Interaction between Cognitive and Non-Cognitive Factors: the Influences of Academic Goal Orientation and Working Memory on Mathematical Performance

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Abstract

Although the effects of achievement goals and working memory on academic performance are well established, it is not clear whether achievement goals and working memory jointly affect academic performance. Children from Primary 4 and 6 (N = 608) were administered (a) measures of working memory and updating from the Automated Working Memory Battery and a running span task, (b) performance and mastery goal measures from the Inventory of School Motivation, and (c) a battery of standardised and curriculum based mathematical tests. Structural equation modelling showed that performance goal had a negative effect on mathematics. Both mastery and performance goals had direct (positive and negative, respectively) effects on working memory capacity. Moderated mediation analysis showed that the negative impact of performance goal on mathematics was stronger for children with lower levels of mastery goal or working memory, than for those with higher levels. These findings suggest that a reduction in the availability of working memory resources may be one reason for a high performance orientation to be associated with poorer academic performance.

Interaction between Cognitive and Non-Cognitive Factors: the Influences of Academic Goal Orientation and Working Memory on Mathematical Performance

Working memory and motivation are important contributors to the success of goal-directed behaviours (Szatkowska, Bogorodzki, Wolak, Marchewka, & Szeszkowski, 2008). Working memory capacity has been found to be strongly and positively associated with children's mathematical performance (Andersson, 2008; Fuchs et al., 2005; Lee, Ng, & Ng, 2009; Swanson & Beebe-Frankenberger, 2004). Children with poorer mathematical abilities have also been found to have lower working memory capacity (e.g., Lee & Peh, 2008). There has been a long history of research on the impact of academic motivation on educational outcomes. Conceptualised as students' energy and drive to engage in learning, it has been shown to be associated with both cognitive performance (e.g., Chan, Schmitt, Deshon, Clause, & Delbridge, 1997; Fortier, Vallerand, & Guay, 1995; Humphreys & Revelle, 1984) and academic achievement (e.g., Martin, Marsh, & Debus, 2001, 2003; Mcinerney, Roche, Mcinerney, & Marsh, 1997).

Although there is an established literature on the relationship between (a) working memory and academic performance and (b) motivation and academic performance, there is a dearth of information on whether working memory and motivation jointly affect performance. Potential linkages between the two constructs had previously been proposed (Pintrich, Roeser, & Degroot, 1994). From a theoretical perspective, working memory can be deemed a mental workspace at which higher cognitive processes are executed, with motivation providing the overall direction and perhaps the amount of cognitive resources that are allocated. Similarly, Brooks and Shell (2006) referred to motivation as the process by which one consciously or unconsciously allocates working memory resources, which in turn, affects one's ability to perform demanding tasks. According to these definitions, working memory capacity places limits on how well or efficiently a task can be performed. Motivation determines how much resource one is willing to apply to that task. In this study, we focused on the executive component of working memory, the achievement goals dimensions of school motivation, and their relationships to mathematical performance.

Working Memory and Mathematics Performance

There are a number of models of working memory (Miyake & Shah, 1999). Some view working memory as a unitary, limited capacity system, where cognitive processes compete for a limited pool of resources (Cowan, 1999; Engle, Kane, & Tuholski, 1999). Others conceptualize working memory as a multi-component system comprising of specialized subsystems. In this study, we rely on the multi-component model proposed by Baddeley and Hitch (1974). According to Baddeley's model, working memory provides a workspace for the simultaneous, but temporary storage and processing of information. The latest version of the model consists of four components: the central executive, phonological loop, visual spatial sketchpad, and an episodic buffer (Baddeley, 2000). Both the phonological loop and the visual spatial sketchpad are short-term storage systems. The former is responsible for storing and rehearsing auditory information. The latter maintains visual spatial information. The central executive was proposed to be involved in coordinating subordinate cognitive processes, switching between tasks, retrieving previously learned strategies or operations, inhibiting irrelevant information, and activating and retrieving information from long-term memory (Baddeley, 1996). The episodic buffer is the newest addition to the model and is thought to facilitate the exchange of information between the central executive and long-term memory. Although much of the earlier works on the model were conducted with adults, Gathercole, Pickering, Ambridge, and Wearing (2004) found the canonical structure of working memory is in place from as early as 6 years of age.

Previous studies have found the central executive to be more closely associated with academic performance than were other components of the working memory system (e.g., Lee, Ng, Ng, & Lim, 2004). Indeed, most studies have found working memory to be more predictive of academic achievement than measures of intelligence (Andersson, 2008; Lee, Ng, et al., 2009; Swanson, 2004) (cf. Lee, Pe, Ang, & Stankov, 2009). Others have found evidence that this relationship is causal in nature. Lee and Ng (2009), for example, used a dual task paradigm and found children's performance on mathematical word problems to be disproportionately and detrimentally affected by a reduction in access to executive resources.

