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Exploring the Relation Between Metacognition, Gender, and Personality in Colombian University Students

Explorando la Relación entre Metacognición, Género y Personalidad en Estudiantes Universitarios Colombianos

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In the present study, the relationship between objective and subjective measures of metacognition, personality traits of the Big Five (extraversion, agreeableness, conscientiousness, neuroticism, and openness) and gender were examined. A convenience sample of 352 university students completed the Metacognitive Awareness Inventory, the Adjectives to Evaluate Personality instrument, and completed 3 domain-specific tests (vocabulary, probabilities, paper folding) along with confidence in performance judgments for each item on these tests. Through a combination of descriptive statistics, zero-order bivariate correlations, simultaneous multiple regression, and a multivariate analysis of covariance, findings indicate that objective and subjective measures of metacognition are weakly related and that subjective measures of metacognition were more strongly related to personality traits. Conscientiousness and openness were the only personality traits that positively predicted metacognition. Gender affected both subjective and objective measures of metacognition, even after controlling for university type (private, public) and perceptions of academic performance (high, low) such that males were more accurate and less biased in their monitoring than females only in mathematical reasoning and they reported higher awareness of their knowledge and regulation of cognition than their female counterparts. Findings support the need to better understand how personality traits and gender affect self-regulated learning skills like metacognition to improve educational practices.

Keywords: metacognition, monitoring, judgment accuracy and error, gender, personality factors

En el presente estudio se examinó la relación entre las medidas objetivas y subjetivas de metacognición, los rasgos de personalidad de los Cinco Grandes (extraversión, amabilidad, responsabilidad, neuroticismo y apertura) y el género. Una muestra de conveniencia de 352 estudiantes completó el Inventario de Conciencia Metacognitiva, el instrumento Adjetivos para Evaluar la Personalidad y completaron 3 pruebas de dominio específico (vocabulario, probabilidades, plegado de papel) junto con la confianza en los juicios de desempeño para cada reactivo en estas pruebas. A través de una combinación de estadísticas descriptivas, correlaciones bivariadas de orden cero, regresión múltiple simultánea y un análisis multivariante de covarianza, los hallazgos indican que las medidas objetivas y subjetivas de metacognición están débilmente relacionadas y que las medidas subjetivas de metacognición están más fuertemente relacionadas con los rasgos de personalidad. Además, la responsabilidad y la apertura fueron los únicos rasgos de personalidad que predijeron positivamente la metacognición. Finalmente, el género afectó las medidas subjetivas y objetivas de metacognición, incluso después de controlar por tipo de universidad (privada, pública) y percepciones del desempeño académico (alto, bajo) de tal manera que los hombres fueron más precisos y menos sesgados en su monitoreo que las mujeres solo en el razonamiento matemático y reportaron una mayor conciencia de su conocimiento y regulación de la cognición que sus contrapartes femeninas. Los hallazgos respaldan la necesidad de comprender mejor cómo los rasgos de personalidad y el género afectan las habilidades de aprendizaje autorregulado como la metacognición para mejorar la práctica educativa.

Palabras clave: metacognición, monitoreo, precisión y error del juicio, género, rasgos de personalidad

Metacognition has traditionally been conceptualized as one of three main components of self-regulated learning (SRL) theory, along with motivation and cognition (Panadero, 2017). Generally, metacognition is defined as the act of taking one's cognition as the object of cognitive thought and it is considered an effortful,

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time-consuming, higher-order process of reflection (Flavell, 1979). The early work of Flavell (1979) described metacognition as involving four main categories: (a) metacognitive knowledge (world knowledge), (b) metacognitive experiences (insight into what information is necessary to fully understand a task/problem), (c) goals/tasks, and (d) actions/strategies. Later, researchers like Palincsar and Brown (1984) conceptualized metacognition as learners' ability to monitor and control their own learning. Subsequently, Schraw and Dennison (1994) developed a more comprehensive conceptualization of metacognition that continues to be used by contemporary metacognitive researchers today.

Metacognition, as it is understood nowadays, is comprised of two main components, knowledge of cognition and regulation of cognition (Schraw & Dennison, 1994). These two dimensions subsume eight micro-processes. Knowledge of cognition is composed of declarative knowledge (a repertoire of cognitive strategies at the learner's disposal), procedural knowledge (a set of heuristics for implementing cognitive strategies), and conditional knowledge (the where, when, and why to apply strategies given task demands). Regulation of cognition, on the other hand, encompasses planning (preparing the ground before the task, such as the resources necessary to complete it and any anticipated challenges that the student may face during the task), information management (the set of strategies to effectively manage the incoming information needed to complete the task), debugging (the set of strategies available to solve learning difficulties), comprehension monitoring (the skills necessary to effectively monitor progress toward task completion), and evaluation (generally recognized as a holistic and general judgment of how well the task was accomplished and then used to gauge future performance; Schraw & Dennison, 1994). Of all these metacognitive aspects, the one that has received the most attention recently in the literature is comprehension monitoring (Boekaerts & Rozendaal, 2010; Efklides, 2008; Winne & Nesbit, 2009).

