# The Role of Metacognitive Awareness and Metacognitive Ability as Predictors of Academic Success in University Students

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## Abstract

Over the past few decades, metacognition has been recognised as one of the most important cognitive factors in educational psychology, and it has been implied that metacognition constitutes a critical aspect of effective learning in university students. However, there are mixed findings in the literature with regard to the relationship between metacognition and academic success. The aim of the current study was to further examine the relationship between metacognitive awareness and academic success, and to address existing gaps in the literature, with the consideration of measures of metacognitive ability. The Metacognitive Awareness Inventory (MAI) was used to measure metacognitive awareness, and calibration was used as a measure of metacognitive ability in $N = 76$ undergraduate psychology students. The relative importance of established predictors, such as intellectual ability, personality traits, and self-efficacy were also investigated in relation to academic success. The results indicate that metacognitive awareness did not predict academic success; however, metacognitive ability, in the form of calibration, and intellectual ability were found to be significant predictors of academic success. Confirmatory factor analysis indicated that a two-factor model of the Metacognitive Awareness Inventory had poor fit in our sample. However, an exploratory factor analysis suggested that a three-factor model was more suitable for this dataset. Furthermore, it was found that metacognitive awareness and metacognitive ability were not significantly related. These findings have implications for how professors can assess their students' metacognition and implement strategies to improve students' metacognitive skills where necessary, ultimately, enhancing academic performance.

## Declaration

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***Signature***

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**Naomi Warmer**

**October, 2018**

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# 1 Introduction

## 1.1 Background

Over the past few decades, there has been growing interest in the factors that influence academic success at university. These have often included cognitive (e.g. aptitude and metacognition), affective (e.g. anxiety and motivation), and personality (e.g. the Big 5) factors accounting for a significant proportion of variance in academic achievement (Onwuegbuzie, Bailey, & Daley, 2000). Among these, metacognition is recognised as an increasingly important cognitive factor in psychology (Pintrich, 2002), and it has been suggested that metacognition constitutes a critical aspect of effective learning in university students. Although one prominent goal of higher education is to promote and develop self-regulated learners (Sperling, Howard, Staley, & DuBois, 2004), students often have varying levels of knowledge about their metacognition in relation to learning and academic success. Some students may be active, self-directed learners who know how they learn and are able to apply what they know to various learning domains, while other students may be passive learners who have little awareness of how they learn and how to regulate their learning (Young & Fry, 2008).

Consequently, it is important to assess the metacognition of university students to determine if metacognitive knowledge and skills are related to academic success. Although research suggests that intelligence and personality are relatively stable constructs (Roberts & DelVecchio, 2000), metacognition, however, can be developed. Thus, if we can propose that metacognition is related to academic achievement, then professors can use various techniques to assess their students' metacognition and implement strategies to improve students' metacognitive skills when necessary, ultimately, enhancing academic performance.

Given the lack of consensus in the existing literature on the relationship between metacognitive awareness and academic success, the current study aims to further investigate this relationship and address some existing limitations and gaps in the literature, with the consideration of measures of metacognitive ability.

In the following we will discuss metacognition in the context of university students; the relationship between measures of metacognition and academic success; and the current established predictors of academic success.

**1.2 Defining Metacognition**

Metacognition has been of recent growing interest among researchers in the field of psychology. Most scholars agree that cognition and metacognition differ in that cognitive skills are acquired knowledge necessary to perform a task, whereas metacognition is ones awareness of that knowledge and is necessary to understand how the task was performed (Garner, 1987; Pressley & Ghatala, 1990). Flavell (1979) first coined the term metacognition in the late 1970s as simply “thinking about thinking”. Metacognition is defined as the ability to reflect upon, understand and control ones learning (Schraw & Dennison, 1994). It can further be referred to as what we know about our cognitive processes and how we use and regulate these processes in order to learn and remember (Schraw & Moshman, 1995). Metacognition has also been described as the ability to calibrate or monitor one’s performance (Dunlosky & Thiede, 1998).

In cognitive and educational psychology, metacognition is often perceived as a type of executive control involving monitoring and self-regulation (McLeod, 1997; Veenman, Van Hout-Wolters, & Afflerbach, 2006). Researchers suggest that metacognition is a multidimensional set of general, rather than domain-specific skills, which first develop in different domains and later crosses domains to become a generalized skill (Schraw, 1998; Veenman et al., 2006). According to Kuhn and Dean (2004), metacognition enables students who are taught a particular strategy in a particular problem context to retrieve and deploy that strategy in a similar but new context. These skills are empirically distinct from general intelligence and may even aid in compensating for deficits in general intelligence.

An individuals' metacognitive awareness skills begin to develop at a young age and continue to evolve with experience (Garner & Alexander, 1989). However, not all individuals develop these skills to the maximum level (Kuhn & Dean, 2004). Researchers have reported differences in metacognitive abilities between aware and unaware learners, indicating that metacognitively aware learners are more strategic and perform better than unaware learners (Baker, 1989; Garner & Alexander, 1989; Pressley & Ghatala, 1990). One explanation is that metacognitive awareness permits individuals to plan, sequence and monitor their learning in a way that directly improves academic performance. Metacognition enables students to be strategic in their learning by, for example, learning new information, rather than focusing on studying information they have already learned (Everson & Tobias, 1998). Therefore, metacognition is imperative for effective learning, as metacognitively aware learners are capable of not only managing their cognitive skills to accurately estimate their knowledge in a range of domains, monitor their learning and update their knowledge, but also in developing effective new cognitive strategies to modify their weaknesses (Everson & Tobias, 1998; Schraw, 1998).

### 1.2.1 Constituent Elements of Metacognition

While several taxonomies have been developed for classifying constituent elements of metacognition, most scholars now agree that metacognition can be categorised into two major components: knowledge of cognition and regulation of cognition (Baker, 1980; Cross & Paris, 1988; Flavell, 1979; Pintrich, 2002; Schraw, 1998; Schraw & Dennison, 1994; Schraw & Moshman, 1995; Sperling et al., 2004; Vrugt & Oort, 2008). Knowledge of cognition refers to what individuals know about their cognitive processes, and includes three subcomponents: declarative, procedural and conditional knowledge (Schraw, 1998; Schraw

& Moshman, 1995). Declarative knowledge refers to knowledge about oneself as a learner and what factors influence how one learns (Young & Fry, 2008). Procedural knowledge is knowledge about how to use and implement learning strategies that are the most effective (Young & Fry, 2008). And conditional knowledge refers to knowledge about when and why to use various cognitive strategies (Schraw & Dennison, 1994). Metacognitive knowledge is often late developing and improves with age, however, many adults struggle to explain what they know about their thinking.

The other component of metacognition is regulation of cognition, which can be thought of as the actual activities in which we engage in order to facilitate and control learning and memory (Schraw & Moshman, 1995). Metacognitive regulation consists of five subcomponents: planning, monitoring, evaluation, information management and debugging strategies (Artz & Armour-Thomas, 1992; Schraw & Dennison, 1994). Briefly, planning involves goal setting and the identification and selection of appropriate strategies that affect performance prior to learning (Schraw & Moshman, 1995; Vrugt & Oort, 2008). Monitoring refers to awareness of ones comprehension and task performance, and can include self-testing (Schraw & Dennison, 1994). Evaluation involves appraising ones processes and efficiency of learning, and re-evaluating ones goals and conclusions (Vrugt & Oort, 2008). Information management consists of strategy sequences to process information more efficiently (Schraw & Dennison, 1994). Finally, debugging strategies are used to correct comprehension and performance errors when facing difficulties (Schraw & Dennison, 1994).

In summary, the current metacognitive framework reveals that metacognition consists of knowledge and regulatory skills that individuals use to control their cognition. Many studies have found metacognitive knowledge and metacognitive regulation to be significantly intercorrelated around $r = .50$, suggesting that knowledge and regulation may work in unison to help students self-regulate their learning (Oz, 2014; Schraw, 1998; Schraw & Dennison, 1994; Sperling et al., 2004). Furthermore, Young and Fry (2008) highlight that students who possess high levels of metacognitive knowledge and regulation, and use their metacognitive skills whilst learning, will excel academically.

### 1.2.2 Metacognitive Awareness

In this context, metacognitive awareness refers to one's awareness of their thinking and the strategies they implement whilst learning. Schraw and Dennison (1994) developed the Metacognitive Awareness Inventory (MAI) to measure the two components of metacognition: knowledge of cognition and regulation of cognition. They performed a constrained exploratory factor analysis on a two-factor model to compare whether these factors corresponded to the knowledge of cognition and regulation of cognition subcomponents of metacognition proposed in the literature. Schraw and Dennison (1994) found that items classified under metacognitive knowledge loaded onto the first factor, while items classified under metacognitive regulation loaded onto the second factor. Few items loaded highly on both factors and two items failed to load onto either factor. These findings suggest that the Metacognitive Awareness Inventory empirically supports the two-component conceptual framework of metacognition. The present study is based on this two-factor model.

### 1.2.3 Metacognitive Ability

Some researchers contend that metacognition not only involves awareness, but also involves ability. In this context, metacognitive ability refers to one's ability to employ and monitor metacognitive skills whilst learning (Everson & Tobias, 1998; Nietfeld, Li, & Osborne, 2005; Schraw, 1994). Few studies have been conducted on how learners perceive their own thinking, i.e. about metacognitive judgement. According to Schraw (2009), metacognitive judgement is how a learner judges their own learning processes. The accuracy and confidence of metacognitive judgements are operationalised in terms of calibration, which is defined as the match between ones confidence or prediction of their ability and their actual performance (Lin & Zabrucky, 1998). For example, if a student could correctly answer all questions on a test, and they are confident they have performed well; then, they are considered well calibrated. In contrast, if they could answer all the questions correctly, but they are not confident whether their performance was good; then, their calibration can be considered poor (Schraw, 2009).