Achievement Goal Orientation

There are a number of perspectives on motivation. The theory of achievement goals focuses on the purposes or reasons an individual is pursuing an achievement task and the standard or criteria that are used to judge performance (Linnenbrink & Pintrich, 2000). Achievement goal orientation was originally conceptualised as a relatively stable unidimensional trait-like disposition, with learning or mastery goal orientation lying on one end and performance goal orientation on the other (Dweck, 1986; Dweck & Leggett, 1988). More specifically, a mastery goal orientation which emphasises becoming proficient in a task via the development of knowledge, skill, and understanding relative to an individual's previous performance was originally viewed as being mutually exclusive to a performance goal orientation, which emphasizes the demonstration of competence through comparison with others. However, more recent findings have provided evidence that individuals can demonstrate simultaneously high levels of both of these goal orientations (e.g. Meece & Holt, 1993). Mastery and performance goals are now generally conceptualised as distinct dimensions, which can coexist and exert simultaneous influences on behaviour (Covington & Müeller, 2001; Lepper & Henderlong, 2000)

Although prior research on goal orientation have consistently demonstrated the associations of mastery goal orientation with a host of performance measures and adaptive patterns of cognition, affect and behaviour (Ames & Archer, 1988; Butler, 1992; Phillips &

Gully, 1997), findings on performance goal orientation were less consistent. Negative, non-significant, and even positive associations with measures of performance have been reported (Bell & Kozlowski, 2002; Elliot, 1999; Meece, Blumenfeld, & Hoyle, 1988). Meece et al. (1988), for example, found fifth- and sixth-grade students' mastery goals and performance oriented goals were both positively associated with cognitive engagement, but there was a significant negative relationship between performance goals and standardised achievement test scores. Bell and Kozlowski (2002) also found that though mastery goal was positively and performance goal orientation negatively related to task performance, the effects of the latter were contingent on students' cognitive capabilities.

Goal Orientation and Working Memory

Although there is a growing number of studies on the relationships between motivation, affect, and executive functioning (e.g., Barker, Mcinerney, & Dowson, 2002; Graham & Golan, 1991; Roebers, Cimeli, Röthlisberger, & Neuenschwander, in press; Savine, Beck, Edwards, Chiew, & Braver, 2010; Szatkowska et al., 2008; Zelazo, Qu, & Müller, 2005), very few studies have examined directly the relationship between goal orientations, working memory, and academic performance. Linnenbrink, Ryan, and Pintrich (1999) found a positive relationship between mastery goal and working memory, and a negative relationship between performance goal and working memory. Both sets of relationship were mediated by negative affect. In a more recent study, Avery and Smillie (in press) examined the effects of achievement goal manipulation on performance in a working memory task Using a n-back task, goal orientation was found to affect performance only under high working memory load, with performance goal resulting in poorer performance than mastery goal.

Focusing on the effects of mental effort and working memory capacity Heitz, Schrock, Payne, and Engle (2008) proposed two hypotheses that are of relevance. According to the effort hypothesis, individual differences in working memory performance are due to the amount of mental resources allocated to a task. This is, in turn, dependent on the importance placed upon successful completion of that task. Inherently self-driven or highly incentivised participants are more willing to put in the effort necessary to maintain high levels of performance. For this reason, they tend to obtain higher working memory scores and achieve higher levels of performance on the criterion tasks. In the context of goal orientation, one extension of this argument is that the effects of performance or mastery goals are wholly or partially mediated by working memory. Depending on the orientation of the individual and the affordances of the situation, a person expands either more or less working memory resources, which has its attendant effects on performance.

Contrary to this view, the second hypothesis specified greater separation between mental effort and working memory. Specifically, that working memory will only be related to task performance if a task requires effortful, attentional control. Using pupillometric data to index mental effort, Heitz et al. (2008) showed that the provision of incentives increased performance and pupil diameter to a similar extent for both high and low span individuals. Their data indicated that low span participants exerted more effort than did those with high spans. Heitz et al. concluded that the effects of motivation were additive to that of working memory capacity on performance. According to this hypothesis, goal orientation and working memory can be considered independent constructs that separately account for a significant proportion of unique variance in mathematics performance.

A final conceptualization is that working memory capacity, because it is one determinant of academic success, shapes attitudes towards mathematics. Jung and Reid (2009) argued that “if working memory capacity is a rate controlling feature of learning and success in understanding leads to more positive attitudes, then working memory capacity might be associated with more positive attitudes” (p. 205). They went on to report that South

Korean students who have low working memory capacity tended to express consistently more negative views about their studies. Of considerable importance was their observation that students who have high working memory capacity tended to try to understand (mastery goal orientation) science knowledge while students who have low working memory capacity tended more to try to memorize science knowledge in order to score well (performance goal orientation). This claim suggests that the effects of working memory on mathematics are partially mediated by goal orientations.

The Present Study

Previous studies typically employed goal induction techniques or used different types of incentives to study their effects on working memory or performance. Although this approach has the benefit of allowing for a true experimental design, induced motivational states may not have the same influences as more trait-like dispositions. The first aim of this study was to examine the interrelationship between working memory, goal orientations and mathematics performance. Mathematics performance was adopted as a measure of academic performance due to its clearly established associations with working memory. Furthermore, goal orientations have been found to be associated with performance in mathematics (e.g., Ho & Hau, 2008). We tested three competing models: (a) mastery and performance goals, in addition to their direct effects on mathematical performance, also affect working memory capacity, which in turn has a direct effect on mathematical performance; (b) working memory and goal orientations contribute independently to mathematics performance; (c) working memory capacity influences the likelihood of adopting different levels of mastery and performance orientation, which in turn affects performance (see Figure 1 for a depiction of all three models).

