42	7.41	31.82	6.60	30.83	5.42
State-anxiety	16.58	7.24	18.35	6.80	20.83	6.86
Goal commitment	19.92	2.81	19.83	4.40	–	–
Total game points (low load)	204.24	71.10	179.48	84.16	169.96	64.97
Total game points (high load)	84.72	43.37	87.13	65.73	99.50	52.14

Note: Mastery-approach, N = 25; Performance-approach, N = 23; No-goal control, N = 24. State mastery-approach and state performance-approach are self-report forms. Those in the no-goal control condition didn't complete a goal commitment measure.

2.2.3. Word game performance

Total Game Points were entered into a 3 × 2 mixed ANOVA with goal group (MAG, PAG, NG) as the between-subjects factor, and secondary load (low, high) as the within-subjects factor. All performance analyses were restricted to trials in which a correct secondary load probe response was made. There was no significant main effect of goal group, $F < 1$, *ns*. There was a significant main effect for secondary load, $F(1,69) = 242.748$, $p < .001$, $\eta p^2 = .779$, with all participants performing better under low (relative to high) working memory load (*Ms* = 184.90 and 90.42 respectively). Additionally, a significant secondary load x goal group interaction, $F(2,69) = 5.646$, $p = .005$, $\eta p^2 = .141$, was found, indicating that the effect of working memory load on word game performance varied between the three experimental groups.

Further analyses revealed that participants in all conditions experienced a significant decline in word game performance from low to high secondary load (MAG, $F(1,24) = 109.39$, $p < .001$, $\eta p^2 = .820$, PAG, $F(1,22) = 68.07$, $p < .001$, $\eta p^2 = .756$, and NG, $F(1,23) = 69.73$, $p < .001$, $\eta p^2 = .752$), but that this effect was largest in the MAG condition (see Table 1 for means), suggesting that MAG pursuit is more strongly influenced by working memory load than PAG pursuit or the NG control. To further examine these apparent differences, a decrement score was calculated by subtracting each participant's word game performance under high secondary load from their performance under low load. In accordance with hypotheses, there was an overall effect of experimental group on decrement scores from low to high secondary load, $F(2,71) = 5.65$, $p = .005$, (see Fig. 3). Planned contrasts revealed that participants in the MAG condition suffered the largest decrement compared to those in other experimental groups, $t(69) = 3.05$, $p = .004$. As predicted, those in the MAG condition suffered a larger decrement compared to those in the PAG condition, $t(69) = 1.84$, $p = .07$, albeit at the trend level.

In sum, although all experimental groups experienced some deterioration of primary task performance between low and high secondary load, the effect was most evident during pursuit of a mastery-approach goal. For those in the mastery-approach condition, high

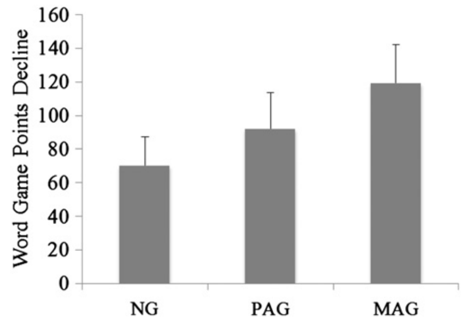

Fig. 3. Experiment 1: Word game points decline from low to high secondary load by goal condition.

working memory engagement under low secondary load could no longer be sustained under high secondary load, resulting in a performance decrement. Findings therefore suggest that working memory plays a more vital role in the pursuit of a mastery-approach goal relative to a performance-approach goal or a no-goal control.

3. Experiment 2

The aim of Experiment 2 is to build upon the dual-task design of Experiment 1 by further examining the role of working memory in achievement goal pursuit using a primary task known to vary in working memory intensity. If mastery-approach pursuit relies heavily on working memory (relative to performance-approach pursuit) then under low secondary load such goal pursuit should enhance performance on parts of a primary task which place heavy demands upon working memory. This advantage should then disappear under high secondary load. A further means of investigating the link between achievement goal pursuit and working memory is to examine self-reported strategy use. If mastery-approach pursuit relies more on working memory intensive strategies than performance-approach pursuit, participants may be able to verbally report on such strategies, discussed below.

A maths game is employed in the current study as the primary goal pursuit task. Solving challenging mathematical problems is known to rely heavily on working memory (Beilock & Carr, 2005; DeStefano & LeFevre, 2004; Stevenson & Carlson, 2003; Trbovich & LeFevre, 2003). Indeed, the impact of high-pressure situations on working memory availability especially undermines maths performance for individuals who typically demonstrate superior maths performance (Ashcraft & Kirk, 2001). Researchers have illustrated that in working memory intensive tasks such as maths-based problem solving, manipulations which disrupt working memory interfere with performance by consuming the resources that are required to perform well (Beilock & Carr, 2005; Beilock, Kulp, Holt, & Carr, 2004; Beilock, Rydell, & McConnell, 2007; Cadinu, Maass, Rosabianca, & Kiesner, 2005). In line with this, if mastery-approach entails a strong reliance on working memory resources, then one would expect high secondary load to particularly interfere with successful goal pursuit.

To investigate possible strategy-related explanations behind findings relating to maths problem solving, some (e.g., Beilock & DeCaro, 2007) have turned to the dual-process theory literature. According to this literature, two distinct processes support performance in problem solving related tasks, namely implicit and explicit processes (also known as rule-based versus associative) (Evans & St, 2003; Sloman, 1996; Stanovich & West, 2000). Implicit strategies involve reliance on mental 'short cuts' and processes believed to operate spontaneously, thus making little demand on working memory (Rydell, McConnell, Mackie, & Strain, 2006). In contrast, explicit strategies involve reliance upon declarative knowledge and 'step-by-step' strategies in order to reach solutions, and place much heavier demands on working memory (Stevenson & Carlson, 2003). According to Siegler (1988a,b), those who tend to employ more working memory resources in order to execute computations tend to rely more upon explicit strategies. However, when there are fewer working memory resources available then there is an increased likelihood that implicitly sourced solutions will prevail.