Metacognitive confidence judgements, measured by calibration, have been suggested to be significant non-cognitive predictors of academic performance with correlations between the predicted performance and the actual performance falling between $r = .40$ and $r = .60$ (Mabe & West, 1982; Stankov, Morony, & Lee, 2014). It has been found that calibration is relatively stable regardless of what the test is measuring. As such, an individual's tendency to be overconfident or underconfident will transfer to different tasks or domains, regardless of personal skill or experience (Burns, Burns, & Ward, 2016). Frumos (2015) suggests that biases and variability of individuals metacognitive judgements on the correctness of their performance reflects the accuracy of their calibration, and thus, metacognitive ability.

Calibration can be assessed in two common ways: prospective judgement and retrospective judgement. Prospective judgement is to predict our performance on a task prior to completing the task. Whereas, retrospective judgement is to assess our confidence and performance after completion of the task (Lin & Zabrucky, 1998; Mabe & West, 1982). Studies have found that both prospective and retrospective judgements are significantly correlated with actual performance. However, retrospective judgements are more accurate than prospective judgements, as there are indications of performance for the learner to compare once they have finished the task.

### 1.3 The Relationship Between Metacognition and Academic Success

Within the current study, we are particularly interested in the way in which metacognition predicts academic success in university students. In the following, academic success will be defined, and a review of the literature surrounding the relationship of academic success with metacognitive awareness and metacognitive ability will be conducted.

### 1.3.1 Defining Academic Success

"Academic Success" is the most widely used construct in higher educational research, yet it lacks clarity and operationalisation because its broad meaning is often misused to encapsulate all desired academic outcomes. The majority of studies focus on academic achievement when defining or measuring academic success (Choi, 2005; DeFreitas, 2012; Tracey, Allen, & Robbins, 2012). Academic achievement captures the quality of students' academic work represented by grades and grade point averages (GPAs), which act as proxy measurements to capture student's attainment of learning objectives and acquisition of necessary skills and competencies (York, Gibson, & Rankin, 2015). Thus, the current study adopts the approach of using academic achievement, measured through student grades, when defining and measuring academic success.

### 1.3.2 Previous Studies Investigating the Relationship Between Metacognition and Academic Success

The recognition of the importance of metacognition in psychology has lead researchers to investigate its relationship with academic success. The assessment of metacognition is challenging for researchers, as metacognition cannot be directly observed in students and there is not a perfect method of measuring it (Pintrich, Wolters, & Baxter, 2000; Sperling, Howard, Miller, & Murphy, 2002). While most studies employ self-report questionnaires or rating scales to measure metacognitive awareness in terms of metacognitive knowledge and metacognitive regulation and relate them to achievement measures (Cross & Paris, 1988; Everson & Tobias, 1998; Schraw & Dennison, 1994; Sperling et al., 2004), other studies measure metacognitive ability by examining confidence judgements and comparing them to actual performance (Everson & Tobias, 1998; Nietfeld et al., 2005; Schraw, 1994). However, research regarding the relationship between metacognitive awareness and academic success has yielded mixed results.

Several studies have found that students with high levels of metacognitive awareness demonstrate high levels of academic achievement. These studies also consider metacognitive awareness to be a strong predictor of academic success (Abdellah, 2015; Kállay, 2012; Martini & Shore, 2008; Oz, 2014; Young & Fry, 2008). Schraw and Dennison (1994) found a significant positive relationship between the Metacognitive Awareness Inventory and test performance in undergraduate psychology students. Furthermore, students with higher levels of metacognitive awareness have been found to use learning strategies more efficiently, which have positive effects on academic performance (Garner & Alexander, 1989; Pintrich & de Groot, 1990; Vrugt & Oort, 2008). The findings of Coutinho (2008) and Gul and Shehzad's (2012) studies reported a significant weak relationship between metacognitive awareness, measured using the Metacognitive Awareness Inventory, and academic achievement in undergraduate students. Furthermore, a study by Young and Fry (2008) found that the knowledge of cognition and regulation of cognition factors both significantly correlated with GPA and final course grade.

In contrast, several studies have reported finding no significant relationship between metacognitive awareness and academic success. A study by Sperling, Howard, Staley and DuBois (2004) found no significant relationship between scores on the Metacognitive Awareness Inventory and measures of academic achievement in college students. In line with this, Pressley and Ghatala's (1990) study of university students also found that metacognitive awareness appeared to be independent of academic achievement. Similarly, metacognitive strategy use was not significantly correlated with academic achievement (Pintrich, Smith, Duncan, & McKeachie, 1991).

Several scholars have found that measures of metacognitive ability are significantly correlated with measures of academic achievement. Everson and Tobias (1998) developed the Knowledge Monitoring Ability Inventory to examine the difference between college students' estimates of their knowledge in the verbal domain and their actual knowledge, as determined by performance on a verbal test. They found that this measure of calibration was significantly related to academic achievement, and it was a reliable predictor for academic success in college. A study conducted by Schraw (1994) found that students' predictions of test performance, made before testing, were significantly correlated with actual test performance. Furthermore, Nietfeld et al. (2005) found monitoring accuracy, in the form of calibration, remained stable across tests, and was significantly related to academic performance.

### 1.3.3 Limitations in the Research

As has been indicated, there have been mixed findings in the literature regarding the relationship between metacognitive awareness and academic success. Therefore, the relationship between the Metacognitive Awareness Inventory and measures of academic achievement warrant further research in a broader context. There is also a significant gap in the literature pertaining to metacognitive ability, as the majority of studies focus on the relationship between metacognitive awareness and academic achievement. Furthermore, there has been few studies conducted on the relationship between metacognitive awareness and metacognitive ability. To address these limitations, the current study undertakes an investigation of the relationship between both metacognitive awareness and metacognitive ability, and with measures of academic achievement.

## 1.4 Established Predictors of Metacognition and/or Academic Success

Within the literature, the relative importance of several variables upon metacognition and academic success have been investigated, which must be considered in the context of the current study. The effects of intellectual ability, personality traits, and self-efficacy will be discussed.

### 1.4.1 Intellectual Ability

Intellectual ability and metacognitive awareness appear to be independent constructs (Howard, McGee, Hong, & Shia, 2000; Swanson, 1990; Vrdoljak & Velki, 2012). Research suggests that metacognitive skills are applicable over a variety of domains, whereas, intellectual abilities apply to a smaller range of tasks (Schraw, 1998; Sternberg, 1988). However, considering metacognitive awareness and intellectual ability as distinct theoretical constructs does not imply that the two are unrelated. Students with a higher degree of metacognitive awareness can compensate for lower levels of intelligence (Howard et al., 2000). Many studies have shown intellectual ability to be the most prominent predictor of academic success in university students (Busato, Prins, Elshout, & Hamaker, 2000; Chamorro-Premuzic & Furnham, 2008; Furnham, Monsen, & Ahmetoglu, 2009), with intelligence predicting up to 25% of variance in academic achievement (Furnham et al., 2009; Jensen, 1998).

### 1.4.2 Personality Factors

Costa and McCrae’s Big 5 Personality Factor model is recognised as the dominant taxonomy for conceptualising personality structure (Schulze & Roberts, 2006). Prior research has acknowledged that personality traits have well-established relationships with academic success (Chamorro-Premuzic & Furnham, 2008; Furnham et al., 2009). However, there is little empirical research regarding the relationship between personality and metacognition.

Personality and metacognition appear to be independent, as personality is a non-cognitive trait, whereas, metacognition is a cognitive process.

Of the Big 5 personality traits, conscientiousness is the most prominent predictor of academic success (Chamorro-Premuzic & Furnham, 2008; Conard, 2006). Highly conscientiousness individuals are motivated, achievement driven and self-disciplined, which facilitates a variety of learning strategies, and ultimately enables higher academic achievement (Costa & R. McCrae, 1992; Heaven, Ciarrochi, & Vialle, 2007; O'Connor & Paunonen, 2007).

Openness to experience, which is characterised by creativity, originality, and imagination, has also been found to be positively correlated with academic performance (Trapmann, Hell, Hirn, & Schuler, 2007); however, less consistently than conscientiousness (Poropat, 2009). Research suggests that the strong positive correlation between openness to experience and intellectual ability moderates this relationship (Chamorro-Premuzic & Furnham, 2008).

### 1.4.3 Self-Efficacy

Bandura (1977) suggests 'efficacy theories' explain why some students are motivated to use strategies, while some are not. Many scholars have found that the use of metacognitive strategies are related to a high level of self-efficacy (Neber & Schommer-Aikins, 2002; Pintrich & de Groot, 1990; Sungur, 2007). Self-efficacy refers to an individual's confidence in their ability to perform necessary tasks to achieve a given outcome (Bandura, 1977). The literature has also established that self-efficacy is one of the most powerful and consistent predictors of academic success at university (Owen & Froman, 1988; Robbins et al., 2004). Self-efficacious students have high competence expectations of themselves, are willing to try different strategies when studying, and persist in their efforts when needed to accomplish tasks, which contributes to conditions that foster learning and academic success (Bandura, 1993; Thomas & Rohwer, 1986). Therefore, it is essential to motivate students to improve their self-efficacy, as once students have high levels of self-efficacy, they will be willing to learn and use metacognitive strategies, enabling high academic achievement.