<insert Figure 1 about here>

Because existing research has provided convincing evidence for the theory of multiple goal pursuit (Barron & Harackiewicz, 2001; Darnon, Muller, Schrager, Pannuzzo, & Butera, 2006; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Wolters, 2004; Wolters, Yu, & Pintrich, 1996), the second aim of this study was to explore the individual and interactive influences of working memory and goal orientations on mathematics performance. Specifically, the best fitted structural model identified among the three models described earlier was extended to include the two-way and three-way interaction effects between working memory, mastery, and performance goal orientations. Given the exploratory nature of this study and the lack of consistent findings in past research, we have decided not to posit any explicit hypotheses of direct, indirect, and possible interactive effects. Although not a specific focus of this study, we also included grade and gender as covariates in our models. Previous studies have found grade related increases in working memory capacity (e.g., Gathercole et al., 2004). Although much attenuated in recent years (Hyde, Fennema, & Lamon, 1990), gender related differences in mathematics performance are still sometimes reported in the literature (Gallagher et al., 2000; Imbo, Vandierendonck, & Rosseel, 2007).

Method

Participants

Children were recruited as part of a larger cohort-sequential study examining the relationships between executive functioning and mathematics proficiencies. Children were recruited via parental consent letters sent to five government-funded schools. All schools were located in middle- to lower-middle-class areas in western Singapore. The current study is based on data from 316 Primary 4 (M_{age} = 10.07, SD = .30, 165 boys) and 292 Primary 6 children (M_{age} = 12.32, SD = .29, 136 boys). Due to absences from school, 85 children had partially missing data. It should be noted that half of the observations in the current dataset were repeated measures collected from the same children when they were in Primary 4 and, two years later, when they were in Primary 6. Corrections were made to the standard errors and chi-square test of model fit to take into account the non-independence of observations using the Mplus TYPE=COMPLEX and CLUSTER commands (Muthén & Muthén, 2010).

Measures and Procedure

Children were administered a large battery of working memory, reading comprehension, intelligence, goal orientation, and mathematical tasks. The tasks were divided into 5 sets and were administered over several sessions. Each set took approximately one hour. Separation between sessions varied depending on school schedule and participants' availability. In most cases, sessions were conducted on consecutive days. In exceptional cases where there was limited access to the students, two sessions were run per day. In this study, we focused on the children's performances on the working memory, goal orientation, and mathematical tasks.

Working Memory Tasks. The children were administered the Listening Recall, Mr. X, Running Span, and Backward Digit Span tasks. In the Listening Recall task (Alloway, 2007a), the children listened to a series of sentences and identified whether each sentence was true or false. At the end of each series of sentences, the children were asked to recall the last word of each sentence, in the order in which they were presented. The task progressed from trials containing one sentence to trials containing six sentences. Each span or block of trials contained six trials. The number of trials that were recalled accurately served as the dependent measure (range = 0 to 36). Alloway (2007b) reported test-retest reliability of .81 for this measure.

In the Mr. X task (Alloway, 2007a), children were shown two Mr. X figures, each holding a ball at one of eight cardinal positions. The children had to decide whether they were holding a ball with the same hand. At the end of each trial, the child had to point to the position at which each ball was held, in the order in which they were pr. The task progressed from trials with one set of Mr. X figures to trials containing seven sets of figures. Each block contained six trials. The total number of trials recalled correctly served as the dependent measure (range = 0 to 42). Alloway (2007b) reported test-retest reliability of .77 for this measure.

In the Running Span task, children were shown a series of animal pictures, one at a time. The children did not know how many items were going to be presented, and were asked to recall a specified number of animals, starting from the last presented item. The number of animals in each trial varied randomly (Min = 3, Max = 11). The task began with the child recalling the last two animals. This increased to the last four. Each block contained two practice and twelve experimental trials. The children received a point for every animal recalled correctly (range = 0 to 108). Lee, Pe, Ang and Stankov (2009) reported test-retest reliability of .69 for this measure.

In the Backward Digit Recall task, students were administered lists of numbers and were asked to recall the numbers in backward sequence after each list had been administered. Each trial contained 2 to 7 numbers. The dependent measure was the number of trials correctly recalled (full range = 0 to 42). Alloway (2007b) reported test-retest reliability of .69 for this measure.

Mathematics Proficiency. Children's mathematics proficiency was assessed using the Mathematical Reasoning and Numerical Operations tasks from the Wechsler Individual Achievement Test (Wechsler, 2001), and separate algebra and arithmetic word problem tasks. In the Numerical Operations task, participants were asked to solve written computational problems, presented in equations. In the Mathematical Reasoning task, participants were asked to solve single- and multi-step word problems, including items related to time, money, and measurement in response to both verbal and visual prompts. We followed the standardised administration procedure. A point given for every correct response (range = 0 to 54 for both tasks).

We included two additional tasks to provide a more comprehensive measure of students' mathematical abilities: algebra and arithmetic word problems. The algebra task, modified from Lee et al. (2004), contained ten grade appropriate word problems. Responses were coded as either right or wrong (range: 0 to 10; KR-20 = .88). The arithmetic task contained 12 grade appropriate word problems that required students to add, subtract, multiply and/or divide. Responses were coded as either right or wrong (range: 0 to 12; KR-20 = .82).

Goal Orientations. Children's mastery and performance goal orientations were assessed using the Inventory of School Motivation (ISM; Ali & Mcinerney, 2004; Mcinerney et al., 1997; Mcinerney & Sinclair, 1991, 1992). The ISM was designed to measure a range of constructs drawn from Maehr's Personal Investment model (Maehr, 1984) and was intended for use in a range of educational and cultural settings across. Mastery goal orientation was assessed using two scales: "Task" (3 items; e.g., "I like to see that I am improving in my schoolwork") and "Effort" (5 items: e.g., "I am always trying to do better in my schoolwork"). Performance goal orientation was examined using four scales: "Competition" (4 items: e.g., "I am only happy when I am one of the best in class at school"); "Power" (3 items: e.g., "I often try to be the leader of a group at school"); "Praise" (5 items: e.g., "At school I work best when I am praised"); "Token" (4 items: e.g., "Getting a reward for my good schoolwork is important to me"). Students responded to each item on a Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The responses to the items were coded such that higher scores reflected higher levels of that particular goal orientation.