Although there is research on the relationship between metacognition and cognitive components during learning, such as learning strategies and strategy use (e.g., Gutierrez & Schraw, 2015, Gutierrez de Blume, 2017), executive functions, like working memory capacity and inhibitory control (e.g., Roderer & Roebers, 2010; Roebers & Spiess, 2017), and various intellectual domains (e.g., Gutierrez et al., 2016; Gutierrez de Blume et al., 2021), no research to date has explored the potential connection between metacognitive components and psychological constructs that extend beyond learning in classroom settings. Thus, the purpose of the present study was to examine the relationship between metacognitive processes, gender, and personality in the same study, rather than in isolation. In addition, the present study sought to extend previous research by employing both objective and subjective measures of metacognition. Each one of these topics is addressed in the following sections.

Objective and Subjective Measures of Metacognition

Metacognition benefits from being a construct that can be measured using more objective approaches, but also via self-report (Schraw, 2009). Objective measures refer to materials, instruments, or apparatuses that do not rely on individuals' own ratings of themselves, but rather employ, for example, an independent, objective observer of individuals' behavior regarding the phenomena of interest (e.g., via a behavior checklist or performance rubric). Conversely, subjective measures, such as surveys, require individuals to self-select to participate and to complete the survey themselves (hence, self-report) (Johnson & Christensen, 2020). Much of the research literature in the social-behavioral sciences is grounded in self-report measures, most notably, surveys (Schraw, 2009). Presumably, they are more popular among researchers because they are easy to administer, require little time from the researcher, and are relatively inexpensive. Objective measures, on the other hand, typically require more involvement from the researcher and necessitate additional resources (e.g., money). Despite their strengths and shortcomings, subjective measures are widely acknowledged as being error-prone because of various within-person factors (e.g., age, intellectual ability, motivation, prior knowledge, culture, gender identity) of participants that are beyond the researcher's control (Johnson & Christensen, 2020). The most egregious offender of this measurement error appears to be the social desirability bias, in which individuals are dishonest (implicitly or explicitly) about the true trait the self-report instrument is measuring because they wish to be seen more favorably by others (Larson, 2019). Objective measures, by contrast, while at times more difficult to administer, are more accurate and less error-prone (Johnson & Christensen, 2020).

Among the objective measures of metacognition are studies that employ metacognitive monitoring indices by comparing judgments of performance to actual performance, most typically on criterion-referenced test of achievement. In this context, monitoring may be applied in a variety of activities, such as judgments of

learning, understanding, and performance either before (predictions) or after a task (postdictions) to promote self-regulation (Efklides, 2011). The prototypical format in metacognitive monitoring studies is to answer a test item and judge whether the answer is correct or incorrect (i.e., make a performance accuracy judgment). For a comprehensive review of the prototypical array for objective measurement of metacognitive judgments, please see Gutierrez et al. (2016) and Schraw et al. (2014). Thus, to include more than one objective measure of metacognitive monitoring, as recommended by Schraw (2009), sensitivity and specificity were employed in this study as objective measures of metacognition.

There exist several self-report surveys that evaluate individuals' perceptions of their own metacognitive skills, such as the Metacognitive Awareness Inventory for Teachers (MAIT; Balcikanli, 2011; Gutierrez de Blume & Montoya Londoño, 2020a). However, for the general population, the most employed instrument for measuring self-report metacognitive awareness is the Metacognitive Awareness Inventory (MAI), originally developed in 1994 by Schraw and Dennison. The MAI is a 52-item survey that measures two broad dimensions of metacognition, knowledge of cognition and regulation of cognition, and it was initially conceived to measure metacognitive aspects of SRL. Within knowledge, the MAI captures three sub-components, declarative, procedural, and conditional; as to regulation, it measures planning, monitoring, information management, debugging, and evaluation. In addition to the objective measures of metacognitive monitoring, the Spanish version of the MAI (Gutiérrez de Blume & Montoya Londoño, 2021; Huertas Bustos et al., 2014) was also administered.

Both subjective (i.e., self-report) and objective measures were employed for three reasons. The first is that objective measures of any psychological construct are far more accurate than subjective ones because they are not relying on individuals' own ratings, which may be biased due to social desirability concerns. The second is that, although subjective measures are less accurate, they provide useful information about how individuals perceive themselves. The third is that extant research on the overlap (or lack of it) between objective and subjective measures of the same construct is not very well understood, and this is not different in metacognition. Thus, one the objectives of this study was to deepen researchers' understanding of the similarity/dissimilarity between these two measurement modalities respecting metacognition. If, in fact, the measures tap into the same construct, conceivably there should be some overlap (i.e., associations) between them.

Metacognition Across Domains of Learning

Metacognition has been studied in both domain-general and domain-specific contexts. Schraw and colleagues (Schraw et al., 1995; Schraw & Nietfeld, 1998), for instance, compared metacognitive monitoring accuracy across a variety of different content domains, such as vocabulary knowledge, analogies, and working memory tasks. They found that confidence and bias (error) were correlated across eight tests, even when performance was not. In a follow-up study that controlled for test difficulty and format, correlations increased still further. Schraw and Nietfeld (1998) found strong between-test associations for eight widely different measures of fluid and crystalized ability. Similarly, Hartwig et al. (2012) found that a general measure of monitoring accuracy on one task predicted future performance on a different task and set of materials. Likewise, Lin et al. (2001) found strong positive relations between different types of pretest (e.g., understanding, confidence, and easiness) and post-test (e.g., certainty and number of test questions answered correctly) measures. Finally, Gutierrez et al. (2016) and Gutierrez de Blume et al. (2021) found that metacognitive monitoring accuracy and bias were inversely related across vocabulary, probabilities, and paper folding tasks, but that, while accuracy was encapsulated within tasks, error was domain independent. Given this line of inquiry, both a domain-general measure of metacognitive skill (MAI Spanish version) and objective measures regarding three domain-specific performance tasks (vocabulary, probabilities, and paper folding) were employed to examine their relationship.