### 1.5 Current Study

The overarching purpose of the current study was to examine metacognitive awareness and metacognitive ability amongst university students, and to clarify the way in which metacognition influences academic success. The relative importance of established predictors, such as intellectual ability, personality traits, and self-efficacy, were also investigated in relation to academic success. Specific aims are displayed in Table 1.

Given the mixed findings in the literature regarding the relationship between metacognitive awareness and academic success, there is scope for clarification of this relationship. The consideration of metacognitive ability in the current study additionally introduces the potential to fill the gaps in the literature and add to current research.

Table 1

*Aims for the Current Study*

| | |
|---|---|
| **Aim 1** | To determine whether we capture the same factor structure of the Metacognitive Awareness Inventory as is put forward in the literature. |
| **Aim 2** | To explore the relationship between measures of metacognitive awareness and metacognitive ability. |
| **Aim 3** | To examine the relative predictive strength of metacognitive awareness and metacognitive ability in regard to academic success. |
| **Aim 4** | To determine whether measures of metacognitive awareness and metacognitive ability can predict academic success above and beyond previously implicated predictors of academic success, such as intellectual ability, personality traits, and self-efficacy. |

## 2 Method

### 2.1 Participants

A total of seventy-six first year undergraduate students (Female = 49, Male, = 27) aged between 17 and 46 years ($M$ = 20.9, $SD$ = 5.39) participated in this study. Participants were recruited from level one undergraduate psychology students enrolled in the course Psychology 1A at the University of Adelaide, who volunteered for course credit.

### 2.2 Materials

Two online self-report questionnaires were assembled for data collection. The first questionnaire included the Raven's Advanced Progressive Matrices Short-Form, to measure intellectual ability; and the Openness Conscientiousness Extraversion Agreeableness Neuroticism Index Condensed scale (OCEANIC), to measure personality traits; and questions regarding predictions of academic performance. The second questionnaire contained the Metacognitive Awareness Inventory (MAI), to measure students' metacognitive awareness; and the Self-Efficacy for Learning Abridged Form (SELF-A), to measure students' learning self-efficacy. The scales used are described in further detail below.

#### 2.2.1 Intellectual Ability

Intellectual ability was measured using the Raven's Advanced Progressive Matrices Short-Form. The 12-item scale is composed of progressively difficult perceptual analytic reasoning problems, each in a matrix format. Participants were required to determine which of eight possible alternatives fits appropriately into a blank space, in order to satisfy specified rules. Participants were asked *"Which numbered piece is missing from the puzzle?"* The APM Short-Form was utilised to reduce completion time by respondents, however, it has near perfect correlations with the original full-length scale ($r$ = .92, $p$ <.001) (Bors & Stokes, 1998). Participants were required to complete two sample items to provide familiarisation with the test items prior to proceeding to the 12-item test. Each participant received a score out of 12, with higher scores indicating higher intellectual ability. For the purpose of this study, the APM Short-Form will be referred to as the APM throughout the paper.

#### 2.2.2 Personality Traits

Personality traits were measured using the OCEANIC, which has high established reliability and validity (Schulze & Roberts, 2006). The 45-item scale requires participants to rate on a 6-point Likert scale (ranging from *Never* to *Always*) how frequently the statements apply to themselves. Participants were given scores for each of the Big 5 Personality Factors. Examples of statements in the scale include *"I am considerate of the feelings of others"* and *"I am organized"* (Schulze & Roberts, 2006). Costa and McCrae's (1992) Big Five Factor model of personality is a robust framework, and is considered the dominant conceptualisation of personality structure in psychology (Schulze & Roberts, 2006).

#### 2.2.3 Metacognitive Ability

Metacognitive ability was measured using participants retrospective assessments of their performance on the Raven's Advanced Progressive Matrices Short-Form immediately after completion. Participants were not given feedback on their performance. Participants were also required to make prospective predictions of their exam grade and final grade for Psychology 1A. These predictions were formulated into a measure of calibration by subtracting the predicted score from the actual performance score. This provided a measure of calibration, which indicated participants level of overconfidence or under confidence. Under confidence was expressed as a negative value, perfect calibration was expressed as zero, and overconfidence was expressed as a positive value.

### 2.2.4 Metacognitive Awareness

Students' metacognitive awareness was measured using the Metacognitive Awareness Inventory (Schraw & Dennison, 1994). The Metacognitive Awareness Inventory consists of 52 items which participants rate on a 6-point Likert scale (ranging from *Strongly Disagree* to *Strongly Agree)*. Participants rated the extent to which they agreed with the statements about their cognition and behaviour when engaging in activities related to Psychology 1A.

The Metacognitive Awareness Inventory has two subscales which represent the two components of metacognitive awareness: knowledge of cognition and regulation of cognition. There are 17 statements related to the knowledge of cognition factor for a possible total of 102 (e.g., *"I use my intellectual strengths to compensate for my weaknesses"*), while there are 35 statements related to the regulation of cognition factor for a possible total of 210 (e.g., *" I consider several alternatives to a problem before I answer"*). Within the metacognitive knowledge component are statements relating to the declarative, procedural and conditional knowledge subcomponents. The metacognitive regulation component includes statements regarding the planning, monitoring, evaluation, information management and debugging strategies subcomponents (Schraw & Dennison, 1994).

The MAI yields a metacognitive knowledge score, a metacognitive regulation score, an individual score for each of the eight subcomponents, and a total metacognitive awareness score for each respondent. The scores for each component are calculated by adding the scores on items related to each component. A total metacognitive awareness score was derived by summing responses to all 52 statements. Higher scores are indicative of a greater ability to reflect upon, understand and control one's learning (Schraw & Dennison, 1994). The Metacognitive Awareness Inventory has been found to have high internal consistency (Cronbach's alpha = .90) and high test-retest reliability ($r$ = .95) (Akin, Abaci, & Cetin, 2007).

### 2.2.5 Self-Efficacy for Learning

Students' learning self-efficacy was measured using the Self-Efficacy for Learning Abridged Form. The 19-item scale required participants to respond to each item using a scale ranging from 0 (*Definitely cannot do it*) to 10 (*Definitely can do it*), indicating the extent to which participants were confident they have the ability to carry out the behaviour in question. The Self-Efficacy for Learning Abridged Form was utilised to reduce respondent completion time, however, it is strongly correlated with the full-length Self-Efficacy for Learning scale ($r$ = .67). The SELF-A has high internal consistency (Cronbach's alpha = .92), and yields significantly better scores than the full length scale (Zimmerman & Kitsantas, 2007). Each participant received a score out of 190 for the SELF-A, where higher scores were indicative of more positive self-efficacy for learning beliefs.

### 2.2.6 Academic Success

Students' academic success was represented by their academic achievement, given by their exam grade and final course grade, expressed as a percentage, in the course Psychology 1A at the end of the semester.

## 2.3 Procedure

Participants were recruited though the University of Adelaide's online Research Participation System. Prior to commencing the study, participants read the information sheet and provided informed consent. The measures utilised in the study were divided into two questionnaires (Part 1 and Part 2), allowing students to complete the two questionnaires within shorter time frames, as opposed to one long sitting. This was devised as a means of reducing participant fatigue and enhancing quality responses. The two questionnaires were administered through an online survey platform, with an estimated completion time of 25-30 minutes each, and remained available for a duration of three months (April – June). The data from Part 1 and Part 2 of the study were then matched up, along with students' course grades, which were obtained through university records.

Identification numbers were used to ensure anonymity of participants identity at all times, and to link students' information. Participants were reassured that results would remain anonymous and that they would not be identifiable. They were given the opportunity to withdraw at any time up until the submission of the questionnaire. The current study was approved by the School of Psychology: Human Research Ethics Subcommittee (Code Number: 18/12).

# 3 Results

## 3.1 Data Screening and Quality Control

Data were analysed using the statistical package R (v3.5.1) with R Studio for Mac (R Core Team, 2018). Eighty-nine students participated in the study; however, six participants were removed from the dataset because their attempt of Part 2 was incomplete. After excluding these participants, the sample size was eighty-three for factor analysis of the Metacognitive Awareness Inventory items. Of these remaining participants, responses from Part 1 and Part 2 of the questionnaires, and academic achievement were then matched. Seven participants did not sit the final exam, thus, no data on their academic performance was available. The final dataset was comprised of seventy-six participants.

## 3.2 Power Analysis

*A priori* power analysis was conducted using G*Power 3.1.9.2. The results indicated that a sample size of $N$ = 64 was necessary to achieve a power level of .80 for detecting medium effect sizes, when adopting a significance criterion of $\alpha$ = .05. Therefore, the study had sufficient statistical power for the primary analysis.

## 3.3 Aim 1: To Examine the Factor Structure of the Metacognitive Awareness Inventory

Existing research on the factor structure of the Metacognitive Awareness Inventory has found a two-factor model comprised of knowledge of cognition and regulation of cognition factors. Accordingly, Aim 1 was to examine whether we capture the same factor structure of the Metacognitive Awareness Inventory in our sample. In addressing this aim, confirmatory factor analysis and exploratory factor analysis were used to investigate the underlying factor structure of the Metacognitive Awareness Inventory. This process is outlined in detail below.

### 3.3.1. Confirmatory Factor Analysis

A confirmatory factor analysis was used to test a forced two-factor model of the Metacognitive Awareness Inventory, which included 17 items for the knowledge of cognition factor and 35 items for the regulation of cognition factor. Data analysis revealed only minor deviations from normality in their distributions.

We fit the model using lavaan version 0.6-2. Maximum likelihood estimation was used, with full information maximum likelihood for the missing data. The latent factors were standardised, allowing estimation of all factor loadings. We found that the two-factor model was not an acceptable fit for the data. The Tucker-Lewis index was .45, which is noticeably lower than the recommended value of >.9. Good models should have RMSEA at or approaching 0, with .05 as the cut off for an acceptable fit. The RMSEA was .103, 95% CI [.097, .109], indicating that the model had poor fit. The factor loadings are presented in Appendix A.