Results

Measures were screened for missing values, outliers, and normality of distribution. Scores that were more than three standard deviations beyond their respective means were replaced by values at three standard deviations. The distributions of all continuous variables were approximately normal. Prior to examining the structural relationship between working memory, goal orientation, and mathematics performance, confirmatory factor analyses were conducted to assess the validity of the measurement models, i.e., the validity of the ISM scales in measuring mastery and performance goals. A combination of indices were used to assess model fit, including the chi-square statistic, the comparative fit index (CFI: >.90 acceptable fit, >.95 excellent fit; Bentler, 1990), the root mean square error of approximation (RMSEA; <.08 acceptable fit, <.05 excellent fit; Browne & Cudeck, 1993), the Akaike Information Criterion (AIC; Akaike, 1974), the Bayesian Information Criterion (BIC; Schwarz, 1978), and the sample-size adjusted BIC (smaller values of AIC and BIC indicate better model fit).

Confirmatory factor analysis revealed that the second-order two factor model of goal orientation (mastery and performance) was only just acceptable, $\chi^2(245) = 600.99$, $p < .001$, CFI = .90, RMSEA = .049, AIC = 37243.10, BIC = 37590.85, Adjusted BIC = 37340.05. The modification indices suggested that two items from the Competition scale ("I am only happy when I am one of the best in class at school" and "Coming first is very important to me at school") and one item from the Power scale ("I work hard at school so that I will be put in charge of a group") should be cross-loaded onto multiple dimensions. As these items did not demonstrate unidimensionality, the model was refitted with these items excluded. Moreover, one item from the Effort scale ("I am always trying to do better in my schoolwork") and the Token scale ("Getting merit certificates helps me work harder at school") loaded weakly onto their respective constructs, the model was refitted with these items excluded from the analyses. Results indicated a substantial improvement in model fit, $\chi^2(146) = 284.76$, $p < .001$, CFI = .95, RMSEA = .040, AIC = 29406.93, BIC = 29684.25, Adjusted BIC = 29484.25. All measured variables loaded significantly onto their respective first-order latent scales (β range = .54 to .79), and the six latent scales also loaded strongly onto their respective second-order latent factors (β range = .59 to .85). The two second-order factors of mastery and performance goal orientations were fairly distinct with moderate latent correlation (p = .36). Prior to the imposition of a structural model, we also examined a measurement model in which working memory, goal orientations and mathematics were evaluated simultaneously. Results suggested that this model fitted the data well, $\chi^2(313) = 629.254$, $p < .05$, CFI = .93, RMSEA = .040, AIC = 41146.59, BIC = 41553.98, Adjusted BIC = 41261.89. The correlations between the latent factors are shown in Table 1.

<insert Table 1 about here>

Structural Relationship between Working Memory, Goal Orientations, and Mathematics Performance

To determine the structural relationship between working memory, goal orientations, and mathematics performance, three competing models were tested (see Figure 1). In all three models gender was included as a control variable. Path coefficients from SEM are shown in Figure 1 and model fit statistics are presented in Table 2. Model 1 postulated that the effects of mastery and performance goals on mathematics are partially mediated by working memory. As depicted in Figure 1, direct paths from mastery and performance goals to working memory were specified in addition to the direct paths from working memory, mastery and performance goals to mathematics. Model 1 provided a reasonable fit to the data, $\chi^2(337) = 717.68$, $p < .001$, CFI = .92, RMSEA = .043, AIC = 40662.48, BIC = 41081.44, Adjusted BIC = 40779.84. Model 2 which postulated that working memory, mastery and performance goal orientations exerted independent effects on mathematics performance provided a slightly weaker fit, $\chi^2(339) = 738.57$, $p < .001$, CFI = .91, RMSEA = .044, AIC = 40680.99, BIC = 41091.14, Adjusted BIC = 40795.88. Model 3 which postulated that the effects of working memory on mathematics are partially mediated by goal orientation also demonstrated acceptable fit, $\chi^2(337) = 723.72$, $p < .001$, CFI = .92, RMSEA = .043, AIC =

40668.79, BIC = 41087.76, Adjusted BIC = 40786.16. A comparison of the information criteria suggests that Model 1 yielded the best fit among the three competing models.

<insert Table 2 about here>

Model 1 accounted for 71.8% of the variance in mathematics, and working memory had the largest unique contribution (β = .69, $p < .001$). In terms of goal orientation, mastery goal had no significant direct effect (β = .08, $p > .05$) on mathematics whilst performance goal orientation (β = -.18, $p < .001$) had a significant negative direct effect on the latter. Nevertheless, mastery goal had a significant positive effect on working memory (β = .18, $p < .01$) whilst performance goal had a significant negative effect on working memory (β = -.23, $p < .001$). To test these potential mediation effects, we followed Baron and Kenny's (1986) procedure for testing mediation (not detailed here) and utilised the Sobel test (1982) to obtain a *z* statistic for the indirect effect of mastery goal (β = .17) and performance goal (β = -.21) on mathematics through working memory. The Sobel test revealed that both of these indirect effects were statistically significant (mastery goal: $z = 2.99$, $p < .01$; performance goal: $z = -4.00$, $p < .001$). Hence, working memory accounted for part of the relationship between mastery and performance goals on mathematics.