Metacognition and Personality

With reference to SRL theory, personality can be conceptualized as a dispositional component of motivation. Personality can be understood as a person's relatively stable dispositions toward certain patterns of cognition, emotion, and behavior (Hogan et al., 1996). Accordingly, some researchers have recognized five main components of personality: agreeableness, emotional stability/neuroticism,

conscientiousness/responsibility, extraversion, and openness to experience (or intellect/imagination; Goldberg et al., 2006; John et al., 2008; McCrae & Costa, 1987).

There are relatively few studies in which researchers have explored the value of non-cognitive predictors of school success, such as the role of different personality factors in metacognitive performance. However, research exists on the relationship between measures of social and psychological adjustment and some aspects of individual differences in the formulation of metacognitive judgments in high school students. This line of research showed that personality traits and cognitive ability are related to the accuracy of self-assessment and that confidence in self- response to a cognitive test is associated with other measures of self-confidence, self-concept, and self-efficacy (Pallier et al., 2002; Stankov et al., 2014).

Some researchers have argued that the operationalization of personality factors may include the trend towards some self-regulation of learning skills (Bidjerano & Dai, 2007). Other researchers, for instance, recognize that conscientiousness/responsibility is associated with the ability to plan, organize, and persist in learning activities and that, similarly, people with high scores on the openness factor are more amenable towards challenging learning experiences (Bidjerano & Dai, 2007; McCrae & Costa, 1987). Along a similar vein, other researchers posit that students with higher self-regulation skills exhibit less neuroticism and extraversion and greater conscientiousness, agreeableness, and openness to experiences (Dörrenbächer & Perels, 2016).

Nevertheless, few studies to date have investigated the predictive effect of personality factors in students' metacognitive monitoring skills. This dearth of research is likely associated with the treatment of metacognition as a "cold" construct, in contrast to a potential "warmer" approach that considers aspects such as motivation, emotions, and personality (Burson et al., 2006; Stankov et al., 2014). Thus, the exploration of the relationship that may exist between personality factors and metacognition can provide important explanations of individuals' self-regulation process of learning. Regarding this vein of inquiry, a series of recent studies found that conscientiousness and openness to experience predicted students' self-report metacognitive skills (Gutierrez-de Blume & Montoya-Londoño, 2020b) and objective measures of metacognitive monitoring (Gutierrez de Blume et al., 2022b). More research is needed, however, to better understand the potentially complex and dynamic relationship between personality and metacognition, a void the present study aimed to fill. Further, additional research on these two psychological constructs would ensure the stability of the scant research on these topics and it would enable researchers to develop unique, individualized metacognitive profiles that align with personality.

Metacognition and Gender

The influence of gender differences on metacognitive skills has received recent attention in the literature. For instance, gender has been found to have a significant moderating effect on metacognitive monitoring, such that males tend to be overconfident in their performance judgments whereas females exhibit a tendency to be underconfident (Ackerman et al., 2011; Gutierrez & Price, 2017; Gutierrez & Schraw, 2015). Interestingly, this effect appears to be consistent across tasks and domains, such as driving skills (Ackerman et al., 2011), mathematics (Chiu & Klaasen, 2010), and physics (Sharma & Bewes, 2011), as well as across the lifespan (Ackerman et al., 2011; Chiu & Klassen, 2010; Denham et al., 2012). More specifically, Ackerman et al. (2011) found that gender was predictive of lower self-rated driving ability, as they discovered that females underrated their driving ability compared to males, and that this effect held even after controlling for baseline driving ability. Regarding domain-specific achievement, research showed that males not only outperformed females in math achievement but that females rated themselves lower in perceptions of their achievement. Additionally, this discrepancy between judgments of performance and actual math performance was more pronounced among females (Chiu & Klassen, 2010; Sheldrake et al., 2014). A similar finding was reported by Sharma and Bewes (2011) in physics. They found that, although males and females did not differ in their physics performance, males tended to be more accurate in their confidence in performance ratings of mechanics, albeit females' bias scores (i.e., judgment errors) were close to that of males, suggesting that they generally understood their lack of understanding of mechanics. Finally, Gutierrez and Schraw (2015) and Gutierrez and Price (2017) found that females, while similarly accurate in their metacognitive monitoring compared to males, also exhibited slight underconfidence. Because the present study occurred in a Latin American country in which traditional gender roles are still being observed by society, it was considered prudent to incorporate gender as another focal point of it to further investigate its effects on metacognition.