Given the two-factor model was not an acceptable fit for the data, we ran an exploratory factor analysis to further investigate the factor structure of the Metacognitive Awareness Inventory.

### 3.3.2 Exploratory Factor Analysis

Inspection of the correlation matrix of the items from the Metacognitive Awareness Inventory revealed many coefficients above the recommended value of .30, demonstrating reasonable shared variance. Bartlett's test of sphericity was statistically significant ($\chi^2$[1326] = 2661.09, $p < .001$), indicating that correlations were significantly large for factorability. The Kaiser-Meyer-Olkin measure of sampling adequacy was .66, which is above the recommended Kaiser value of .60. Thus, confirming the current sample was suitable for factor analysis.

Best practice in exploratory factor analysis recommended by Costello and Osborne (2005) was employed. Principal axis factoring analysis with oblique (promax) rotation was used to analyse the data from the Metacognitive Awareness Inventory. Initial assessment of eigenvalues exceeding Kaiser's criterion of 1 suggested a 16-factor solution. Despite the default in most statistical software packages is to retain all factors with eigenvalues greater than unity, there is consensus that this is among the least accurate methods for selecting the number of factors to retain (Costello & Osborne, 2005). Therefore, alternate methods for factor retention were adopted. Parallel analysis was conducted, and the results suggested a five-factor solution. Inspection of the associated Scree Plot (Figure 1) also showed five points above the point of inflexion. Given there were multiple points located around the inflexion point, several analyses with two, three, four and five-factor solutions were examined based on their fit and interpretability. The item loading tables were compared, with attention paid to ensure item loadings were equal to or above .30, there were few cross-loadings, and that each factor had five or more strongly loading items equal to or above .50 (Costello & Osborne, 2005). Examination of the models suggest that statistically there could be a two-factor or three-factor structure. We found that the two-factor structure resulted in more cross-loadings and did not align with the theoretical structure proposed by Schraw and Dennison (1994). However, upon interpretation of the three-factor model loadings, it was decided that this solution fit the data best, as there were zero cross-loadings and each factor had five or more strongly loading items. The three factors explained 35% of variance and four items did not load onto any factor at .30 or greater (see Table 2).

The identified factors underlying the Metacognitive Awareness Inventory may be interpreted as follows: Factor 1 can be interpreted as items related to *regulation*; Factor 2 represents items associated with *adaptation*; and Factor 3 is reflective of items linked to *knowledge*. The model provides interpretable factors, with a clear distinction between three types of metacognitive awareness.

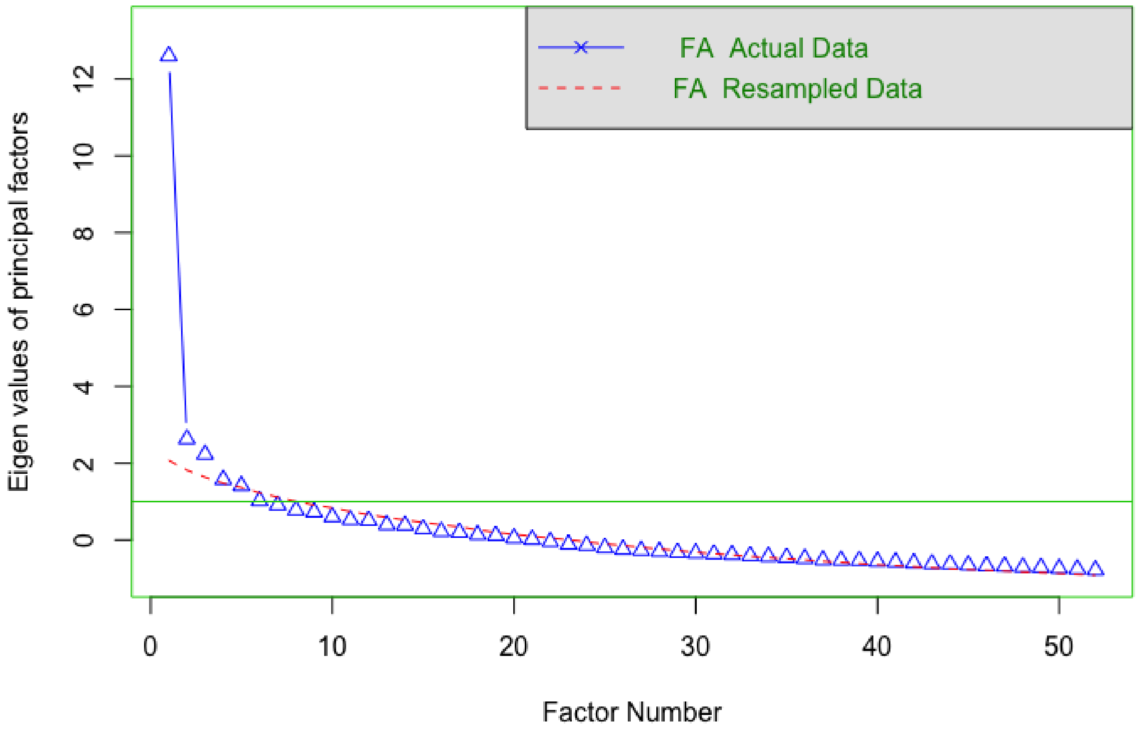


*Figure 1*. Parallel Analysis Scree Plot for the Metacognitive Awareness Inventory.

### 3.3.3 Summary of Factor Analyses

The confirmatory factor analysis indicated that a two-factor model was not an acceptable fit in our sample. However, the exploratory factor analysis suggested that a three-factor model was more suitable for this dataset, which we labelled regulation, adaptation and knowledge. Given the small sample, it is quite possible that we could not find the two-factor structure because we did not have enough participants. Although the exploratory factor analysis suggested a three-factor structure, and given the small sample, in the subsequent analyses we will consider both the original two-factor structure and the newly derived three-factor structure as potential models.

Table 2

*Principal Axis Factoring Loadings (pattern matrices) with Promax Rotation for the Metacognitive Awareness Inventory using a Three-Factor Solution (N = 83)*

| Items | Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| I ask myself questions about the material before I begin | **.79** | -.06 | -.09 |
| I periodically review to help me understand important relationships | **.70** | -.15 | .11 |
| I summarize what I've learned after I finish | **.68** | -.01 | .04 |
| I ask myself if there was an easier way to do things after I finish a task | **.66** | -.02 | -.22 |
| I ask myself how well I accomplish my goals once I'm finished | **.63** | .03 | -.04 |
| I find myself analysing the usefulness of strategies while I study | **.61** | -.07 | .19 |
| I ask myself questions about how well I am doing while I am learning something new | **.61** | -.10 | .23 |
| I ask myself periodically if I am meeting my goals | **.57** | .00 | -.06 |
| I pace myself while learning in order to have enough time | **.56** | -.01 | -.01 |
| I organise my time to best accomplish my goals | **.54** | .04 | .17 |
| I ask myself if I have considered all options after I solve a problem | **.54** | .29 | -.09 |
| I ask myself if I learned as much as I could have once I finish a task | **.52** | .00 | .02 |
| I set specific goals before I begin a task | **.48** | .07 | .03 |
| I ask myself if I have considered all options when solving a problem | **.42** | .37 | -.06 |
| I think about what I really need to learn before I begin a task | **.41** | -.05 | .27 |
| I draw pictures or diagrams to help me understand while learning | **.35** | .19 | -.18 |
| I ask myself if what I'm reading is related to what I already know | -.05 | **.77** | -.05 |
| I learn best when I know something about the topic | -.28 | **.68** | .14 |
| I stop and re-read when I get confused | .08 | **.64** | -.07 |
| I consider several alternatives to a problem before I answer | -.03 | **.61** | -.22 |
| I try to use strategies that have worked in the past | -.10 | **.60** | -.01 |

| | | | |
|---|---|---|---|
| I think of several ways to solve a problem and choose the best one | .46 | **.60** | -.46 |
| I learn more when I am interested in the topic | .05 | **.56** | -.10 |
| I read instructions carefully before I begin a task | -.01 | **.53** | .09 |
| I stop and go back over new information that is not clear | .06 | **.53** | .19 |
| I try to translate new information into my own words | -.06 | **.52** | .11 |
| I slow down when I encounter important information | .04 | **.43** | .25 |
| I focus on the meaning and significance of new information | .20 | **.41** | .25 |
| I use different learning strategies depending on the situation | .20 | **.40** | .11 |
| I create my own examples to make information more meaningful | -.05 | **.37** | .27 |
| I re-evaluate my assumptions when I get confused | .21 | **.35** | .18 |
| I can motivate myself to learn when I need to | .08 | **.35** | .20 |
| I ask others for help when I don’t understand something | .23 | **.31** | .12 |
| I am a good judge of how well I understand something | -.33 | .08 | **.68** |
| I consciously focus my attention on important information | -.08 | .11 | **.65** |
| I know what the teacher expects me to learn | -.08 | .05 | **.61** |
| I am good at organising information | -.06 | .15 | **.55** |
| I am good at remembering information | .02 | -.07 | **.51** |
| I know what kind of information is most important to learn | -.24 | .36 | **.50** |
| I use my intellectual strengths to compensate for my weaknesses | .20 | .05 | **.49** |
| I understand my intellectual strengths and weaknesses | .03 | -.05 | **.49** |
| I have control over how well I learn | .06 | -.17 | **.45** |
| I know when each strategy I use will be most effective | .32 | -.01 | **.42** |
| I know how well I did once I finish a test | .05 | -.22 | **.40** |
| I am aware of what strategies I use when I study | .32 | .00 | **.38** |
| I use the organisational structure of the text to help me learn | .19 | .10 | **.37** |
| I find myself using helpful learning strategies automatically | .03 | .32 | **.36** |

| | | | |
|---|---|---|---|
| I change strategies when I fail to understand | .13 | .28 | **.31** |
| I find myself pausing regularly to check my comprehension | .25 | .07 | .20 |
| I focus on overall meaning rather than specifics | .20 | -.19 | .09 |
| I try to break studying down into smaller steps | .05 | .20 | .18 |
| I have a specific purpose for each strategy I use | .12 | .16 | .28 |
| Explained Variance (%) | 13.00 | 12.00 | 10.00 |
| Cumulative Explained Variance (%) | 13.00 | 25.00 | 35.00 |

*Note.* Bolded values load onto factor at ≥.30; Factor 1 = *"regulation"*; Factor 2 = *"adaptation"*; Factor 3 = *"knowledge"*.