If mastery-approach pursuit relies more on working memory (relative to performance-approach), as findings from our first experiment appear to suggest, then we expect to observe the use of explicit task strategies by participants inducted into a mastery-approach state. The use of such a strategy should facilitate performance on challenging parts of a primary task that demand working memory. However, in the presence of high secondary load this advantage would be expected to disappear, with load consuming resources necessary for an explicit task strategy. Conversely, if performance-approach pursuit relies less on working memory, then this state should more readily engage implicit strategies. Reliance on implicit strategies would limit performance on challenging parts of a primary task which demand working memory (on the basis that implicitly derived answers don't permit as superior accuracy as explicit strategies), but would reduce susceptibility to experiencing a decline in performance under high secondary load.

In sum, it is predicted that a) mastery-approach pursuit will more readily engage the use of explicit strategies while performance-approach will more readily engage the use of implicit strategies, b) such differential engagement will particularly exert an effect on challenging (high-demand) parts of a primary achievement task, and c) on such challenging parts, the presence of high secondary load will be particularly damaging for mastery-approach goal pursuit by consuming the resources necessary for continued explicit strategy use under high load.

3.1. Method

3.1.1. Participants

Eighty University of London undergraduates (57 females) participated for course credits. Age was recorded in the same ranges as in Experiment 1, with a modal range of 18–25 years accounting for 90% of the sample. Informed consent was obtained prior to participation.

3.1.2. Experimental task

Similar to Experiment 1, participants performed a primary achievement goal pursuit task under dual-task conditions programmed using e-prime (Schneider et al., 2002).

3.1.2.1. Primary task. The primary goal pursuit task consisted of sets of Modular Arithmetic problems in which participants are presented with a problem statement (e.g. "6 = 3 (mod 2)"), and are required to make a true or false judgment on this problem within 20 s. Problem statements[4] are solved by subtracting the middle number from the first (e.g. 6–3) and then dividing the result of this subtraction by the mod number (e.g. 3/2). If this division results in a whole number the participant is required to make a true response, if the result is not a whole number then a false response is required. Problem statements remained on screen until a response was made or until 20 s had elapsed. Problem statements were manipulated to be either low or high in working memory demand. Demand level was determined by whether the first step of the problem statement had a number larger than 20 and required a borrow operation, thereby placing more demand on working memory processes (Ashcraft & Kirk, 2001).

3.1.2.2. Secondary task. As in Experiment 1, the primary task was interleaved with a secondary task (see Fig. 4). Given the numerical nature of the primary problem statement task, the secondary task consisted of letters rather than digits. In the condition of low secondary load, a

[4] We would like to thank Sian Beilock for kindly providing the set of Modular Arithmetic problems.

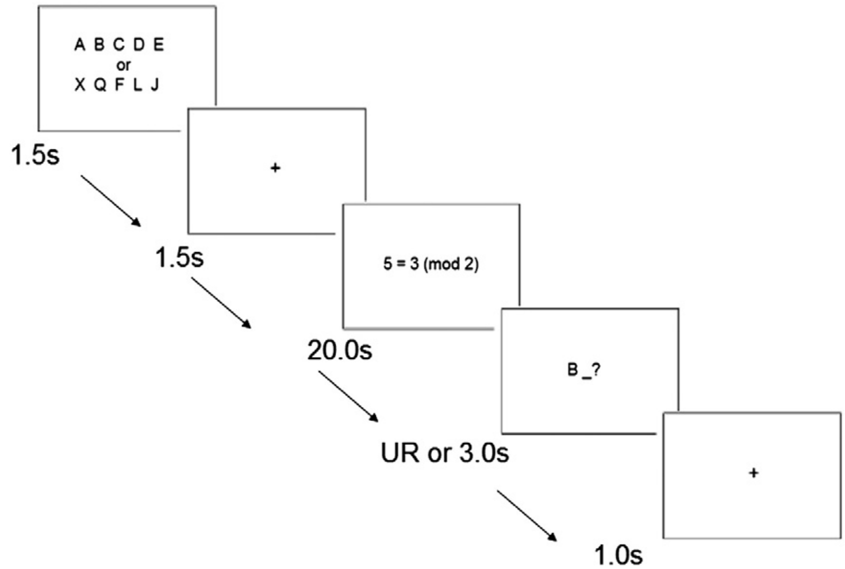

Fig. 4. Experiment 2: Example task trial illustrating possible low and high secondary load memory sets (with a low-demand modular arithmetic problem, and low load probe, specifically presented).

memory set was always presented in fixed order consisting of the letters A–B–C–D–E. However, in the high secondary load condition the letters X–Q–L–F–J were used with the letter X always remaining in the first position of the set but the order of the letters Q–L–F–J was varied at random. Correspondingly, memory probes presented were equally likely to be A–B–C or D in the low load condition and any of the letters X–Q–L–F–J in the high load condition. All other aspects of the secondary task interleaved with the primary problem statement task were as described in Experiment 1.

3.1.2.3. Primary and secondary task interleaved design. Following a practice tutorial, participants completed a baseline block of eight primary task problem statements under low secondary load (4 low-demand and 4 high-demand problem statements, randomly presented) followed by two counterbalanced experimental blocks (1 block per secondary load). The two main experimental blocks contained 24 trials each, for which a set of 24 primary task problem statements were generated for each block, each containing 12 low-demand and 12 high-demand problem statements, presented in a different random order for each participant. Half of the problem statements in each main block required a 'true' response. No trial based feedback on problem statement response accuracy was provided. Low-demand and high-demand problem statement performance was calculated by summing the number of correct responses to statements for each block. This created the key dependent variable; *Low-Demand Problem Accuracy* (*Low Load*), *High-Demand Problem Accuracy* (*Low Load*), *Low-Demand Problem Accuracy* (*High Load*), *High-Demand Problem Accuracy* (*High Load*).

3.1.3. Manipulation of achievement goal states

The same method of manipulation as described in the previous experiment was used, however an increasing points based system was used. Participants were told that they would receive points for correct responses to the problem statements, specifically, 3 points for the first correct response made, 4 points for the second and 5 points for the third consecutive correct response made, and so on. However, as soon as an incorrect response was made, participants kept their total points achieved at that moment but had to start back at 3 points again for the next correct response. This system was implemented to make it difficult for participants to estimate their score, which would have reduced the plausibility of feedback provided.