The Present Study

The literature previously reviewed has four emerging themes that support the need for the present investigation. The first is that metacognition is a broad, complex psychological phenomenon that subsumes several micro-processes, such as conditional knowledge and comprehension monitoring. The second is that, while there is research on metacognition employing objective or subjective measures and other psychological constructs, no research to date has examined both objective and subjective measures of metacognition in the same study to better understand how they align or overlap, if at all. The third is that only sparse research has been conducted exploring objective metacognitive monitoring measures in more than one domain of learning. The fourth is that evidence exists of several fields of research that have attempted to explore the relationship between metacognitive skills and other cognitive (e.g., performance and confidence judgments), socio-demographic (e.g., gender and age), and personality in isolation, but never simultaneously. This limits the understanding of how psychological phenomena operate together. Hence, the objectives of the present study were to examine the relationship between metacognitive processes, gender, and personality, and to extend previous research by employing both objective and subjective measures of metacognition in the same study. With these topics in mind, several research questions were developed.

(a) Is there overlap between objective measures (sensitivity and specificity) and subjective measures (knowledge of cognition and regulation of cognition dimensions of the MAI) of metacognition across three intellectual domains (vocabulary, probabilities, and paper folding)?
(b) Which is the relationship between objective and subjective measures of metacognition and the big five personality factors (agreeableness, emotional stability/neuroticism, conscientiousness/responsibility, extraversion, and openness to experience/intellect/ imagination)?
(c) What is the predictive effect of personality factors on objective and subjective measures of metacognition across three intellectual domains?
(d) What is the influence of gender (male, female) on objective and subjective measures of metacognition across three intellectual domains while controlling for academic performance (high, low) and university type (private, public)?

It was hypothesized that there are weak-to-moderate associations between objective and subjective measures of metacognition (Hypothesis 1a); however, higher associations were expected between objective measures of monitoring and subjective metacognitive regulatory components than with the subjective knowledge components (Hypothesis 1b). Personality factors were predicted to be related to subjective measures of metacognition, but, perhaps, not as strongly to objective measures (Hypothesis 2). It was also expected, based on recent research (Gutierrez-de Blume & Montoya-Londoño, 2020b), that conscientiousness and openness to experience positively predict subjective measures of metacognition, but to a lesser extent objective measures of metacognitive monitoring (Hypothesis 3). Finally, males were predicted to exhibit greater overconfidence and slightly increased monitoring accuracy compared to females (Hypothesis 4a), and that males report higher subjective metacognitive knowledge of cognition and regulation of cognition relative to females, as a function of their higher overconfidence, as seen in previous research (e.g., Gutierrez & Price, 2017) (Hypothesis 4b).

Method

Research Design

The present study employed a correlational research design incorporating a combination of descriptive and inferential statistics.

Participants

A non-probabilistic convenience sampling was used. Participants were 384 university students enrolled in one private and one public university in Manizales, Colombia. Inclusion criteria were as follows: (a) participants had to be enrolled in the university during the first and second semesters of 2020; (b) students were required to be enrolled in the two courses from which participants were recruited (cognitive neuropsychology and child developmental neuropsychology); (c) none of the students was diagnosed with a neurological or psychiatric condition, according to the student's record on the comprehensive monitoring process implemented by the university; and (d) all students have signed an informed consent form, indicating

voluntary participation and permission for their data to be used for research purposes. The only exclusion criterion was that data was discarded for those who did not sign an informed consent form.

Some students decided not to participate after only a few moments into the study and were excluded due to incomplete data. Others ended their participation at various points in the study or failed to provide credible responses. A total of 32 students were excluded, leaving 352. Of these, 120 participants identified as male (34.1%) and 232 (65.9%) as female. Even though an *other* option was offered to be more inclusive, none of the participants selected this identity. Their age ranged from 17 to36 years (M = 21.80, SD = 3.07), with the progress toward degree completion (in academic semesters) ranging from 1 to12 semesters (M = 5.57, SD = 2.40). A series of regression analyses showed that age did not significantly influence any of the outcomes of interest to the present study, all p-values ≥ 0.08. Most participants (292; 83.2%) reported attending a public university (here defined as any institution of higher education receiving any public funds for its operation). Regarding self-reported academic achievement, 124 (35.2%) participants rated their average academic achievement to be high, 221 (62.8%), in the middle/average, and 7 (2.0%), low.

Instruments

Objective Measures of Monitoring Accuracy Across Domains

Three 15-item multiple-choice tests were used to assess vocabulary knowledge, probability estimation, and mental paper-folding ability. The tests were selected based on the Radex model (Marshalek et al., 1983), which suggests that vocabulary knowledge assesses a crystalized ability, while paper folding and basic mathematical computations assess fluid abilities. The scores of the three tests were not expected to correlate by no more than 0.30, assuming that they assess separate cognitive abilities.

The Appendix provides an example of each type of question. The vocabulary and probabilities test items each included four possible options, only one of which was correct. The paper folding test items included five possible options, only one of which was correct. The authors of this study developed the vocabulary and probabilities tests in previous research (Gutierrez et al., 2016), whereas the paper folding items were taken from Ekstrom et al. (1976). These 45 domain-specific test items (15 per domain) have been previously piloted and validated in English- (Gutierrez et al., 2016) and Spanish-speaking samples (Gutierrez de Blume et al., 2021). The items showed adequate difficulty and discrimination among pilot and full-scale samples. For the present sample of 352 participants, the Cronbach's coefficients by test were: vocabulary α = 0.78; probabilities α = 0.81; and paper folding α = 0.88.