Interaction between Working Memory and Goal Orientation

To ascertain possible interaction effects between working memory and goal orientation on mathematics performance, latent interaction structural equation modelling, based on Model 1 above, was conducted using Mplus 6 (Muthén & Muthén, 2010). Similar to testing interaction effects using hierarchical regression, we first tested the main effects in step 1. We then examined the main effects together with all the two-way interactions in step 2, followed by the inclusion of the three-way interaction effect in step 3. Since the conventional model fit indices are not available for latent interaction analysis in Mplus, the (AIC; Akaike, 1974), (BIC; Schwarz, 1978), and the sample-size adjusted BIC were used to select the best model for which the estimates were interpreted.

Based on the AIC and adjusted BIC, the tertiary model was deemed to provide the best fit to the data; although it should it noted that the sizable three-way interaction effect was only marginally significant ($\beta = -.23$, $p = .10$). This model explained 80.8% of the variance in mathematics performance. Significant and positive main effects were detected for both working memory ($\beta = .66$, $p < .001$) and mastery goal ($\beta = .16$, $p < .01$) on mathematics performance, whilst a strong negative direct effect was detected for performance goal ($\beta = -.23$, $p < .001$). Sobel test indicated that the indirect effects of both mastery goal and performance goal on mathematics via working memory were statistically significant (mastery goal: $\beta = .13$, $z = 2.78$, $p < .01$; performance goal: $\beta = -.10$, $z = -2.34$, $p < .05$). Moreover, the significant gender effect on mathematics ($\beta = .16$, $p < .01$) and mastery goal ($\beta = -.23$, $p < .01$) indicated that though boys performed better than girls in the mathematics tasks, girls had higher levels of mastery goal orientation than boys. This is consistent with the literature in which findings have generally indicated that girls are more likely than boys to hold mastery goals (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006). Grade level also had significant relationships with working memory ($\beta = .56$, $p < .001$) and performance goal ($\beta = -.32$, $p < .001$), in that Primary 6 children were found to have higher levels of working memory than Primary 4 children, but the younger children reported higher levels of performance goal.

<insert Table 3 about here>

Our latent interaction SEM analysis provided support for a two-way interaction effect between performance goal and working memory ($\beta = .22$, $p < .01$), and an interaction effect between mastery and performance goals ($\beta = .22$, $p < .05$). To identify the locus of this interaction effect, simple slope analyses were conducted to visualise the strength of the performance goal to mathematics relationship across high, medium, and low-levels of working memory and mastery goals; computed as the mean and +1 and −1 standard deviations from the mean (Aiken & West, 1991). For children with lower working memory capacities, having high performance goals have a negative effect on mathematics achievement. The interaction between mastery and performance goals shows that high performance goal is associated with poorer mathematical performance when children also have low mastery goals (see Figure 2).

<insert Figure 2 about here>

The secondary interaction effects were qualified by a marginally significant three-way interaction effect ($\beta = -.23$, $p = .10$) between working memory, mastery goal, and performance goal orientations. Simple slope analyses revealed that for children with high levels of working memory, no relationship between performance goal and mathematics was detected for those with high, medium, or low levels of mastery goals (see the three horizontal slopes in the rightmost part of Figure 2). For children with medium and low levels of working memory, performance goal had no relationship with mathematics for those with high mastery goals, but significant negative relationships were found for those with medium and low mastery goals (see slopes in the middle and leftmost parts of Figure 3). More specifically, these results indicated that performance goal had negative impact on mathematics only for those children with medium or low levels of both working memory and mastery goals.

<insert Figure 3 about here>

Discussion

Although the ISM has largely been used with older children and adult participants, the hierarchical model described by McInerney and his colleagues (e.g., Ali & Mcinerney, 2004) provided a satisfactory fit to the mastery and performance data obtained from our 10 and 12 year olds. A unique contribution of this study is that it provides an evaluation of the relationship between goal orientations, working memory capacity, and mathematical performance. We tested three models. In Model 1, the effects of goal orientations on mathematics were specified as being partially mediated by working memory. In Model 2, working memory and goal orientations contributed independently to mathematics performance. In Model 3, the effects of working memory on mathematics were partially mediated by goal orientation.

Although all three models provided reasonable fit to the data, Model 1 provided the best fit. Mastery goal did not have a significant direct relationship with mathematical performance. In comparison, performance goal was much more closely associated with performance. Children with higher performance orientation had poorer mathematical achievement. Of particular interest was that both mastery and performance goals had direct effects on working memory capacity. Children with a higher mastery orientation had better working memory capacity. In contrast, children with higher performance orientation had poorer working memory capacity. Working memory capacity was correlated positively with mathematical achievement.

Overall, these findings provide partial support to the effort hypothesis. One interpretation of the findings is that goal orientations affect the amount of working memory resources participants are prepared to expend. These findings seem to stand in contrast to findings from Heitz et al. (2008) and Avery and Smillie (in press). In Heitz et al. (2008), they found the provision of incentives improved cognitive performance irrespective of working memory capacity. If participants with higher performance orientation can be assumed to be more responsive to the provision of incentives, the present findings suggest that participants with higher performance goals, but not those with lower performance goals, should have poorer cognitive performance. Avery and Smillie (in press) found performance goal resulted in poorer performance than mastery goal only under high working memory load. In contrast, we found performance goal has both direct and indirect effects on performance.