Following a baseline block, participants in the MAG condition read the following set of instructions prior to starting the first of two experimental blocks:

> *"Your round 1 score is X points. Your aim for this task is to develop your skill at performing the problem statements well. As such your goal for round 2 is to do better than your total round 1 score, which means getting more than X points in round 2. Round 2 will be more than twice as long as round 1, so your score will be adjusted accordingly at the end of the round to make for a fair comparison to the previous round score. The computer will tell you at the end of round 2 whether you achieved above your previous round score."*

In contrast, following a baseline block those in the PAG condition read the following set of instructions prior to starting the first of two main experimental blocks:

> *"Your aim for this task is to demonstrate your skill at performing the problem statements well in comparison to other students who have taken part. The average total score of students who have taken part so far in round 2 is X points. Your goal for round 2 is to do better than this average student round 2 score, which means getting more than X points in round 2. For your information, round 2 will be longer than the round you just completed. The computer will tell you at the end of round 2 whether you achieved above the average student score for the round."*

Goal instructions were then repeated once more between the first and second (also last) main experimental block with all reference to block length as shown in the instructions above, removed. As in Experiment 1, both goal conditions received a standardised set of target scores, and participants were told that they had reached their assigned goal for each main block. Participants in the NG condition received only standard task instructions, no points system or target goals were provided for such control participants.

3.1.4. Psychometric measures

3.1.4.1. Working memory capacity. We employed the same measure of working memory capacity (OSPAN; Turner & Engle, 1989) as described in Experiment 1.

3.1.4.2. State anxiety. On this occasion the state form of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) was used to assess experiences of anxiety during task performance in order to separately assess anxiety under low and high load task conditions. This scale ($\alpha = .88$; an average reliability taken from scores across the two reporting occasions) consists of 20 statements (e.g., '*I feel calm*' and 'I *feel nervous*') all starting with 'I feel' and completed with a one word anxiety related feeling.

3.1.4.3. Strategy use. In order to assess differences in problem statement solving strategies, i.e., as means of determining whether participants were following a multi-step strategy to solving the problem statements or not, we presented participants with the following question on a piece of A4 paper at the end of the first and the second (last) task block (adapted from Beilock & DeCaro, 2007); '*Can you write in the space provided how you mostly solved the challenging problem statements in the last round*'.

3.1.5. Manipulation checks

The same manipulation check measures as in Experiment 1 were used to assess task purpose, goal assigned, motivational state and goal commitment. All references in the phrases of the task purpose check list were to 'the problem statement game'. The mastery-approach and performance-approach scales of the Horvath et al. (2001) motivational state scale achieved internal consistency reliabilities of .88 and .90 respectively. Additionally, the Hollenbeck et al. (1989) goal commitment scale had an internal consistency reliability of .80.

3.1.6. Procedure

Participants were tested in the same sound proof laboratory as used in Experiment 1. The same procedure as described in Experiment 1 was followed with the following exceptions: After completing a practice tutorial followed by a baseline block, goal states were then induced before completing two main experimental blocks. Across all conditions, between the first and second main experimental block participants completed the STAI measure and then completed this measure again at the end of the second (also last) experimental block. Following this second STAI measure, participants completed the manipulation check measures in counterbalanced order, finally followed by the strategy use questions. Testing sessions lasted approximately 75 min.

3.2. Results and discussion

3.2.1. Manipulation checks

Task purpose, $\chi^2 = 29.05$, $df = 3$, $p < .001$, and goal assigned, $\chi^2 = 41.76$, $df = 3$, $p < .001$, checks confirmed that MAG and PAG participants correctly identified their goal state condition, and no differences in goal commitment between these conditions were found, $t(52) = .891$, $p = .377$, with both MAG ($M = 21.85$, $SD = 3.25$) and PAG ($M = 21.18$, $SD = 2.19$) participants reporting strong commitment to goals assigned. Significant group differences for Goal State checks on mastery-approach, $F(2,77) = 6.438$, $p = .003$, and performance-approach, $F(2,77) = 10.693$, $p < .001$, scales, also revealed that those in the MAG ($M = 15.15$, $SD = 3.790$) condition scored higher in state mastery-approach than those in the PAG ($M = 12.82$, $SD = 4.01$), $t(53) = 2.21$, $p = .031$, or NG ($M = 11.44$, $SD = 3.49$), $t(50) = 3.66$, $p = .001$, and that those in the PAG ($M = 14.57$, $SD = 3.54$) scored higher in state performance-approach than those in the MAG ($M = 9.96$, $SD = 4.69$), $t(53) = 4.12$, $p < .001$, and NG ($M = 10.60$, $SD = 3.66$), $t(51) = 4.01$, $p < .001$. Thus, manipulation of goal states was effective.

3.2.2. Preliminary analyses

Descriptive statistics are presented in Table 2. Gender, age and the order in which participants completed the experimental blocks under low or high secondary load, for both low and high-demand problem statements, had no effect on problem statement performance (*all p's* > .30). No group differences on baseline problem statement performance were found for either low-demand problems, $F(2,77) = 1.12$, $p = .33$, or high-demand problems, $F(2,77) = 2.30$, $p = .11$. There were no significant group differences in working memory capacity ($p = .92$) (*Ms*: MAG = 31.04, PAG = 31.29, NG = 31.64). All participants' self-reported state-anxiety was greater under high secondary load ($M = 40.80$, $SD = 8.71$) relative to low load ($M = 32.94$, $SD = 8.35$), $t(79) = 8.91$, $p < .001$. However, groups did not significantly differ in reported state-anxiety under low secondary load, $F(2,77) = .76$, $p = .47$, or under high secondary load, $F(2,77) = .83$, $p = .44$. Thus it would be difficult to explain any between group differences in terms of state anxiety. For all participants and regardless of primary task problem statement demand, secondary load task (probe) responses were significantly slower under high load (RT, in milliseconds) (RT: $M = 1177$, $SD = 344.9$), $F(1,79) = 10.06$, $p = .002$, and less accurate ($M = 14.9$, $SD = 4.6$), $F(1,79) = 119.40$, $p < .001$, than those under low load (RT: $M = 1031$, $SD = 187.2$) (Accuracy: $M = 24.1$, $SD = 4.1$), suggesting the manipulation of secondary working memory load was effective. Furthermore, responses to high-demand problem statements, regardless of secondary load condition, were significantly slower (RT: $M = 8271$, $SD = 2487.7$), $F(1,79) = 351.68$, $p < .001$, and less accurate ($M = 8.6$, $SD = 2.3$), $F(1,79) = 126.47$, $p < .001$, than those to low-demand problem statements (RT: $M = 4137$, $SD = 1285.5$) (Accuracy: $M = 11.3$, $SD = .83$), indicating that the manipulation of problem statement demand was effective. Mean RT to probes under low secondary load, $F(2,77) = .256$, $p = .77$, and under high secondary load, $F(2,77) = .640$, $p = .530$, were not found to differ between groups. Similarly, no group differences in secondary task (probe) accuracy under low load, $F(2,77) = 1.37$, $p = .26$, or high load, $F(2,77) = .555$, $p = .58$, were found.