Students' confidence in performance judgments for each test were employed to calculate raw frequencies of four cells as well as two composite measures. The cells were: cell a [correct performance judged to be correct], cell b [incorrect performance judged to be correct or overconfidence], cell c [correct performance judged to be incorrect or underconfidence], and cell d [incorrect performance judged to be incorrect]. Raw cell frequencies were chosen to be included for each test for two reasons. First, examination of the individual cell frequencies makes it possible to see micro-processes of metacognitive monitoring (i.e., accurate judgments, aligned with cells a and d, and erroneous judgments, aligned with cells b and c) at the most fundamental level, and thus, provides more information. Second, including cell raw frequencies avoids any computational challenges that may be inherent in composite indices of metacognitive monitoring (e.g., Schraw et al., 2013, 2014).

In addition to the domain-specific raw cell frequencies, two composite measures of metacognitive monitoring were included, *sensitivity* and *specificity*, which have previously shown to be superior metrics of metacognitive monitoring than other composite indices (Schraw et al., 2014). *Sensitivity* assesses the proportion of judgments of correctness when items are answered correctly and, thus, can be conceptually understood as "true hits". *Specificity*, on the other hand, assesses the proportion of judgments of incorrectness when items are answered incorrectly and, hence, can be defined as "true misses". The formulas employed to calculate these two composite measures are the following:

$$Sensitivity = \frac{a}{a + c}$$

$$Specificity = \frac{d}{b + d}$$

In both formulas each letter represents one of the cells of the 2x2 performance/judgment array. Cells *a* and *d* express accurate metacognitive monitoring, whereas cells *b* (overconfidence) and *c* (underconfidence) express erroneous monitoring and are referred to as *illusion of knowing* and *illusion of not knowing*, respectively (Serra & Metcalfe, 2009).

Subjective Measures of Metacognition: Metacognitive Awareness Inventory

Self-report metacognitive awareness was measured using the Metacognitive Awareness Inventory (MAI). The MAI was originally developed and validated by Schraw and Dennison (1994). The MAI is a 52-item instrument that measures metacognition through its five processes scales: Planning, Information Management Strategies, Monitoring, Debugging Strategies, and Evaluation. Sample items of these scales are: "I constantly wonder if I am meeting my goals" (monitoring); "I reevaluate what I have learned when I get confused" (debugging strategies); "I know how well I did in an assessment once the test is over" (evaluation); "I think about what I really need to learn before I begin a task" (planning); and "I slow down when I encounter important information" (information management). Students responded to the items on a 0-100 sliding scale, ranging from *not at all true of me* (0) to *very true of me* (100). The items are also classified by type of cognition knowledge: declarative, procedural, and conditional. Sample items of these type are: "I am aware of what strategies I use when I study" (declarative knowledge); "I try to use strategies that have worked in the past" (procedural knowledge); and "I have a specific purpose for each strategy I use" (conditional knowledge).

Scores were calculated by taking the average of the items that make up each scale, respectively. Next, the mean scores of declarative, procedural, and conditional knowledge were used to compute the knowledge of cognition and the regulation of cognition was comprised of the mean scores of planning, information management, monitoring comprehension, debugging, and evaluation.

The Spanish-version of the MAI has been piloted and validated in two separate studies (Gutiérrez de Blume & Montoya Londoño, 2021; Huertas Bustos et al., 2014), which reported appropriate internal consistency reliability and construct validity. Internal consistency reliability coefficients for the present sample were knowledge of cognition, $\alpha = 0.86$ and regulation of cognition, $\alpha = 0.90$. This two-factor structure of the MAI mirrors that initially reported by Schraw and Dennison (1994).

Personality

Personality factors were measured using the List of Adjectives to Assess Personality (Adjetivos para Evaluar la Personalidad [AEP]; Ledesma et al., 2010; Sánchez & Ledesma, 2013). It is an instrument based on the model of the Big Five Personality Inventory (B5PI; Goldberg, 1992; Goldberg, et al., 2006). However, unlike the original 50-item B5PI, the AEP uses a different format and additional items, albeit they both converge on the same five latent personality factors—agreeableness, conscientiousness, extraversion, neuroticism, and openness. The AEP is composed of a list of 67 descriptive adjectives of personality traits such as "kind" and "generous" for Agreeableness; "nervous" and "anxious" for Neuroticism; "responsible" and "organized" for Conscientiousness; "sociable" and "withdrawn" for Extraversion; and "imaginative" and "creative" for Openness. Students responded to the items on a 0-100 sliding scale ranging from *not at all true of me* (0) to *very true of me* (100). Cronbach's alpha for the five factors in the present study were: agreeableness, 0.81; conscientiousness, 0.82; extraversion, 0.85; neuroticism, 0.79; and openness, 0.84.

University Type and Academic Performance

The two covariates in the analysis, university type and academic performance, were gathered via two questions in the demographic section of the questionnaire. Participants were asked to indicate whether the university they attended was either public/state-sponsored or private. Academic performance was obtained by asking students to indicate their overall mean academic score, from 0 to 7, which is the equivalent of the grade point average employed in the United States. Next, the median of academic performance was employed to categorize students into either high or low academic performance for data analysis purposes.

Procedure

All ethical guidelines for conducting research involving human participants were followed, including obtaining voluntary informed consent. More specifically, the study adhered to the ethical guidelines provided

by Resolution 8430 of October 4, 1993, for studies considered to be of minimal risk to human beings (Scientific, technical and administrative standards, 1993). The research ethics committee of the University of Manizales approved this research with human participants. Further, participants did not receive credit or any other form of incentive for participating in the study, and they were informed that they could withdraw from the study at any time without penalty.