It is perhaps premature to conclude whether these variations in findings are true differences or differences resulting from variation in methodology and approach. Heitz et al. (2008) and Avery and Smillie (in press) both focused on how the effects of goal orientation were moderated by situational motivational factors. In contrast, the initial structural models we evaluated considered how the effects of working memory and more trait-like goal orientations are mediated by each other. Research from the wider motivation literature suggests that whether attributes are state versus trait based can have differential effects on performance. The processing efficiency theory (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007), for example, argued that the negative impact of anxiety on test performance is at its maximum when individuals with high trait anxiety are placed in a high situational stress environment. In our study, the extent to which the test environment was perceived as stressful or more encouraging of a mastery or performance approach was not directly measured. This is perhaps an issue that can be examined in future studies.

Another source of difference between the present and the earlier studies is in our analytical approach. The earlier studies focused on how performance was moderated by goal orientation; our initial analyses focused on mediation. This divide is partially ameliorated by our moderated mediation analyses. The analyses demonstrated significant secondary interaction effects between (a) working memory and performance goal, and (b) mastery and performance goals. Only for children with low working memory capacity did having high performance goal have a negative effect on mathematics achievement. This finding can be deemed consistent with Avery and Smillie's (in press), in that children with lower working memory capacity are more likely to be overwhelmed by the cognitive demands of tasks and thus are more likely to be working under heavier working memory load than are children with higher working memory capacity. Findings of interaction between motivational state and task difficulty on performance have also been found in Graham and Golan (1991) and Barker, McInerney, and Dowson (2002).

The interaction between mastery and performance goals suggests that the influence of a low mastery goal is catalytic in nature: although not associated with poorer performance on its own, a combination of low mastery and high performance goals is associated with particularly poor performance. Why then is having a high performance goal orientation associated negatively with mathematical performance? The finding that the relationship between performance and performance is mediated by working memory offers a plausible explanation. From the test anxiety literature, the processing efficiency model argues that being anxious or worried is itself demanding of working memory resources. Within a limited capacity system, the more resources being tied up will result in less resources being available to others tasks. In the context of children with a performance orientation, one possibility is that the competitive and social comparative aspects of this orientation produce a level of anxiety or worry. This then reduces available working memory resources. This detrimental effect is left unbuffered when children are not otherwise driven by a mastery orientation.

It is of note that the two secondary interaction effects were involved in a marginally significant three-way interaction. Only for children with low or medium levels of both working memory capacity and mastery goal did having high performance goal have a negative effect on mathematics achievement. This finding suggests that though the direct influence of mastery goals is relatively small, it seems to afford a degree of protection against the detrimental influences of high performance goals. Having a higher working memory capacity affords a similar, but more comprehensive protection. Children with a higher working memory capacity did well regardless of their mastery or performance goals.

The present findings suggest that some of the variance in working memory capacity can be explained by variation in goal orientation. This finding adds to the existing data, which suggests that experimentally induced variation in motivation results in changes in working memory capacity (Avery & Smillie, in press; Heitz et al., 2008). What remains unclear is whether such state versus trait based variation in goal orientation has additive or other differential effects on working memory.

From a theoretical perspective, these findings reinforce the importance of measuring performance and mastery goals separately. They also demonstrate the importance of examining the interaction of cognitive and non-cognitive contributors to performance. Indeed, the inclusion of the working memory measures allowed us to offer a more mechanistic explanation of how achievement goals may affect performance.

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Table 1.

Intercorrelations among working memory, goal orientation and mathematics performance

	Working Memory		Mastery Goals		Performance Goals	
Working Memory	-					
Mastery Goals	.13		-			
Performance Goals	-.18	*	.35	**	-	
Mathematics	.74	***	.12		-.29	**

Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 2.

Fit statistics for the three competing structural models

Model	$\chi 2$	*df*	RMSEA	CFI	TLI	AIC	BIC	Adjusted BIC	Model Description
Model 1	717.68	337	.043	.918	.908	40662.48	41081.44	40779.84	Effects of goal orientation on mathematics is partially mediated by working memory
Model 2	738.57	339	.044	.914	.904	40680.99	41091.14	40795.88	Working memory and goal orientation independently contribute to mathematics performance
Model 3	723.72	337	.043	.917	.907	40668.79	41087.76	40786.16	Effects of working memory on mathematics is partially mediated by goal orientation

Table 3.

Predicting mathematics performance: results from latent interaction structural equation modelling

	Main		+Secondary		+Tertiary	
Main Effects						
Working Memory	.62	***	.64	***	.66	***
Mastery Goals	.12	*	.18	**	.16	**
Performance Goals	-.16	**	-.22	**	-.23	***
Mastery → Working Memory	.20	**	.20	**	.19	**
Performance → Working Memory	-.15	*	-.15	*	-.15	*
Two-Way Interaction Effects						
Working Memory x Mastery			-.04		-.08	
Working Memory x Performance			.19	**	.22	**
Mastery x Performance			.14		.22	*
Three-Way Interaction Effect						
Working Memory x Mastery x Performance					-.23	†
Control						
Gender	.15	**	.15	**	.16	**
Gender → Mastery	-.23	**	-.23	**	-.23	**
Gender → Performance	-.04		-.04		-.04	
Gender → Working Memory	-.05		-.05		-.05	
Grade	.64	***	.62	***	.63	***
Grade → Mastery	-.02		-.02		-.02	
Grade → Performance	-.32	***	-.32	***	-.32	***
Grade → Working Memory	.57	***	.57	***	.56	***
Variance Explained	78.8%		80.1%		80.8%	
Model fit						
AIC	40372.74		40364.54		40363.05	
BIC	40809.35		40814.38		40817.30	
Sample-Size Adjusted BIC	40495.05		40490.55		40490.30	

Note. * $p < .05$; ** $p < .01$; *** $p < .001$; † $p = .10$.