3.2.3. Problem statement performance

Problem Statement Accuracy was examined in a 2 (Secondary load: low, high) × 2 (Problem Statement Demand: low, high) × 3 (Achievement Goal Condition; MAG, PAG, NG), ANOVA. All analyses were restricted to trials in which a correct secondary load probe response was made. A significant main effect for secondary load, $F(1,77) = 185.28$, $p < .001$, $\eta p^2 = .706$, indicated that all participants performed poorer under high secondary load than low load, regardless of problem statement demand. Also, a significant main effect for problem statement demand was confirmed, $F(1,77) = 115.85$, $p < .001$, $\eta p^2 = .601$, with all participants having lower accuracy on high-demand problems (compared to low-demand problems) regardless of secondary load.

Table 2
Experiment 2: means and standard deviations of variables by goal condition.

	Mastery-approach		Performance-approach		No-goal control	
	M	*SD*	*M*	*SD*	*M*	*SD*
State mastery-approach	15.15	3.79	12.82	4.01	11.44	3.48
State performance-approach	9.96	4.68	14.57	3.54	10.60	3.66
Working memory capacity	31.04	6.27	31.29	5.18	31.64	5.25
State-anxiety (low load)	34.52	9.03	31.86	7.84	32.44	8.19
State-anxiety (high load)	42.56	8.38	39.79	8.54	40.04	9.27
Goal commitment	21.85	3.24	21.18	2.19	–	–
Low-demand problem accuracy (low load)	11.26	1.40	11.32	1.30	11.36	.86
High-demand problem accuracy (low load)	9.30	2.55	7.96	3.20	9.00	2.84
Low-demand problem accuracy (high load)	7.59	3.34	7.64	2.85	7.76	2.26
High-demand problem accuracy (high load)	4.37	2.57	5.54	2.42	4.60	2.21

Note: Mastery-approach, N = 27; Performance-approach, N = 28; No-goal control, N = 25. State mastery-approach and state performance-approach are self-report forms. Those in the no-goal control condition didn't complete a goal commitment measure.

A significant three-way interaction was also obtained, $F(2,77) = 3.18$, $p = .047$, $\eta p^2 = .076$. This reflected a significant 2 (secondary load: low, high) × 3 (Achievement Goal Condition; MAG, PAG, NG) interaction for high-demand problem statements, $F(2,77) = 3.81$, $p = .026$, $\eta p^2 = .090$, but not low-demand problem statements, $F(2,77) = .006$, $p = .994$, $\eta p^2 < .001$, suggesting that the impact of secondary load on performance of high-demand problem statements differed across goal groups. Further analysis confirmed that participants in all conditions experienced a significant decline on high-demand problem statement accuracy from low to high secondary load (MAG, $F(1,26) = 89.72$, $p < .001$, $\eta p^2 = .775$, PAG, $F(1,27) = 8.60$, $p = .007$, $\eta p^2 = .241$, NG, $F(1,24) = 45.73$, $p < .001$, $\eta p^2 = .656$), but that this effect was largest in the MAG condition and smallest in the PAG condition. Results suggest that PAG participants depend less on working memory relative to MAG and NG. There was also an effect of experimental group on calculated decrement scores (consistent with Experiment 1) from low to high secondary load, $F(2,79) = 3.81$, $p = .026$, (see Fig. 5). Planned contrasts revealed that participants in the MAG condition suffered the largest decrement compared to those in other experimental groups, $t(77) = 1.81$, $p = .07$. In line with predictions and the results of Experiment 1, those in the MAG condition suffered a larger decrement than those in the PAG condition, $t(77) = 2.62$, $p = .011$.

3.2.4. Task strategies

The first author and a research assistant both independently coded reported task strategies, both blind to assigned goal condition. Analyses showed a high level of agreement between coders, $k = .82$. The strategies used to solve problem statements reported by participants were examined under low and high secondary load, and classified into one of the following three categories (again, in accordance with the work of Beilock & DeCaro, 2007). First, a working memory intensive explicit strategy was identified in reports that demonstrated reliance upon an incremental, step-by-step strategy (e.g., "*I treated the equals sign as a minus sign and subtracted the second number from the first in my head, and then worked out how many times the number at the end went into that answer*"). Second, a less working memory intensive implicit strategy was identified in reports that made use of 'short cuts' eliminating a step-by-step strategy (e.g., "*I was mostly rounding the numbers and roughly deciding if it was right or not.*", and "*All the numbers together just looked liked it would be true because sometimes it was clear that the mod number would fit exactly*"). A third category ('random') was used to represent any strategies that didn't make sense or lacked sufficient detail to clearly identify as explicit or implicit.