All instruments described in the Instruments section were placed into the Qualtrics platform for digital delivery. Participant informed consent was collected first, followed by general instructions and more specific instructions for each of the instruments immediately before each of them began. Within the 15-item test block for each domain-specific test, only one item and its possible solutions appeared on the screen per each mouse click. Directly beneath each response, participants indicated whether they judged the response to be correct (i.e., *yes* or *no*). Each of the 15 scores on each test was assigned to one of the four cells formerly described. Data were collected from February to July 2020.

Data Analysis

Data were evaluated for univariate normality using skewness and kurtosis values and histograms with overlaid normal curve, as well as multivariate normality using Cook's D and Mahalanobis distance (Tabachnick & Fidell, 2013, Chapter 4, pp. 60-116). All variables in the present study approximated univariate normality and every skew and kurtosis value was less than the absolute value of 1, as well as multivariate normality, based on the linear combination of dependent measures. Data were also screened for univariate outliers, using box-and-whisker plots, and for multivariate outliers, through standardized residuals. No cases were deemed outliers; thus, all 352 cases were retained for analysis. As previously stated, 32 cases (8.3% of the total sample of 384) had missing data. Therefore, to ensure that the missing pattern could be considered as missing completely at random (MCAR), Little's MCAR χ^2 statistic (Little & Rubin, 2002; Schaeffer & Graham, 2002) was performed. A significant χ^2 (i.e., $p < .05$) would suggest that the pattern of missing data is not MCAR (i.e., missing not at random), which poses a problem for interpretation of results because they may be biased due to systematic differences in non-responses (Tabachnick & Fidell, 2013, Chapter 4, pp. 60-116). However, the results of this test for the present data were non-significant across all groups, all p-values ≥ 0.56, suggesting that the missing pattern in the data could be considered MCAR. Other assumptions, such as normality, homoscedasticity, homogeneity of variance, homogeneity of variance-covariance matrices, and homogeneity of regression coefficients were met. None of the objective metacognitive monitoring variables (i.e., cell raw frequencies and *sensitivity* and *specificity*) were included in the same analysis because the composite indices of monitoring are calculated by using some combination of the cell raw frequencies and, hence, would lead to multicollinearity in the data.

Research questions 1 and 2 were answered by conducting descriptive statistics and bivariate zero-order correlations, Pearson's r. The third research question was answered by carrying out a series of standard/simultaneous ordinary least squares (OLS) regressions, with the five personality factors—agreeableness, neuroticism, conscientiousness, extraversion, and openness—serving as predictors and objective composite measures of metacognitive monitoring—*sensitivity* and *specificity*—and the subjective measures of metacognitive awareness—knowledge and regulation of cognition—serving as the criterion in each model, respectively. Only the objective composite measures of metacognitive monitoring was used because including analyses with the cell raw frequencies would have required an additional 12 regressions, which would have unduly inflated Type I error. The final research question was answered by performing two one-way multivariate analyses of covariance (MANCOVA), with gender (male, female) serving as the between-subjects factor and the 12 cell raw frequencies serving as dependent measures in the first analysis, and the two subjective measures of knowledge and regulation serving as outcomes in the second analysis. University type (private, public) and self-reported academic performance (high, low) served as covariates.

The Bonferroni adjustment to statistical significance was applied to the inferential analyses to obviate Type I error inflation. Effect sizes for the MANCOVAs were reported as partial η^2 (η^2_p) and those for the OLS regression analyses were reported as R^2. Cohen (1988) provided the following interpretive guidelines for η^2_p: 0.010-0.059 as small, 0.060-0.139 as moderate, and ≥ 0.140 as strong. For R^2, these values were: 0.010-0.249 as small, 0.250-0.499 as moderate, and ≥ 0.500 as strong.

Results

Descriptive statistics for the variables of interest to the present study are displayed in Table 1.

Table 1
Descriptive Statistics of Objective and Subjective Metacognitive Monitoring and Personality Factors

Variable	*M*	*SD*
Vocabulary Cell *a*	9.93	2.07
Vocabulary Cell *b*	1.48	1.37
Vocabulary Cell *c*	1.42	1.53
Vocabulary Cell *d*	2.17	1.47
Probabilities Cell *a*	4.84	2.97
Probabilities Cell *b*	3.61	2.98
Probabilities Cell *c*	2.29	2.11
Probabilities Cell *d*	4.26	2.88
Paper folding Cell *a*	7.16	4.65
Paper folding Cell *b*	2.81	3.34
Paper folding Cell *c*	1.61	2.02
Paper folding Cell *d*	3.42	3.20
Sensitivity – Vocabulary	0.87	0.13
Specificity – Vocabulary	0.61	0.33
Sensitivity – Probabilities	0.66	0.31
Specificity – Probabilities	0.56	0.32
Sensitivity – Paper folding	0.75	0.32
Sensitivity – Paper folding	0.59	0.36
MAI knowledge	67.61	13.87
MAI regulation	66.04	12.87
Agreeableness	64.99	7.74
Neuroticism	51.55	10.72
Conscientiousness	47.28	5.98
Extraversion	25.76	6.80
Openness	35.04	4.91

Note. Key: Cell *a* = correct performance judged to be correct; Cell *b* = incorrect performance judged to be correct; Cell *c* = correct performance judged to be incorrect; Cell *d* = incorrect performance judged to be incorrect. *n* = 352.