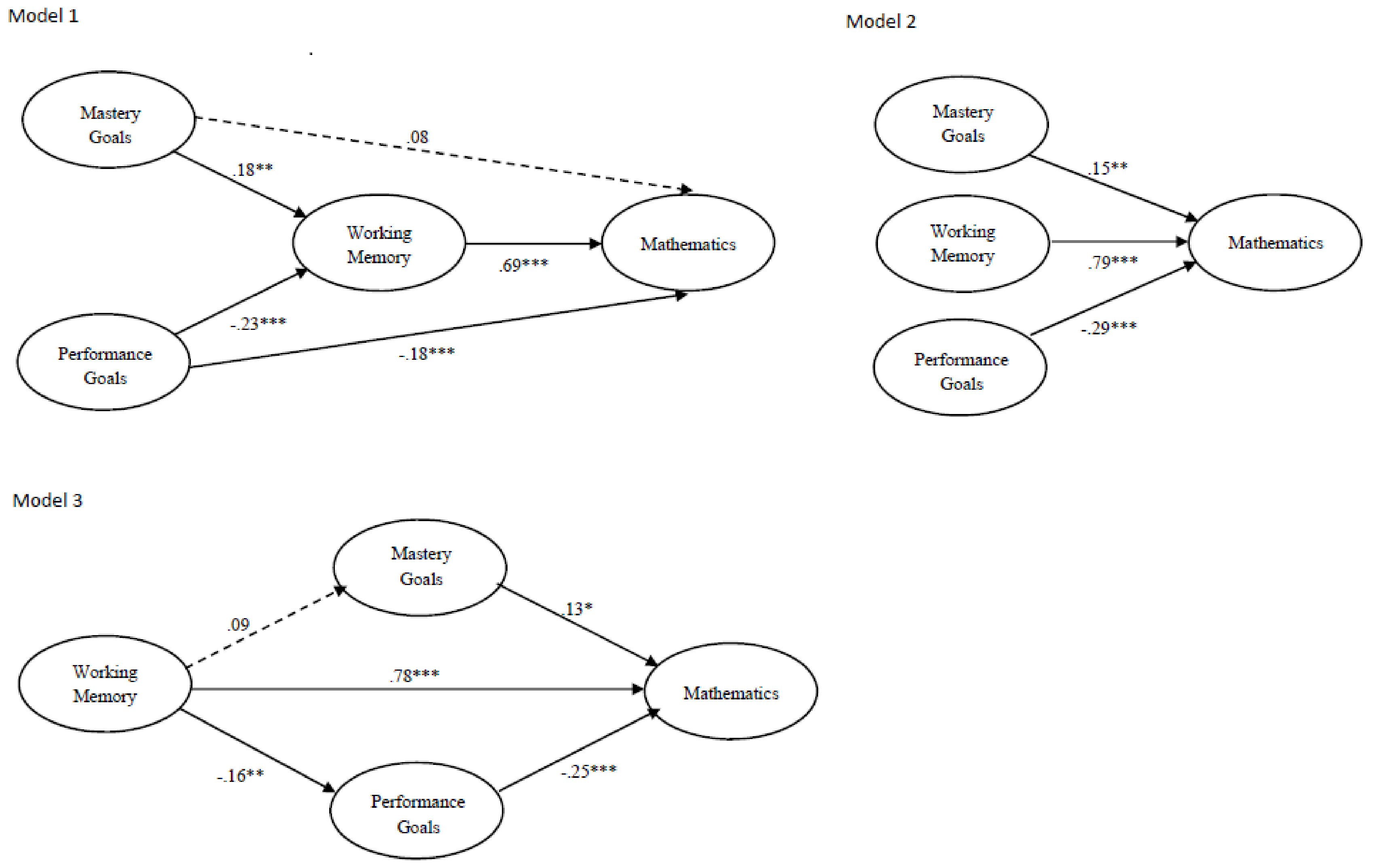

Figure 1. Three competing structural models depicting the relationship between working memory, goal orientation, and mathematics performance. * $p < .05$; ** $p < .01$; *** $p < .001$