### 3.4 Aim 2: The Relationship between Metacognitive Awareness and Metacognitive Ability

Aim 2 was to explore the relationship between measures of metacognitive awareness and metacognitive ability. Upon inspection of the correlation analyses (Table 3), it was apparent that there were strong significant relationships within each of these measures of metacognition. A strong significant positive correlation was found between the original knowledge of cognition and regulation of cognition factors ($r$ = .74, $p$ < .001). The three newly derived factors were also found to be significantly correlated. Similarly, the measures of metacognitive ability were significantly intercorrelated (see Table 3).

Interestingly, each of these measures of metacognition were largely independent from each other. The two original factors were not significantly correlated with the newly derived factors or measures of metacognitive ability. Similarly, the three newly derived factors did not significantly correlate with the original factors or measures of metacognitive ability. It was also found that the measures of metacognitive ability were not significantly related to the original factors or the newly derived factors (see Table 3). These findings were surprising, as they suggest that there is no meaningful relationship between metacognitive awareness and metacognitive ability. Therefore, these measures of metacognition appear to be three separate constructs.

Table 3

*Correlation Matrix for the Relationship between the Original Factors, the Newly Derived Factors, and Measures of Metacognitive Ability (N = 76)*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Original Factors | 1. Knowledge | 1 | | | | | | | |
| | 2. Regulation | **.74*** | 1 | | | | | | |
| Newly Derived Factors | 3. Regulation | .01 | .07 | 1 | | | | | |
| | 4. Adaptation | .04 | -.06 | **.58*** | 1 | | | | |
| | 5. Knowledge | .04 | .10 | **.59*** | **.57*** | 1 | | | |
| Metacognitive Ability | 6. APM calibration | -.12 | -.01 | -.02 | -.12 | -.11 | 1 | | |
| | 7. Exam calibration | -.02 | .14 | -.01 | -.15 | -.02 | **.35*** | 1 | |
| | 8. Final calibration | .04 | .13 | -.13 | -.16 | -.12 | **.40*** | **.82*** | 1 |

*Note.* Correlations = Pearson's *r*; *N* = 83 for the newly derived factors, in the second section of the table**; * = p<.001.**

### 3.5 Aim 3: The Relative Predictive Strength of Metacognitive Awareness and Metacognitive Ability in Regard to Academic Success

Aim 3 was to explore the relative predictive strength of metacognitive awareness and metacognitive ability with regard to academic success. Correlation analyses (see Table 4) were used to test this aim.

Examination of the correlation analyses revealed that there were no significant relationships between the three newly derived factors and academic success (see Table 4). In addition, the two original factors very weakly correlated with academic success. A weak, but significant, positive correlation was found between knowledge of cognition and final grade ($r$ = .23, $p$ = .04), suggesting that greater levels of metacognitive knowledge were only slightly related to higher final grades. Furthermore, no significant relationships were found between knowledge of cognition and exam grade, and regulation of cognition and academic success.

Upon inspection of the correlation analyses (see Table 4), it was apparent that measures of metacognitive ability had strong significant relationships with academic success. A strong significant negative correlation was found between exam calibration and exam grade ($r$ = -.60, $p$ < .001). Similarly, we found a strong significant negative relationship between final calibration and final grade ($r$ = -.56, $p$ < .001). These findings suggest that overconfidence is related to poorer performance, and under confidence is related to better performance.

We also measured metacognitive ability using an independent calibration measure, in the form of calibration on the Raven's Advanced Progressive Matrices Short-Form, and found that APM calibration was significantly negatively correlated with exam grade ($r$ = -.28, $p$ < .01) and final grade ($r$ = -.30, $p$ < .01). This suggests that overconfidence on an independent calibration task is related to poorer academic performance, and under confidence on an independent calibration task is related to better academic performance.

The results indicate that the newly derived and original factors, as measures of metacognitive awareness, do not seem to have any strength as predictors of academic success. In contrast, both exam calibration and final calibration, as measures of metacognitive ability, appear to have strong predictive strength of academic success. Independent measures of metacognitive ability, as measured by APM calibration, also appear to have predictive strength of academic success. These findings suggest that metacognitive ability has greater predictive strength of academic success than metacognitive awareness. In the following, we will run regression analyses to determine whether measures of metacognitive ability can predict academic success above and beyond previously established predictors of academic success.

Table 4

*The Relationships Between Academic Success and the Original Factors, the Newly Derived Factors, and Measures of Metacognitive Ability (N = 76)*

| | | Academic Success | |
|---|---|---|---|
| | | Exam Grade | Final Course Grade |
| Original Factors | Knowledge | .18 | **.23**** |
| | Regulation | .07 | .11 |
| Newly Derived Factors | Regulation | .08 | .14 |
| | Adaptation | -.02 | -.02 |
| | Knowledge | -.05 | .01 |
| Metacognitive Ability | APM calibration | **-.26**** | **-.30**** |
| | Exam calibration | **-.60*** | **-.50*** |
| | Final grade calibration | **-.51*** | **-.56*** |

*Note.* Correlations = Pearson's *r*; *N* = 83 for the newly derived factors, in the second section of the table; *** *p* < .001; ** *p* < .05.**

### 3.6 Aim 4: To Determine if Measures of Metacognitive Awareness and Metacognitive Ability can Predict Academic Success Above and Beyond Established Predictors

Aim 4 was to determine whether measures of metacognition can predict academic success above previously implicated predictors. Although there were no significant relationships found between metacognitive awareness and academic success, there were, however, strong significant negative relationships found between measures of metacognitive ability and academic success. Given these relationships, a multiple regression analysis was conducted to determine whether metacognitive ability predicted academic success above and beyond previously established predictors of academic success.

#### 3.6.1 Multiple Linear Regression Analysis

Inspection of the correlation analyses (see Table 5) revealed that of the established predictors, only intellectual ability significantly correlated with both exam grade ($r = .51$, $p <$

.001) and final grade (*r* = .50, *p* < .001). Surprisingly, there were no significant relationships with academic success for openness, conscientiousness and self-efficacy (see Table 5). In the following multiple linear regression analyses, we will look at predicting exam grade and final grade based on intellectual ability and the level of calibration students have.

Table 5

*The Relationship between Academic Success and Previously Implicated Predictors of Academic Success (N = 76)*

| | Academic Success | |
|---|---|---|
| | Exam Grade | Final Course Grade |
| Intellectual ability | **.51*** | **.50*** |
| Openness | .18 | .15 |
| Conscientiousness | .09 | .14 |
| Self-efficacy | .21 | .18 |

*Note. N* = 76; Correlations = Pearson's *r*, ***** ***p*** **< .001.**

### 3.6.2 Multiple Linear Regression Results

We employed multiple linear regression to explore the predictors of exam grade. To do this we set up two regression models. The first of which predicts exam grade based on intellectual ability alone. And the second which predicts exam grade based upon intellectual ability and two measures of metacognitive ability: exam calibration and APM calibration.

The results of the first regression model indicated that intellectual ability significantly explained 26% of the variance in exam grade ($F$ [1, 74] = 25.98, $p$ <.001). The results of the second regression model indicated that the three predictors explained 55.7% of the variance in exam grade ($F$ [3, 72] = 30.18, $p$ <.001). It was found that intellectual ability, exam calibration and APM calibration all significantly predicted exam grade (see Table 6), which was expected, given they each significantly correlated with exam grade (see Table 4 and Table 5).

The relative importance of the variables in predicting exam grade were then assessed (see Table 6). In the second regression model, the relative importance of intellectual ability was 37%, and the inclusion of the calibration variables within the model revealed that together they contributed to 63% of the absolute variance.

Table 6

*Comparison of Regression Models for Predictors of Exam Grade*

| | Exam Grade | | | |
|---|---|---|---|---|
| | Model 1<br>*F*(1, 74) = 25.98, *p* < .001<br>$R^2$ = 0.26 | | Model 2<br>*F*(3, 72) = 30.18, *p* < .001<br>$R^2$ = 0.56<br>$R^2$ change = 0.30 | |
| | Beta | RI | Beta | RI |
| Intellectual Ability | **2.26**** | 1.0 | **2.25**** | 0.37 |
| Exam Calibration | | | **-0.54**** | 0.57 |
| APM Calibration | | | **1.14*** | 0.06 |

*Note. N* = 76; RI = Relative Importance; **** *p* <001, **p* <.05.**

We also employed multiple linear regression to explore the predictors of final grade. To do this we set up two regression models. The first of which predicts final grade based on intellectual ability alone. And the second which predicts final grade based upon intellectual ability and two measures of metacognitive ability: final calibration and APM calibration.