Bivariate, zero-order correlations, Pearson's *r*, for the cell raw frequencies by domain, MAI knowledge and regulation of cognition, and personality factors can be found in Table 2, while Table 3 includes the correlations for *sensitivity* and *specificity* by domain, MAI knowledge and regulation of cognition, and personality factors.

Relationships Between Objective and Subjective Measures of Metacognition

Interestingly and of special significance to metacognition research, the correlation matrix displayed in Table 2 revealed that there were only weak correlations between objective measures of metacognitive monitoring and subjective measures of metacognitive awareness, with most of the correlations being statistically significant. All the correlations were in the theoretically expected direction. Given that the regulation of cognition scale measures regulatory behaviors (e.g., monitoring and control during learning), that dimension would be expected to correlate at least moderately with objective measures of metacognitive monitoring. However, this did not bear out in the present investigation.

Table 2

Zero-Order Correlation Matrix of Vocabulary, Probabilities, and Paper Folding Cell Raw Frequencies (a, b, c, and d), MAI Knowledge and Regulation, and Personality Factors

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Vocab *a*	-	-.62**	-.64**	-.16*	.26**	-.30**	-.32**	.29**	.24**	-.21**	-.38**	.12	.25**	.27**	.19*	-.20**	.29**	.06	.31**
2. Vocab *b*		-	.29**	-.36**	-.22**	.34**	.39**	-.41**	-.11	.17*	.31**	-.22**	-.22**	-.28**	-.15*	.09	-.27*	.05	-.24**
3. Vocab *c*			-	-.41**	-.19**	.30**	.37**	-.40**	-.08	.13	.42**	-.29**	-.23**	-.24**	-.16*	.15*	-.09	.19*	-.29**
4. Vocab *d*				-	.03	-.21**	-.29**	.39**	-.16*	.01	-.19*	.34**	.20*	.21**	.10	-.02	.30**	-.17*	.28**
5. Prob *a*					-	-.70**	-.53**	.08	.43**	-.41**	-.41**	.06	.22**	.29**	.14	-.08	.30**	-.10	.27**
6. Prob *b*						-	.41**	-.61**	-.31**	.44**	.49**	-.32**	-.19**	-.20**	-.03	.06	-.27*	.11	-.25**
7. Prob *c*							-	-.61**	-.16*	.30**	.44**	-.36**	-.23**	-.25**	-.17*	.13	-.25**	.20**	-.30**
8. Prob *d*								-	-.01	-.25**	-.41**	.53**	.11	.21**	.01	-.08	.22**	-.18*	.27**
9. Fold *a*									-	-.74**	-.52**	-36**	.03	.01	.06	-.07	.04	-.02	.05
10. Fold *b*										-	.45**	-.25**	-.10	-.07	-.09	.05	-.03	.02	-.02
11. Fold *c*											-	-.35**	-.16*	-.17*	-.17*	.16*	-.03	.13	-.05
12. Fold *d*												-	.15*	.18*	.10	-.08	.05	-.08	-.02
13. K													-	.77**	.39**	-.23**	.43**	-.24**	.45**
14. R														-	.41**	-.18*	.44**	-.17*	.40**
15. A															-	-24**	.42**	-.33**	.25**
16. N																-	-.22	-.42**	-.11
17. C																	-	-.31**	.08
18. E																		-	-.31**
19. O																			-

Note. Key: Vocab = Vocabulary; Prob = Probabilities; Fold = Paper folding; K = MAI knowledge of cognition; R = MAI regulation of cognition; A = Agreeableness; N = Neuroticism; C = Conscientiousness; E = Extraversion; O = Openness; Cell *a* = correct performance judged to be correct; Cell *b* = incorrect performance judged to be correct; Cell *c* = correct performance judged to be incorrect; Cell *d* = incorrect performance judged to be incorrect.

* $p < 0.05$, ** $p < 0.01$ (one-tailed test of significance), $n = 352$

Relationships Between Objective and Subjective Measures of Metacognition and Personality Factors

Regarding the correlation patterns in Tables 2 and 3, in response to the second research question, some interesting patterns emerged from the data. The first is that, for both the individual cell raw frequencies across domains and *sensitivity* and *specificity*, the personality factors of conscientiousness and openness correlated significantly and at a higher magnitude than the other three factors (agreeableness, neuroticism, and extraversion). Looking first at the cell raw frequencies in Table 2, for overconfidence and underconfidence, which are manifestations of erroneous metacognitive judgments, the correlations were inverse with conscientiousness and openness whereas they were positive for correct performance judged to be correct and incorrect performance judged to be incorrect, which represent accurate judgments. The associations with conscientiousness and openness were, however, all positive with *sensitivity* and *specificity* due to the way these objective composite measures are defined and operationalized (see Table 3). The second is that, of all three domains, correlations were weakest, with most of them non-significant, among personality factors and paper folding variables (cell raw frequencies, *sensitivity* and *specificity*). The third is that correlations between personality factors and subjective measures of metacognition (i.e., knowledge and regulation of cognition) were, overall, higher than with any metric of objective metacognitive monitoring (i.e., cell raw frequencies or the composite monitoring measures), albeit associations between objective metacognitive monitoring metrics and conscientiousness and openness still remained the highest compared to the other personality factors.