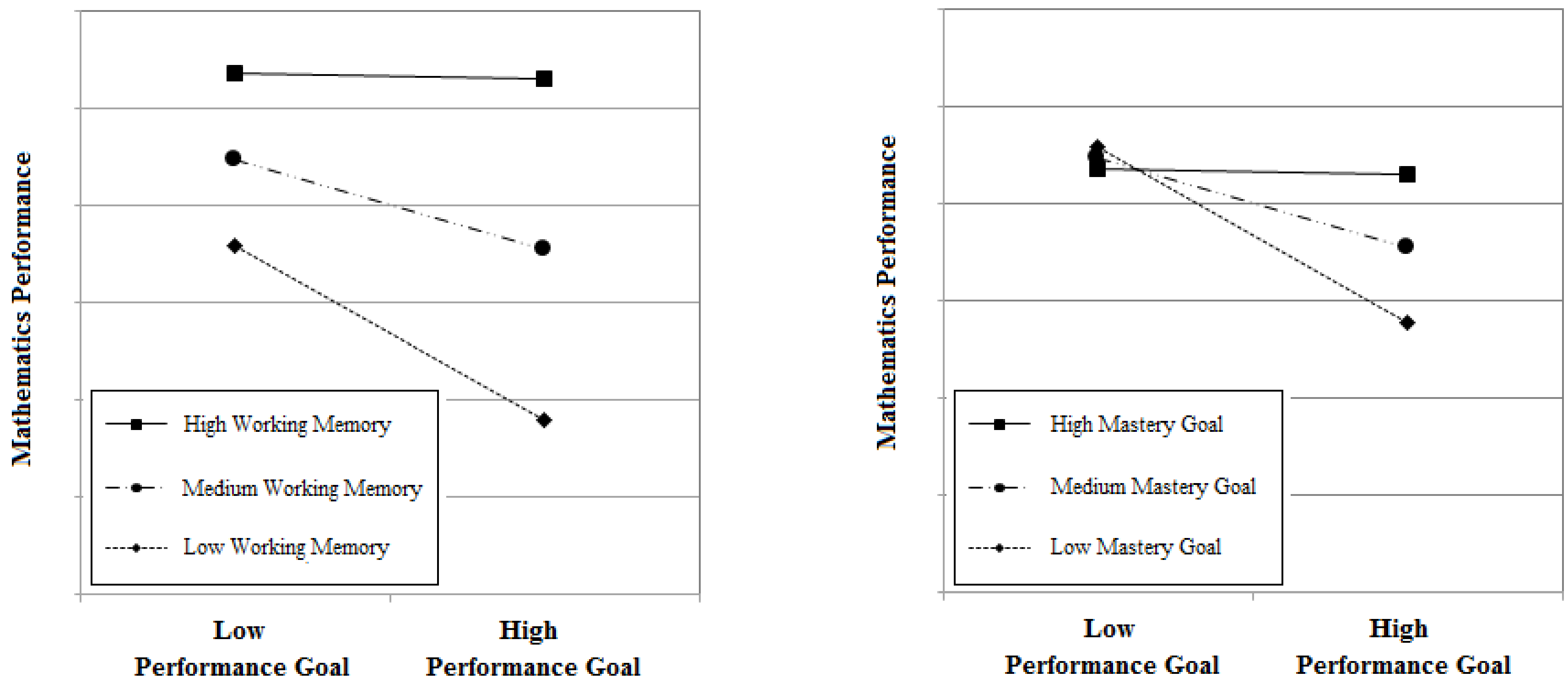

Figure 2. The two-way interaction effects between performance goal and working memory (left panel), and performance and mastery goals (right panel) on mathematics.

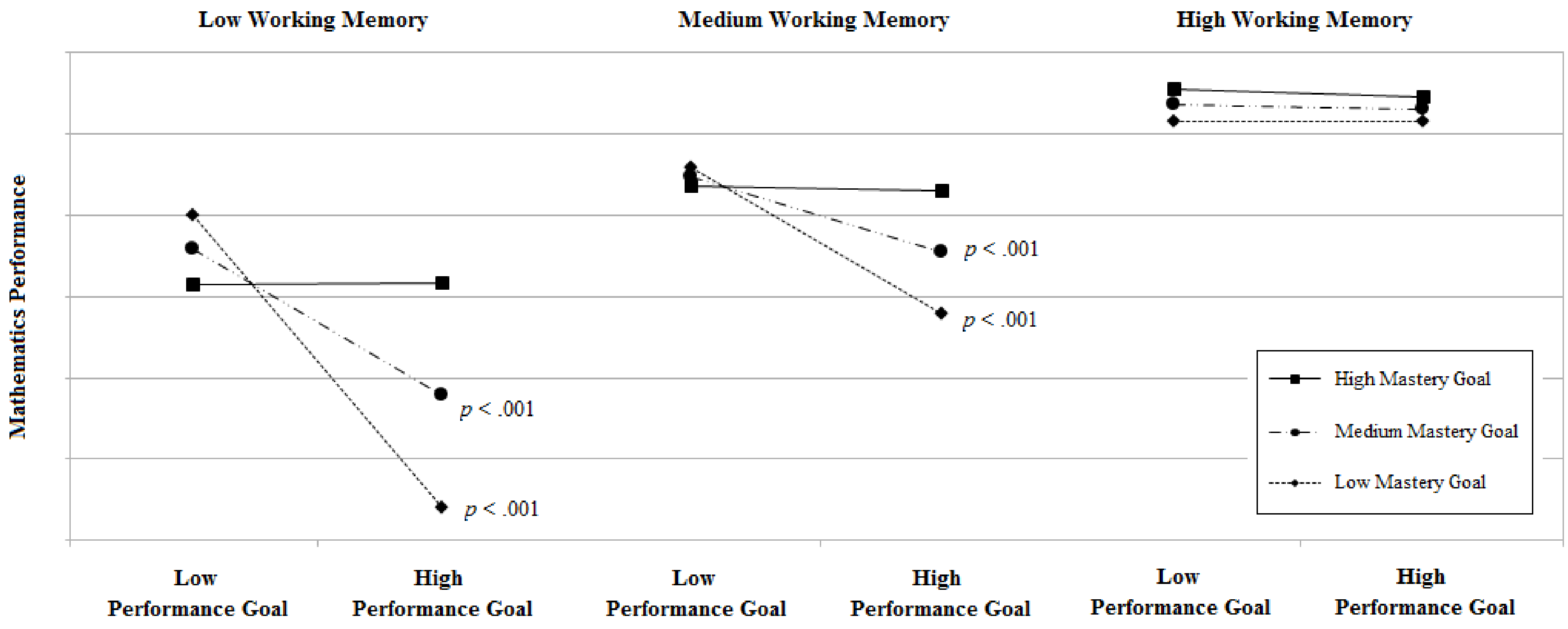

Figure 3. The three-way interaction effect between performance goal, mastery goal, and working memory on mathematics