The results for the first regression model indicated that intellectual ability significantly explained 25.3% of the variance in final grade (*F* [1, 74] = 25, *p* <.001). The results of the second regression model indicated that the three predictors explained 50.1% of the variance in final grade (*F* [3, 72] = 24.07, *p* <.001). It was found that both intellectual ability and final calibration significantly predicted final grade (see Table 7), however, APM calibration did not, which was unexpected, given APM calibration significantly correlated with final grade (see Table 4).

The relative importance metrics for the first regression model can be seen in Table 7. In the second regression model, the relative importance of intellectual ability was 40% and the inclusion of the calibration variables within the model revealed that together they contributed to 60% of the absolute variance.

In summary, the statistical analyses revealed that intellectual ability, exam calibration and APM calibration significantly explained over 50% of the variance in exam grade in our sample. Similarly, while intellectual ability and final calibration did significantly explain some of the variance in final grade, APM calibration was not significantly predictive of final grade. These findings suggest that metacognitive ability, in the form of final calibration and exam calibration predict academic success above and beyond intellectual ability.

Table 7

*Comparison of Regression Models for Predictors of Final Course Grade*

| | Final Course Grade | | | |
|---|---|---|---|---|
| | Model 1<br>$F(1, 74) = 25$, $p < .001$<br>$R^2 = 0.25$ | | Model 2<br>$F(3, 72) = 24.07$, $p < .001$<br>$R^2 = 0.50$<br>$R^2$ change = 0.25 | |
| | Beta | RI | Beta | RI |
| Intellectual Ability | **1.86**** | 1.0 | **1.86**** | 0.40 |
| Final Calibration | | | **-0.57**** | 0.52 |
| APM Calibration | | | 0.91 | 0.08 |

*Note.* RI = Relative Importance; **** *p* <001, **p* <.05.**

## Discussion

Researching the metacognition and academic success of university students is of practical importance, as higher academic achievement provides many long-term benefits for their future endeavours. Given there is currently mixed findings in the literature with regard to the relationship between metacognitive awareness and academic success, and there is a gap in the literature concerning the study of metacognitive ability, the current study aimed to provide some clarity, as well as address existing limitations, by incorporating measures of both metacognitive awareness and metacognitive ability. We found that metacognitive awareness did not significantly predict academic success in the sample, however, metacognitive ability and intellectual ability did. Factor analyses revealed that a two-factor model of the Metacognitive Awareness Inventory had poor fit in our sample, however, a three-factor model was found to have acceptable fit for this dataset. Investigating the way in which metacognitive awareness and metacognitive ability were related also provided some interesting insight. We found significant relationships within each of these measures of metacognition, however, metacognitive awareness and metacognitive ability were not significantly related. In the following, we will discuss the results and their practical implications, along with methodological strengths and limitations.

### 4.1 Aim 1: Examining the Factor Structure of the Metacognitive Awareness Inventory

The first aim was to explore the underlying factor structure of the Metacognitive Awareness Inventory. The current study did not capture the same two-factor structure of the Metacognitive Awareness Inventory as is put forward in the literature. The results of the confirmatory factor analysis revealed that the forced two-factor model was not an acceptable fit in our sample and did not resemble the theoretical structure comprised of knowledge of cognition and regulation of cognition factors (Schraw & Dennison, 1994). Further, the exploratory factor analysis suggested that a three-factor model was a more suitable fit for our dataset. The three factors retained in the current study were interpretable and representative of items in the Metacognitive Awareness Inventory. They were interpreted as regulation of cognition and knowledge of cognition factors, which had some overlap with the original two-factors, however, there was also a third factor, which could be interpreted as adaptation of metacognitive awareness skills.

The disparity between the two-factor theoretical structure and the structures that emerged in our sample suggests that perhaps metacognitive awareness, as conceptualised in the Metacognitive Awareness Inventory, does not have a stable factor structure and may not capture or measure metacognitive awareness adequately. As the Metacognitive Awareness Inventory was developed over 20 years ago, there is potential that the components it measures are not capturing metacognitive awareness adequately in students due to widespread changes in the university learning experience over the past few decades.

The findings associated with this particular aim should be interpreted with caution. Due to the limitation of a small sample, it is quite possible that we could not find the theoretical two-factor structure put forward in the literature because we did not have enough participants. These findings warrant future research, which should consider exploring the underlying factor structure of the Metacognitive Awareness Inventory using an adequate sample, to determine whether the theoretical two-factor structure or an alternative model measures metacognitive awareness more reliably in students.

## 4.2 Aim 2: The Relationship Between Metacognitive Awareness and Metacognitive Ability

Given the gap in the literature concerning the relationship between metacognitive awareness and metacognitive ability, the current study aimed to provide some insight into this relationship. The data revealed that there were strong significant intercorrelations within each of these measures of metacognition. However, metacognitive awareness and metacognitive ability were found not to be significantly related, suggesting that potentially no meaningful relationship exists between metacognitive awareness and metacognitive ability, and perhaps they are two independent constructs. Given the gap in the literature regarding this relationship, further research is largely warranted to explore and clarify the relationship between metacognitive awareness and metacognitive ability.

Surprisingly, the results indicated that the two measures of metacognitive awareness, the original factors and the newly derived factors, were not significantly correlated, suggesting that these two measures of metacognitive awareness are possibly measuring different components of the metacognitive awareness construct. However, generalisability of this finding is restricted due to the small sample in the study.

A strong significant positive relationship was found between the original knowledge and regulation factors ($r$ = .74, $p$ <.001), which is in line with previous research that found these components of metacognitive awareness to be intercorrelated around $r$ = .50 (Schraw & Dennison, 1994; Sperling et al., 2004). However, the strength of this relationship suggests that the knowledge and regulation factors possibly are not measuring different components of metacognitive awareness in the sample, potentially explaining why we did not find the theoretical two-factor structure of the Metacognitive Awareness Inventory in our study.

### 4.3 Aim 3: The Relative Predictive Strength of Metacognitive Awareness and Metacognitive Ability in Regard to Academic Success

The current study aimed to explore the relative predictive strength of metacognitive awareness and metacognitive ability with regard to academic success at university, whilst addressing limitations in the literature on these relationships. The results revealed that metacognitive awareness was not significantly predictive of academic success. Of the original factors, knowledge of cognition had a weak, but significant, correlation with final grade ($r$ = .23, $p$ = .04), suggesting that greater levels of metacognitive knowledge were only slightly related to higher final grades. However, given this is barely significant, we should interpret with caution. Further, the newly derived factors did not significantly correlate with academic performance. The absence of a significant relationship between metacognitive awareness and academic success may reflect limitations in the measurement of metacognitive awareness in the current study, or potentially may be due to the small sample. However, given the mixed findings in the literature on this relationship, the current study provides further evidence to suggest there is no meaningful relationship between metacognitive awareness and academic success. These findings are in line with a variety of adequately powered studies which found no significant relationship between metacognitive awareness and academic success (Pintrich et al., 1991; Pressley & Ghatala, 1990; Sperling et al., 2004). These findings, however, also contradict a number of studies which found a significant relationship between metacognitive awareness and academic success (Abdellah, 2015; Kállay, 2012; Martini & Shore, 2008; Schraw & Dennison, 1994; Young & Fry, 2008), suggesting that perhaps this significant relationship only exists in certain student samples.

The data revealed that metacognitive ability was significantly predictive of academic success in the sample. Significant negative relationships were found between both exam calibration and academic success ($r$ = -.60), and final calibration and academic success ($r$ = -.56). Interestingly, we found a direct dependency between the direction of exam calibration and exam grade, and the direction of final calibration and final grade, which was based on the way we calculated calibration and was related to students actual performance score. This direct dependency suggested that students who were overconfident in their performance prediction actually performed worse, and students who were underconfident actually performed better than predicted. A possible explanation for this finding is that students who were underconfident in their knowledge for the assessment compensated by studying harder, and performed better. Whereas, overconfident students who were confident they knew the content for the assessment did not study as hard, and performed worse. Underconfident students potentially employed more metacognitive strategies in their learning than overconfident students, to compensate for their lack of confidence in their predicted performance. These findings are supported by previous research which found that predictions of test performance were significantly correlated with actual test performance (Schraw, 1994). Further, the results revealed a significant negative relationship existed between an independent measure of calibration (APM calibration) and academic success. However, this relationship did not have the same kind of direct dependency because APM calibration was an independent measure. Rather, this relationship had an underlying dependency, suggesting that overconfidence on an independent calibration task was related to poorer academic performance, and under confidence on an independent calibration task was related to better academic performance.

These findings suggest that metacognitive ability has greater relative predictive strength of academic success than metacognitive awareness. Potentially, it is not the calibration itself that drives this relationship, rather, it is a skill these students have, which is not being measured by the Metacognitive Awareness Inventory, which allows them to be well calibrated and apply this metacognitive skill to other test situations. Future research should consider exploring potential underlying strategies and processes of this metacognitive skill.

### 4.4 Aim 4: Determine if Measures of Metacognitive Awareness and Metacognitive Ability can Predict Academic Success Above and Beyond Established Predictors

The final aim was to determine whether measures of metacognitive awareness and metacognitive ability can predict academic success above previously implicated predictors of academic success. The results indicated that intellectual ability significantly correlated with measures of academic success at $r$ = .50, which is consistent with previous literature

(Chamorro-Premuzic & Furnham, 2008; Furnham et al., 2009). Surprisingly, conscientiousness, openness to experience and self-efficacy did not significantly correlate with academic success (see Grand Correlation Matrix in Appendix B) in the present study. This was unexpected, given previous research have found these constructs to be significant predictors of academic success (Owen & Froman, 1988; Trapmann et al., 2007). It is quite possible that we did not find these constructs to be significantly related to academic success in our sample due to the study being underpowered.