Table 3 depicts the percentage of participants who reported using each strategy under low and under high secondary load by experimental condition. It was important to illustrate that explicit strategies better predict superior performance on high-demand problem statements, under low secondary load at least, and to examine which strategy predicted, if any, more superior performance on high-demand problem statements under high secondary load. Explicit strategies should be less likely to predict superior high-demand problem statement accuracy under high secondary load due to the limited availability of resources that such a strategy would require. Whilst controlling for experimental condition, first, high-demand problem statement accuracy under low secondary load was regressed on reported strategy use (dummy coded). A significant model was found, $F(4,79) = 9.28$, $p < .001$, with explicit strategies significantly predicting accuracy ($\beta = .769$), $t(79) = 5.04$, $p < .001$, and implicitly driven strategies predicting at a trend level ($\beta = .303$), $t(79) = 2.01$, $p = .05$. This suggests that explicit strategies were a better overall predictor of high-demand problem statement accuracy under low secondary load than implicit ones. Secondly, (controlling for experimental condition) high-demand problem statement accuracy under high secondary load was regressed on reported strategy use (dummy coded). A significant model was found, $F(4,79) = 6.04$, $p < .001$, with explicit strategies sharing no relation with accuracy ($\beta = .088$), $t(79) = .403$, $p = .69$, but with implicit strategies predicting higher accuracy ($\beta = .566$), $t(79) = 2.50$, $p = .015$. This pattern of results is suggestive of a double dissociation, whereby explicit strategies are associated with higher performance on high-demand problems under a low secondary load, and implicit strategies are associated with higher performance on high-demand problems under a high secondary load. Chi-square tests revealed a significant association between experimental condition and high-demand problem statement strategy use under both low ($\chi^2 = 10.428$, $df = 4$, $p = .034$) and high ($\chi^2 = 15.725$, $df = 4$, $p = .003$) secondary load. Under low secondary load, employment of either an explicit or implicit strategy varied between those in the mastery-approach condition compared to those in the performance-approach condition ($\chi^2 = 10.10$, $df = 1$, $p = .001$). The use of an explicit strategy was mostly evident amongst those in the mastery-approach condition (63%), relative to those in the performance-approach condition (21.4%) who demonstrated the least use of this strategy. The use of implicit based strategies under low secondary load however was most strongly evident for those in the assigned performance-approach condition (64.3%), relative to those in the mastery-approach condition (25.9%) who demonstrated the most minimal reliance upon such strategies. Under high secondary load, employment of either an explicit or implicit strategy also varied between those in the mastery-approach condition compared to those in the performance-approach condition ($\chi^2 = 8.65$, $df = 1$, $p = .001$). The use of an explicit strategy was mostly evident amongst those in the mastery-approach condition (55.6%), in comparison to those in the performance-approach condition (17.9%). Conversely, an implicit strategy was most strongly evident for those in the performance-approach condition (78.6%) in comparison to those in the mastery-approach condition (40.7%). Interestingly as can be seen in Table 3, under high secondary load it appears that the strategy use of participants in the no-goal control condition is most similar to that of participants in the mastery-approach condition.

Overall, these results suggest that participants pursuing a mastery-approach goal were most likely to rely on an explicit strategy under low secondary load. This continued to be the case under high secondary load, despite a slight increase in implicit strategy use and decrease in

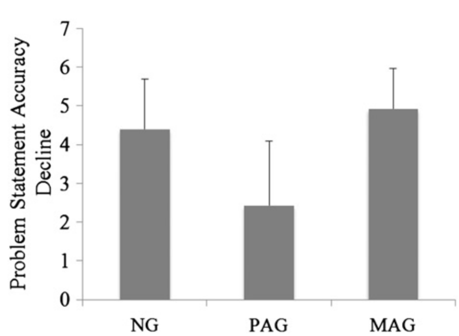

Fig. 5. Experiment 2: High-demand problem statement accuracy decline from low to high secondary load by goal condition.

Table 3
Experiment 2: percentage of participants using each strategy under low and high load by goal condition.

	Mastery-approach	Performance-approach	No-goal control
Low load			
Explicit	63%	21.4%	48%
Implicit	25.9%	64.3%	40%
Random	11.1%	14.3%	12%
High load			
Explicit	55.6%	17.9%	52%
Implicit	40.7%	78.6%	32%
Random	3.7%	3.6%	16%

Note: Mastery-approach, N = 27; Performance-approach, N = 28; No-goal control, N = 25.

explicit strategy use. As such, those in the mastery-approach condition were tending to persevere with a working memory intensive strategy even when there were fewer resources to accommodate such a strategy. This seems likely to account for the large decline in high-demand problem statement accuracy from low to high secondary load. On the other hand, those pursuing a performance-approach goal were most likely to employ implicit strategies under both low and high secondary load. This seems likely to account for their relatively smaller decline in high-demand problem statement accuracy from low to high secondary load.

4. General discussion

This research demonstrates, for the first time, that working memory plays a selective role in achievement goal pursuit. The availability of working memory appears to be more important for mastery-approach goal pursuit relative to performance-approach goal pursuit. A focus on developing self-referential skill (mastery-approach) relies heavily on working memory for successful goal execution, facilitated by task strategies that place heavy demands on such resources. Conversely, a focus on demonstrating normative skill (performance-approach) depends somewhat less on working memory, facilitated by the use of task strategies that place little demand on such resources.

In Experiment 1, those pursuing a mastery-approach goal suffered the largest word game performance decline following an increase in secondary working memory load. Although those pursuing a performance-approach goal and those in the no-goal condition, also suffered a word game performance decline from low to high secondary load, these effects were smaller than those in the mastery-approach condition. This suggests that pursuit of a mastery-approach goal relied more heavily on working memory in order to perform the word game well, relative to performance-approach goal pursuit and those pursing no assigned goal. Decrement score analyses confirmed this overall pattern of results, with those assigned a mastery-approach goal experiencing a significantly larger primary word game performance decrement from low to high secondary load than those participants in the other conditions.

In Experiment 2, all participants (regardless of goal group) appeared to perform parts of a task which placed little demand on working memory similarly under low and under high secondary load. However, consistent with Experiment 1 findings, it was found that those pursuing a mastery-approach goal experienced the largest performance decline under high secondary load on those parts of a task that placed high-demands on working memory resources. This is consistent with the notion that higher secondary load consumes the working memory resources engaged during mastery-approach goal pursuit when demands are high. Those pursuing a performance-approach goal experienced the smallest decline in high-demand problem statement accuracy from low to high secondary load. Thus, results confirm that those pursuing a mastery-approach goal rely more on the availability of working memory resources than participants in the other conditions.

Interestingly in Experiment 2, those in the no-goal control condition performed quite similarly to those in the mastery-approach condition, which was unexpected (opposite to Experiment 1). This highlights interest in the extent to which achievement goal states are enhancing or limiting working memory engagement. Importantly, Experiment 1 and 2 participants in the no-goal condition were not induced into either a mastery-approach or performance-approach state (according to manipulation checks). Motivational state may have nonetheless varied between the control participants in the two experiments (e.g., different task requirements activating different default goals which were not captured). Despite clear achievement goal effect consistencies, this highlights a future research question in terms of what 'no-goal' control actually entails in the context of achievement motivation.