The current study found that metacognitive ability, in the form of calibration, was the strongest predictor of academic success, and predicted academic success above intellectual ability in both the exam grade and final grade models. This finding was interesting, as it is not consistent with previous literature that suggests intellectual ability is the strongest predictor of academic success (Busato et al., 2000; Chamorro-Premuzic & Furnham, 2008; Furnham et al., 2009).

Exam calibration, APM calibration and intellectual ability significantly accounted for 56% of the variance in exam grade, suggesting these three predictors play a significant role in predicting exam grade. Further, final calibration, APM calibration and intellectual ability accounted for 50% of the variance in final grade. Final calibration and intellectual ability significantly predicted final grade, however, APM calibration did not, which was unexpected, given APM calibration significantly correlated with final grade. This suggests that perhaps an underlying confounding relationship exists when final calibration, APM calibration and intellectual ability are modelled together. Therefore, this finding warrants future research to explore what may be occurring in more detail.

The finding that metacognitive ability is the strongest predictor of academic success in this sample has practical implications. Given there is limited research regrading metacognitive ability's predictive strength of academic success, the findings in this study could be a starting point for future research to explore the predictive strength of metacognitive ability, specifically in the form of calibration. If we can suggest that metacognitive ability is a strong established predictor of academic success in university students, then there is potential for universities to introduce interventions to improve students' metacognitive ability processes and strategies. However, future research needs to be conducted to clarify the benefit of intervention use.

### 4.5 Further Limitations and Methodological Considerations

Some additional methodological limitations should be considered when interpreting the results. Firstly, employing self-report measures made it difficult for researchers to verify if students' responses on metacognition and learning self-efficacy were accurate as they relate to study behaviours and academic success. The use of self-report measures also potentially leaves the data vulnerable to social desirability bias, as participants may have tailored their responses to reflect perceived desirable responses rather than their actual responses, thus, affecting the validity of the results.

Despite consensus in the literature that academic success is operationalised best by measures of academic achievement, students' exam and final Psychology 1A grades in the sample may not have been representative of the participants overall academic success at university. For example, some students may not demonstrate their learning best in an exam assessment due to external factors, such as anxiety, influencing their performance ability. Using students' GPA, satisfaction with overall university and course experience, and attainment of learning objects may be a better way of operationalising academic success in future research. This would, however, introduce additional challenges, as certain courses at university are argued to be more demanding or challenging than others.

Additionally, the generalisability of the results is limited, as only first year psychology students volunteered to participate in the study. High achieving students may be overrepresented, as the average final grade for this sample was 76 (equivalent to a Distinction), which suggests we haven't managed to capture the whole range of academic performance within this sample. A possible explanation for this is that low performing students do not take part in the research participation component of the Psychology 1A course. If we do not have academic performance information on these students, then it is difficult to generalise the findings. To overcome this limitation, future studies should consider recruiting professors to administer the surveys to their students at the beginning of the semester as a course requirement, or recruiting students from a variety of domains and year levels may be a better way of obtaining participants in future studies. An advantage of this is recruiting a wider range of outcome scores in the sample. With recruitment constraints, this was not feasible in the current study.

**4.6 Methodological Strengths**

The primary strength of the current study was the use of measures of both metacognitive awareness and metacognitive ability to investigate their relationship with each other and with academic success. To the researcher's knowledge, this is one of the few study's that assess both metacognitive awareness and metacognitive ability. Incorporating both measures of metacognition addressed a number of limitations in the existing literature. This provided some clarity on the mixed findings of the relationship between metacognitive awareness and academic success, partially filled the gap in the literature pertaining to the way in which metacognitive ability, in the form of calibration, influences academic performance, and provided a starting point for future research to explore the relationship between metacognitive awareness and metacognitive ability.

## 4.7 Future Research Directions

In the previous sections, we have made a number of suggestions for future research directions. Further research directions are as follows: as the current study has established the importance of metacognitive ability in predicting academic success, future research should further examine how metacognitive ability, in the form of calibration, impacts academic success, to determine if more robust correlations can be obtained when sampling is across domains and year levels and sample sizes are larger. Future research could also investigate the merit of the Metacognitive Awareness Inventory and measures of metacognitive ability as screening tools for professors to use to determine students' level of metacognition. Professors can then flag students who could improve their metacognitive skills, and tailor interventions to meet the needs of these students, which may contribute to the attainment of higher academic achievements.

The current study should also be replicated, taking into consideration the identified limitations, in order to establish a greater body of evidence in the area of metacognition.

## 4.8 Conclusions

Although metacognitive awareness was found to be a poor predictor of academic success, the results of the present study make an important contribution to the understanding of metacognitive ability. The results provide meaningful insight into the ways in which students metacognitive ability, in the form of calibration, strongly predict academics success. This study is a valuable starting point for future research to explore the predictive strength of students' metacognitive ability. Such studies could consequently provide rich information about metacognitive ability's predictive strength and recommend intervention possibilities for professors to screen and improve their students' metacognitive skills. The current study also highlights the possibility that the theoretical two-factor structure of the Metacognitive

Awareness Inventory may not capture the components of metacognitive awareness adequately and suggests that the underlying factor structure requires further investigation.

As the number of individuals entering higher education increases, it is essential to identify metacognitively unaware learners and consequently introduce strategies to improve their metacognition and attainment of higher academic success.

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## Appendix A: Factor Loadings for Confirmatory Factor Analysis

| Latent Factor | Indicator | B | SE | Z | p-value | Beta |
|---|---|---|---|---|---|---|
| Knowledge | x3 | 0.307 | 0.089 | 3.445 | .001 | 0.385 |
| Knowledge | x5 | 0.411 | 0.105 | 3.915 | 0 | 0.432 |
| Knowledge | x10 | 0.468 | 0.091 | 5.156 | 0 | 0.550 |
| Knowledge | x12 | 0.544 | 0.104 | 5.234 | 0 | 0.556 |
| Knowledge | x14 | 0.416 | 0.095 | 4.373 | 0 | 0.476 |
| Knowledge | x15 | 0.376 | 0.096 | 3.915 | 0 | 0.432 |
| Knowledge | x16 | 0.473 | 0.097 | 4.876 | 0 | 0.525 |
| Knowledge | x17 | 0.434 | 0.118 | 3.683 | 0 | 0.411 |
| Knowledge | x18 | 0.572 | 0.107 | 5.356 | 0 | 0.568 |
| Knowledge | x20 | 0.326 | 0.112 | 2.920 | .004 | 0.330 |
| Knowledge | x26 | 0.601 | 0.121 | 4.989 | 0 | 0.534 |
| Knowledge | x27 | 0.569 | 0.098 | 5.780 | 0 | 0.603 |
| Knowledge | x29 | 0.594 | 0.103 | 5.788 | 0 | 0.605 |
| Knowledge | x32 | 0.293 | 0.091 | 3.234 | .001 | 0.363 |
| Knowledge | x33 | 0.526 | 0.090 | 5.851 | 0 | 0.610 |
| Knowledge | x35 | 0.595 | 0.095 | 6.276 | 0 | 0.646 |
| Knowledge | x46 | 0.303 | 0.093 | 3.269 | .001 | 0.368 |
| Regulation | x1 | 0.595 | 0.132 | 4.519 | 0 | 0.479 |
| Regulation | x2 | 0.227 | 0.091 | 2.482 | 0.013 | 0.275 |
| Regulation | x4 | 0.503 | 0.108 | 4.665 | 0 | 0.493 |
| Regulation | x6 | 0.514 | 0.101 | 5.094 | 0 | 0.531 |
| Regulation | x7 | 0.177 | 0.127 | 1.389 | 0.165 | 0.165 |
| Regulation | x8 | 0.522 | 0.110 | 4.741 | 0 | 0.499 |
| Regulation | x9 | 0.476 | 0.091 | 5.206 | 0 | 0.541 |
| Regulation | x11 | 0.548 | 0.087 | 6.264 | 0 | 0.630 |
| Regulation | x13 | 0.378 | 0.085 | 4.429 | 0 | 0.471 |
| Regulation | x19 | 0.496 | 0.127 | 3.909 | 0 | 0.421 |
| Regulation | x21 | 0.623 | 0.107 | 5.826 | 0 | 0.595 |
| Regulation | x22 | 0.654 | 0.109 | 6.002 | 0 | 0.610 |
| Regulation | x23 | 0.522 | 0.102 | 5.127 | 0 | 0.536 |
| Regulation | x24 | 0.765 | 0.121 | 6.301 | 0 | 0.633 |
| Regulation | x25 | 0.467 | 0.139 | 3.354 | .001 | 0.365 |
| Regulation | x28 | 0.699 | 0.111 | 6.290 | 0 | 0.632 |
| Regulation | x30 | 0.657 | 0.096 | 6.878 | 0 | 0.677 |
| Regulation | x31 | 0.513 | 0.125 | 4.099 | 0 | 0.439 |
| Regulation | x34 | 0.510 | 0.127 | 4.016 | 0 | 0.431 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Regulation | x36 | 0.588 | 0.110 | 5.344 | 0 | 0.553 |
| Regulation | x37 | 0.387 | 0.132 | 2.932 | .003 | 0.322 |
| Regulation | x38 | 0.703 | 0.107 | 6.553 | 0 | 0.653 |
| Regulation | x39 | 0.416 | 0.104 | 4.002 | 0 | 0.430 |
| Regulation | x40 | 0.504 | 0.093 | 5.393 | 0 | 0.557 |
| Regulation | x41 | 0.475 | 0.094 | 5.069 | 0 | 0.528 |
| Regulation | x42 | 0.508 | 0.116 | 4.394 | 0 | 0.468 |
| Regulation | x43 | 0.509 | 0.104 | 4.910 | 0 | 0.516 |
| Regulation | x44 | 0.524 | 0.089 | 5.891 | 0 | 0.599 |
| Regulation | x45 | 0.792 | 0.124 | 6.361 | 0 | 0.637 |
| Regulation | x47 | 0.337 | 0.114 | 2.948 | .003 | 0.324 |
| Regulation | x48 | 0.118 | 0.126 | 0.942 | .346 | 0.106 |
| Regulation | x49 | 0.620 | 0.095 | 6.514 | 0 | 0.650 |
| Regulation | x50 | 0.567 | 0.118 | 4.815 | 0 | 0.506 |
| Regulation | x51 | 0.525 | 0.089 | 5.870 | 0 | 0.598 |
| Regulation | x52 | 0.482 | 0.099 | 4.860 | 0 | 0.511 |

*Note.* Indicator = items from the MAI; B = Standardised Parameter Estimates; SE = Error Variances; Z = z score; Beta = Standardised Regression Coefficients.