Crouzevialle and Butera (2012) recently found that performance-approach pursuit depletes working memory resources relative to a control condition. Crouzevialle and Butera interestingly suggest that pressure to outperform others generates 'outcome' concerns which deplete working memory resources available for the activity at hand. Current findings pertain more to whether different kinds of achievement goal states differentially rely on the availability of working memory resources (via task solving strategies employed). Despite these different research approaches, importantly, the work of Crouzevialle and Butera is somewhat compatible with the current findings. That is, Crouzevialle and Butera (2012) find that performance-approach goal pursuit results in off-task related consumption of resources and the current work explores what those pursuing a performance-approach goal might do with the limited remaining task relevant resources (employ task strategies that demand less working memory). However it is important to note that Crouzevialle and Butera (2012) used the same modular arithmetic task employed in Experiment 2 of the present paper. Interestingly, these authors suggested that it is highly unlikely that short-cut strategies would be used to facilitate performance on this task. Their reasoning for this suggestion is that each problem statement appears only once, and the experimental setting left no time for participants to prepare for the task. Against this, the present research (Experiment 2) reveals self-reported strategy use can explain differences in the performance displayed by groups under high secondary load. Specifically, reliance upon less working memory intensive strategies (implicit) was more evident for those in the performance-approach condition, whereas reliance upon more working memory intensive strategies (explicit) was more evident for those in the mastery-approach condition. Such findings may help to explain previous research demonstrating superior cognitive performance for mastery-approach (Bereby-Meyer & Kaplan, 2005; Escribe & Huet, 2005), especially when a task is executively demanding (Avery & Smillie, 2013; Graham & Golan, 1991). This is further fitting with previous research associating strategic surface processing as more favourable with performance-approach goal pursuit (arguably a strategy adopted in order to work with limited task-relevant resources), and, deeper processing of material as more favourable with mastery-approach goal pursuit (Graham & Golan, 1991; Harackiewicz & Linnenbrink, 2005). Although these processing preferences are variable, the current findings therefore illustrate that even when the resources necessary for such superior performance in effortful conditions are consumed, mastery-approach goal pursuit appears to continue to rely upon a working memory intensive strategy.

It is interesting that those in a state of mastery-approach appeared to favour more effortful strategies, even when this was detrimental to their performance. This is consistent with research which shows that a mastery-approach focus can result in unintentional sabotage of achievement by increased engagement in tangential studying rather than strategically targeting learning objectives (Senko & Miles, 2007; but also see Schwinger & Stiensmeier-Pelster, 2011). Alternatively, it may be the case that being in a state of mastery-approach actually makes individuals worse at detecting alternative task strategies which will specifically aid outcome success. In other words, they are too consumed (distracted) by implementing something of interest, rather than realising what actually needs to be done to achieve a specified outcome (see Bodmann, Hulleman, & Harackiewcz, 2008). If reliance upon working memory intensive strategies allows individuals in a state of mastery-approach to satisfy the goal of 'developing competence', then this might make them less susceptible to directing their attention to strategies (i.e., away from the instructed strategy) which would help them actually achieve a certain task score or academic grade. This idea would be consistent with research which has shown that those with more available working memory resources are better at focusing their attention on task properties and ignoring irrelevant information, whereas, those with less available working memory are less able to allocate attentional resources to one specific strategy (Conway et al., 2001). This would also be consistent with research which outlines that working memory availability provides more goal-directed control of attention, minimising interference (Lavie & de Fockert, 2005; see Lavie, 2010 for review).

As such, continued investigation of the achievement goal-working memory strategy based relations would benefit from utilising a task for which detection of alternative task strategies could be more objectively addressed through actual task performance.

In both Experiments 1 and 2, participants are presented with a set of consistently positive target feedback scores across task blocks (e.g., mastery-approach: *Yes, you scored better than your previous round score*). It is possible that this positive feedback design feature may have reduced feelings of uncertainty about goal-attainment for both goal groups. Given that participants still comparably report being in heightened mastery-approach and performance-approach goal pursuit states according to assigned conditions (i.e., they clearly do report to be concerned with achieving their assigned goal even if feelings of competence were enhanced), one is less apprehensive about the accountability of this design feature in terms of between group differences observed. Also, if positive feedback is removed and uncertainty is increased then arguably both goal groups would be equally susceptible to experiencing anxiety regarding *task specific* goal achievement. Future research would benefit greatly from inclusion of direct, objective, measures of perceived competence and possible modifications of assigned achievement goals when employing a similar feedback design to the current research. Also, provision of 'actual' task feedback rather than standardised feedback in future studies would offer insight into the stability of the magnitude and direction of effects observed in the present work. In the current work, difficulty levels of the primary tasks utilised were not manipulated but kept constant. It would be interesting in future research to utilise true feedback scores within an increasingly challenging achievement goal task framework where possible learning curves, and the impact of this on engagement of working memory resources, could be more closely examined. Lastly, it is also worth noting here that the aim of the current research was to investigate the role of working memory in *approach* motivated goal pursuit. Consideration of *avoidance* based achievement goals (performance-avoid, mastery-avoid) and of the interactive effects of approach-avoidance achievement goals in relation to working memory is essential in order for this research area to progress.

In this work, we used a standard manipulation of working memory load, comparing a condition with high load with a condition with no load. We note that, as the low load condition involved no load at all, the low and high load conditions differed not only in terms of the load on working memory, but also in terms of the requirement to perform a single versus a dual task. Dual task performance may rely on similar cognitive control functions to working memory, and high working memory load and dual task performance have been shown to have similar effects on performance on attention tasks (Lavie, Hirst, de Fockert, & Viding, 2004). Further work is needed to distinguish between the effects of working memory load and dual task performance on achievement goal pursuit.

5. Conclusions

In summary, the present research has shown, for the first time, that working memory plays a critical role in the pursuit of achievement goals, and that this role depends upon whether ones motivated focus is on developing self-referential skill or demonstrating normative skill. Strengths of the research include the use of multiple manipulation checks, which all confirmed the effective inducement of desired motivational states, increasing confidence in attributing results to between state achievement goal group effects. Furthermore, the present findings are also not confounded by goal group differences in state-anxiety, increasing confidence that effects observed are unlikely to be explained in terms of differences in affect that the goal manipulations might have fostered. The present findings advance understanding of the interplay between motivation and cognition, building on pioneering research in this area (e.g., Gable & Harmon-Jones, 2008; Gasper, 2004; Gray, 2001; Phillips, Bull, Adams, & Fraser, 2002). These findings may inform the development of training performance strategies designed to either minimise or maximise allocation of working memory resources. They also help to address more basic questions in psychology concerning the mechanisms through which motivation translates into action and achievement.

Acknowledgements

The first author (R. E. Avery) would like to acknowledge financial support from Goldsmiths, University of London. The first author would also like to acknowledge Emma Smith (University of Surrey) for her assistance in coding Experiment 2 task strategies.

References

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology. General*, *130*, 224–237.

Avery, R. E., & Smillie, L. D. (2013). The impact of achievement goal states on working memory. *Motivation and Emotion*, *37*, 39–49.

Baddeley, A.D. (1986). *Working memory*. Oxford: Clarendon Press.

Baddeley, A.D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*, 417–423.

Baddeley, A.D., & Hitch, G. J. (1974). Working memory. In G. H. Bower (Ed.), *Recent advances in learning and motivation*, *Vol. VIII*, New York: Academic Press.

Barker, K. L., McInerney, D.M., & Dowson, M. (2002). Performance approach, performance avoidance and depth of information processing: A fresh look at relations between students academic motivation and cognition. *Educational Psychology*, *22*, 571–589.

Beilock, S. L., & Carr, T. H. (2005). When high-powered people fail: Working memory and "choking under pressure" in math. *Psychological Science*, *16*, 101–105.

Beilock, S. L., & DeCaro, M. S. (2007). From poor performance to success under stress: Working memory, strategy selection, and mathematical problem solving under pressure. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*, 983–998.

Beilock, S. L., Kulp, C. A., Holt, L. E., & Carr, T. H. (2004). More on the fragility of performance: Choking under pressure in mathematical problem solving. *Journal of Experimental Psychology. General*, *133*, 584–600.

Beilock, S. L., Rydell, R. J., & McConnell, A.R. (2007). Stereotype threat and working memory: Mechanisms, alleviation, and spill over. *Journal of Experimental Psychology. General*, *136*, 256–276.

Bereby-Meyer, Y., & Kaplan, A. (2005). Motivational influences on transfer of problem-solving strategies. *Contemporary Educational Psychology*, *30*, 1–22.

Bodmann, S., Hulleman, C. S., & Harackiewcz, J. M. (2008). Achievement goal systems: An application of goal systems theory to achievement goal research. *International Journal of Social Psychology*, *21*, 71–96.

Cadinu, M., Maass, A., Rosabianca, A., & Kiesner, J. (2005). Why do women underperform under stereotype threat? Evidence for the role of negative thinking. *Psychological Science*, *16*, 572–578.

Conway, A.R. A., Cowan, N., & Bunting, M. F. (2001). The cocktail party phenomenon revisited: The importance of working memory capacity. *Psychonomic Bulletin & Review*, *8*, 331–335.

Crouzevialle, M., & Butera, F. (2012). Performance-approach goals deplete working memory and impair cognitive performance. *Journal of Experimental Psychology. General*. http://dx.doi.org/10.1037/a0029632.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*, 450–466.

DeShon, R. P., Brown, K. G., & Greenis, J. L. (1996). Does self-regulation require cognitive resources? Evaluation of resource allocation models of goal setting. *Journal of Applied Psychology*, *81*, 595–608.

DeStefano, D., & LeFevre, J. A. (2004). The role of working memory in mental arithmetic. *European Journal of Cognitive Psychology*, *16*, 353–386.

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, *41*, 1040–1048.

Elliot, A. J. (1999). Approach and avoidance motivation and achievement goals. *Educational Psychologist*, *34*, 169–189.

Elliot, A. J. (2005). A conceptual history of the achievement goal construct. In A. J. Elliot, & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 52–72). New York: The Guilford Press.

Elliot, A. J., & Church, M.A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology*, *72*, 218–232.

Elliot, A. J., & Harackiewicz, J. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology*, *70*, 461–475.

Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology*, *80*, 501–519.

Elliot, A. J., Shell, M. M., Henry, K., & Maier, M. (2005). Achievement goals, performance contingencies, and performance attainment: An experimental test. *Journal of Educational Psychology*, *97*, 630–640.

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, *11*, 19–23.

Escribe, C., & Huet, N. (2005). Knowledge accessibility, achievement goals, and memory strategy maintenance. *British Journal of Educational Psychology*, *75*, 87–104.

Evans, J., & St, B. T. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Science*, *7*, 454–459.

Gable, P. A., & Harmon-Jones, E. (2008). Approach-motivated positive affect reduces breadth of attention. *Psychological Science*, *19*, 476–482.

Gasper, K. (2004). Do you see what I see? Affect and visual information processing. *Cognition and Emotion*, *18*, 405–421.

Gevins, A., & Cutillo, B. (1993). Spatiotemporal dynamics of component processes in human working-memory. *Electroencephalography and Clinical Neurophysiology*, *87*, 128–143.

Graham, S., & Golan, S. (1991). Motivational influences on cognition: Task involvement, ego involvement, and depth of information processing. *Journal of Educational Psychology*, *83*, 187–194.

Gray, J. R. (2001). Emotional modulation of cognitive control: Approach–withdrawal states double-dissociate spatial from verbal two-back task performance. *Journal of Experimental Psychology. General*, *130*, 436–452.

Halpern, D. F., & Wai, J. (2007). The world of competitive scrabble: Novice and expert differences in visuospatial and verbal abilities. *Journal of Experimental Psychology. Applied*, *13*, 79–94.

Harackiewicz, J. M., & Linnenbrink, E. A. (2005). Multiple achievement goals and multiple pathways for learning: The agenda and impact of Paul R. Pintrich. *Educational Psychologist*, *40*, 75–84.