# Appendix B: Grand Correlation Matrix of all Variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Exam Grade | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. Final Grade | **.92**[a] | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. Total | .12 | .16 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Knowledge | .18 | **.23**[c] | **.87**[a] | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. Regulation | .07 | .11 | **.97**[a] | **.74**[a] | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Declarative | **.26**[c] | **.28**[c] | **.68**[a] | **.88**[a] | **.54**[a] | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. Procedural | .06 | .10 | **.75**[a] | **.80**[a] | **.67**[a] | **.52**[a] | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 8. Conditional | .11 | .18 | **.85**[a] | **.90**[a] | **.75**[a] | **.65**[a] | **.71**[a] | 1 | | | | | | | | | | | | | | | | | | | | | | |
| 9. Planning | .09 | .13 | **.84**[a] | **.61**[a] | **.88**[a] | **.39**[a] | **.62**[a] | **.65**[a] | 1 | | | | | | | | | | | | | | | | | | | | | |
| 10. Manage | .13 | .15 | **.87**[a] | **.77**[a] | **.85**[a] | **.62**[a] | **.63**[a] | **.75**[a] | **.61**[a] | 1 | | | | | | | | | | | | | | | | | | | | |
| 11. Monitoring | -.04 | -.02 | **.86**[a] | **.61**[a] | **.90**[a] | **.43**[a] | **.57**[a] | **.63**[a] | **.78**[a] | **.70**[a] | 1 | | | | | | | | | | | | | | | | | | | |
| 12. Debugging | .14 | .19 | **.77**[a] | **.60**[a] | **.79**[a] | **.47**[a] | **.51**[a] | **.60**[a] | **.63**[a] | **.71**[a] | **.59**[a] | 1 | | | | | | | | | | | | | | | | | | |
| 13. Evaluation | -.01 | .03 | **.77**[a] | **.52**[a] | **.82**[a] | **.35**[b] | **.48**[a] | **.55**[a] | **.70**[a] | **.55**[a] | **.75**[a] | **.49**[a] | 1 | | | | | | | | | | | | | | | | | |
| 14. Factor 1 | .08 | .14 | .05 | .01 | .07 | -.09 | .04 | .12 | .05 | -.03 | .06 | .12 | .12 | 1 | | | | | | | | | | | | | | | | |
| 15. Factor 2 | -.02 | -.02 | -.12 | .04 | -.06 | -.03 | .11 | .06 | -.02 | -.10 | -.12 | .07 | -.05 | **.58**[a] | 1 | | | | | | | | | | | | | | | |
| 16. Factor 3 | -.05 | .01 | .09 | .04 | .10 | -.09 | .17 | .10 | .12 | -.01 | .10 | .13 | .13 | **.59**[a] | **.57**[a] | 1 | | | | | | | | | | | | | | |
| 17. Age | .14 | .14 | .22 | .20 | .20 | .18 | .15 | .18 | .17 | .14 | **.28**[b] | .13 | .14 | .03 | -.01 | .13 | 1 | | | | | | | | | | | | | |
| 18. Gender | **.37**[a] | **.30**[b] | -.15 | -.17 | -.12 | -.07 | -.17 | **-.23**[c] | -.12 | -.07 | -.19 | -.09 | -.04 | -.09 | -.02 | -.12 | .08 | 1 | | | | | | | | | | | | |
| 19. IA | **.51**[a] | **.50**[a] | .16 | .15 | .15 | .20 | .13 | .05 | .09 | **.23**[c] | -.04 | **.28**[b] | .10 | -.10 | -.07 | .00 | .10 | **.50**[a] | 1 | | | | | | | | | | | |
| 20. O | .18 | .15 | **.40**[a] | **.31**[b] | **.41**[a] | **.35**[a] | .11 | **.27**[c] | **.37**[a] | **.28**[b] | **.47**[a] | .22 | **.37**[a] | -.10 | -.10 | -.09 | .20 | .11 | .10 | 1 | | | | | | | | | | |
| 21. C | .09 | .14 | **.49**[a] | **.45**[a] | **.47**[a] | **.40**[a] | **.41**[a] | **.38**[a] | **.50**[a] | **.29**[b] | **.36**[a] | **.42**[a] | **.44**[a] | -.02 | -.01 | .07 | .18 | -.20 | .10 | **.34**[b] | 1 | | | | | | | | | |
| 22. E | -.15 | -.09 | .15 | .16 | .14 | .22 | -.02 | .15 | .06 | .10 | .14 | .12 | .18 | .04 | -.20 | -.21 | -.10 | -.12 | -.17 | .13 | **.28**[b] | 1 | | | | | | | | |
| 23. A | -.10 | .00 | **.46**[a] | **.31**[b] | **.49**[a] | .14 | **.32**[b] | **.40**[a] | **.49**[a] | **.28**[b] | **.45**[a] | **.43**[a] | **.47**[a] | .04 | .03 | .07 | .02 | -.20 | -.01 | .22 | **.52**[a] | **.37**[a] | 1 | | | | | | | |
| 24. N | -.14 | -.17 | .00 | -.03 | .02 | -.18 | .12 | .05 | .05 | -.04 | .04 | -.02 | .06 | .01 | .19 | .08 | -.20 | **-.23**[c] | -.22 | .17 | -.04 | **-.27**[c] | .02 | 1 | | | | | | |
| 25. SE | .21 | .18 | **.50**[a] | **.46**[a] | **.48**[a] | **.41**[a] | **.43**[a] | **.37**[a] | **.42**[a] | **.41**[a] | **.29**[b] | **.47**[a] | **.45**[a] | .04 | .06 | .15 | .11 | .04 | **.39**[a] | .08 | **.36**[a] | .15 | .13 | .02 | 1 | | | | | |
| 26. APM Calib | **-.28**[b] | **-.30**[b] | -.05 | -.12 | -.01 | -.12 | -.09 | -.10 | -.10 | -.05 | .13 | -.14 | .09 | -.02 | -.12 | -.11 | .07 | -.06 | **-.53**[a] | -.11 | -.02 | .05 | -.05 | -.02 | -.13 | 1 | | | | |
| 27. Exam Calib | **-.60**[a] | **-.50**[a] | .09 | -.02 | .14 | .04 | -.07 | -.05 | .02 | .07 | **.23**[c] | -.01 | **.28**[b] | -.01 | -.15 | -.02 | -.02 | -.10 | -.18 | -.03 | -.06 | **.28**[b] | .05 | -.06 | .15 | **.35**[b] | 1 | | | |
| 28. Final Calib | **-.51**[a] | **-.56**[a] | .08 | -.04 | .13 | .02 | -.07 | -.08 | .02 | .07 | .21 | .00 | **.26**[c] | -.13 | -.16 | -.12 | -.06 | -.01 | -.18 | -.01 | -.04 | **.31**[b] | .04 | .00 | **.26**[c] | **.40**[a] | **.82**[a] | 1 | | |
| 29. Satisfaction | .13 | .19 | **.33**[b] | **.31**[b] | **.31**[b] | **.36**[b] | .16 | .22 | **.27**[c] | **.24**[c] | **.33**[b] | **.24**[c] | **.25**[c] | .01 | -.04 | -.02 | .10 | -.03 | .12 | .11 | .19 | .19 | **.38**[a] | -.15 | .15 | -.07 | **.24**[c] | .14 | 1 | |
| 30. Engage | .11 | .12 | **.43**[a] | **.37**[a] | **.42**[a] | **.33**[b] | **.31**[b] | **.31**[b] | **.45**[a] | **.31**[b] | **.39**[a] | **.36**[b] | **.29**[b] | .09 | .11 | .15 | .13 | -.17 | .11 | -.01 | **.37**[a] | .21 | **.42**[a] | -.07 | **35**[b] | -.14 | .14 | .12 | **.72**[a] | 1 |

***Note.*** Correlations = Pearson's *r*; Total = Total MAI Score; Manage = Management; Factor 1 = *"Regulation"*; Factor 2 = *"Adaptation"*; Factor 3 = *"Knowledge"*; IA = Intellectual Ability; O = Openness to Experience; C = Conscientiousness; E = Extraversion, A = Agreeableness, N = Neuroticism; APM Calib = APM Calibration; Exam Calib = Exam Calibration; Final Calib = Final Calibration; Satisfaction = Satisfaction with the course; Engage = Engagement with the course; **a = p<.001; b = p<.01; c = p<.05.**