Hofmann, W., Schmeichel, B. J., Friese, M., & Baddeley, A.D. (2011). Working memory and self-regulation. In K. D. Vohs, & R. F. Baumeister (Eds.), *The handbook of self-regulation: Research, theory, and applications*, *2*, New York, NY: Guilford.

Hollenbeck, J. R., Williams, C. L., & Klein, H. J. (1989). An empirical examination of the antecedents of commitment to difficult goals. *Journal of Applied Psychology*, *74*, 18–23.

Horvath, M., Scheu, C. R., & DeShon, R. P. (2001). Goal orientation: Integrating theory and measurement. *Paper presented at the 16th Annual Conference of the Society for Industrial and Organizational Psychology, San Diego, CA*.

Hulleman, C. S., Durik, A.M., Schweigert, S. A., & Harackiewicz, J. M. (2008). Task values, achievement goals, and interest: An integrative analysis. *Journal of Educational Psychology*, *100*, 398–416.

Ikeda, M., Iwanaga, M., & Seiwa, H. (1996). Test anxiety and working memory system. *Perceptual and Motor Skills*, *82*, 1223–1231.

Krawczyk, D. C., & D'Esposito, M. (2011). Modulation of working memory function by motivation through loss-aversion. *Human Brain Mapping*. http://dx.doi.org/10.1002/hbm.21472.

Lavie, N. (2010). Attention, distraction and cognitive control under load. *Current Directions in Psychological Science*, *19*, 143–148.

Lavie, N., & de Fockert, J. W. (2005). The role of working memory in attentional capture. *Psychonomic Bulletin & Review*, *12*, 669–674.

Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology. General*, *133*, 339–354.

Linnenbrink, E., Ryan, A., & Pintrich, P. (1999). The role of goals and affect in working memory functioning. *Learning and Individual Differences*, *11*, 213–230.

MacLeod, C., & Donnellan, A.M. (1993). Individual differences in anxiety and the restriction of working memory capacity. *Personality and Individual Differences*, *15*, 163–173.

Miller, E. K., & Cohen, J.D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neurosciences*, *24*, 167–202.

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, *91*, 328–346.

Phillips, L. H., Bull, R., Adams, E., & Fraser, L. (2002). Positive mood and executive function: Evidence from Stroop and fluency tasks. *Emotion*, *2*, 12–22.

Robbins, T. W., Anderson, E., Barker, D. R., Bradley, A.C., Fearnyhough, C., Henson, R., et al. (1995). Working memory in chess. *Memory & Cognition*, *24*, 83–93.

Ryan, R. M., Koestner, R., & Deci, E. L. (1991). Varied forms of persistence: When free-choice behavior is not intrinsically motivated. *Motivation and Emotion*, *15*, 185–205.

Rydell, R. J., McConnell, A.R., Mackie, D.M., & Strain, L. M. (2006). Of two minds: Forming and changing valence-inconsistent implicit and explicit attitudes. *Psychological Science*, *17*, 954–958.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime user's guide*. Pittsburgh: Psychology Software Tools Inc.

Schwinger, M., & Stiensmeier-Pelster, J. (2011). Prevention of self-handicapping—The protective function of mastery goals. *Learning and Individual Differences*, *21*(6), 699–709.

Senko, C., Durik, A.M., & Harackiewicz, J. (2008). Historical perspectives and new directions in achievement goal theory: Understanding the effects of mastery and performance-approach goals. In J. Y. Shah, & W. L. Gardner (Eds.), *Handbook of motivation science* (pp. 100–113). New York: Guilford Press.

Senko, C., & Harackiewicz, J. M. (2005). Achievement goals, task performance, and interest: Why perceived goal difficulty matters. *Personality and Social Psychology Bulletin*, *31*, 1739–1753.

Senko, C., Hulleman, C. S., & Harackiewicz, J. M. (2011). Achievement goal theory at the crossroads: Old controversies, new challenges, new directions. *Educational Psychologist*, *46*, 26–47.

Senko, C., & Miles, K. M. (2007). *Pursuing their own learning agenda. How mastery-orientated students jeopardise their class performance*. Unpublished Manuscript.

Siegler, R. S. (1988a). Individual differences in strategy choices: Good students, not-so-good students, and perfectionists. *Child Development*, *59*, 833–851.

Siegler, R. S. (1988b). Strategy choice procedures and the development of multiplication skill. *Journal of Experimental Psychology. General*, *117*, 258–275.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3–22.

Spielberger, C. C., Gorsuch, R. L., & Lushene, R. (1970). *State–Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychology Press.

Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate? *The Behavioral and Brain Sciences*, *23*, 645–726.

Steele-Johnson, D., Heintz, P., & Miller, C. E. (2008). Examining situationally induced state goal orientation effects on task perceptions, performance, and satisfaction: A two-dimensional conceptualization. *Journal of Applied Social Psychology*, *38*, 334–365.

Stevenson, L. M., & Carlson, R. A. (2003). Information acquisition strategies and the cognitive structure of arithmetic. *Memory & Cognition*, *31*, 1249–1259.

Trbovich, P. L., & LeFevre, J. (2003). Phonological and visual working memory in mental addition. *Memory & Cognition*, *31*, 738–745.

Treisman, M., & Doctor, E. (1987). Memory scanning: A comparison of the dynamic stack and exhaustive serial scan models with an extension of the latter. *Acta Psychologica*, *64*, 39–92.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language*, *28*, 127–154.

Van Yperen, N. W., Elliot, A. J., & Anseel, F. (2009). The influence of mastery-avoidance goals on performance improvement. *European Journal of Social Psychology*, *39*, 932–943.

Van Yperen, N. W., Hamstra, M. R. W., & Van der Klauw, M. (2011). To win, or not to lose, at any cost: The impact of achievement goals on cheating. *British Journal of Management*, *22*, 5–15.

Wegge, J. (2001). Motivation, information processing and performance: Effects of goal setting on basic cognitive processes. In A. Efklides, J. Kuhl, & R. Sorrentino (Eds.), *Trends and prospects in motivational research* (pp. 271–298). Dordrecht: Kluwer.

Worthy, D. A., Markman, A.B., & Maddox, W. T. (2009). What is pressure? Evidence for social pressure as a type of regulatory focus. *Psychonomic Bulletin and Review*, *16*, 344–349.