Table 3

Zero-Order Correlation Matrix of Vocabulary, Probabilities, and Paper Folding Composite Monitoring Indices (Sensitivity and Specificity), MAI Knowledge and Regulation, and Personality Factors

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. SensVoc	-	0.42**	0.36**	0.43**	0.27**	0.34**	0.23**	0.24**	0.16*	-0.14	0.30**	-0.20*	0.29**
2. SpecVoc		-	0.34**	0.39**	0.16*	0.29**	0.24**	0.25**	0.14	-0.07	0.31**	-0.11	0.32**
3. SensProb			-	0.69**	0.47**	0.47**	0.27**	0.28**	0.17*	-0.09	0.32**	-0.19*	0.35**
4. SpecProb				-	0.45**	0.49**	0.19*	0.19*	0.06	-0.08	0.29**	-0.17*	0.34**
5. SensFold					-	0.68**	0.12	0.11	0.11	-0.10	0.02	-0.06	0.02
6. SpecFold						-	0.12	0.13	0.15*	-0.09	0.04	-0.07	0.05
7. K							-	0.77**	0.39**	-0.23**	0.43**	-0.24**	0.45**
8. R								-	0.41**	-0.18*	0.44**	-0.17*	0.40**
9. A									-	-0.24**	0.42**	-0.33**	0.25**
10. N										-	-0.22**	0.42**	-0.11
11. C											-	-0.31**	0.08
12. E												-	-0.31**
13. O													-

Note. Key: SensVoc = Sensitivity for vocabulary; SpecVoc = Specificity for vocabulary; SensProb = Sensitivity for probabilities; SpecProb = Specificity for probabilities; SensFold = Sensitivity for paper folding; SpecFold = Specificity for paper folding; K = MAI knowledge of cognition; R = MAI regulation of cognition; A = Agreeableness; N = Neuroticism; C = Conscientiousness; E = Extraversion; O = Openness.

* $p < 0.05$, ** $p < 0.01$ (one-tailed test of significance), $n = 352$

Predictive Effect of Personality Factors and Objective and Subjective Measures of Metacognition

Results of the OLS regressions are displayed in Table 4.

Table 4
Ordinary Least Squares Regression of Personality and Metacognitive Variables

Predictor	*B*	95% CI of *B*	*β*	*t*	*p*
		Sensitivity vocabulary			
Agreeableness	0.00		0.10	1.58	0.113
Neuroticism	-0.00		-0.05	-0.89	0.375
Conscientiousness	0.31	0.09, 0.55	0.29	5.74	< 0.001
Extraversion	-0.00		-0.06	-0.96	0.481
Openness	0.14	0.03, 0.31	0.18	3.62	0.002
		Specificity vocabulary			
Agreeableness	0.00		0.08	1.32	0.191
Neuroticism	-0.00		-0.00	-0.03	0.973
Conscientiousness	0.28	0.03, 0.39	0.28	4.01	< 0.001
Extraversion	-0.00		-0.06	-0.87	0.394
Openness	0.13	0.05, 0.27	0.18	3.08	0.002
		Sensitivity probabilities			
Agreeableness	0.01		0.04	1.07	0.352
Neuroticism	0.00		0.01	0.08	0.944
Conscientiousness	0.24	0.03, 0.46	0.24	3.29	0.002
Extraversion	0.01		0.01	0.07	0.946
Openness	0.16	0.06, 0.37	0.15	2.42	0.004
		Specificity probabilities			
Agreeableness	0.00		0.01	0.05	0.973
Neuroticism	-0.00		-0.02	-0.28	0.785
Conscientiousness	0.35	0.25, 0.70	0.31	4.01	< 0.001
Extraversion	0.01		0.05	1.41	0.417
Openness	0.28	0.15, 0.58	0.21	3.51	0.002
		Sensitivity paper folding			
Agreeableness	0.01		0.11	1.65	0.124
Neuroticism	-0.00		-0.07	-1.25	0.212
Conscientiousness	0.00		0.05	-0.84	0.400
Extraversion	-0.00		-0.01	-0.26	0.802
Openness	0.00		0.03	0.34	0.731
		Specificity paper folding			
Agreeableness	0.01		0.08	1.38	0.267
Neuroticism	-0.00		-0.06	-0.92	0.363
Conscientiousness	0.00		0.04	0.57	0.575
Extraversion	0.00		0.02	0.10	0.928
Openness	0.00		0.01	0.22	0.821
		MAI knowledge of cognition			
Agreeableness	2.25		0.05	0.92	0.370
Neuroticism	-2.46		-0.08	1.23	0.111
Conscientiousness	13.68	9.54, 17.81	0.35	6.50	0.001
Extraversion	0.82		0.02	0.42	0.676
Openness	3.71	2.05, 6.98	0.23	4.24	0.001
		MAI regulation of cognition			
Agreeableness	3.69		0.04	0.80	0.431
Neuroticism	-2.53		-0.06	-1.14	0.259
Conscientiousness	26.88	18.99, 34.78	0.36	6.69	< 0.001
Extraversion	2.79		0.04	0.74	0.450
Openness	10.68	4.41, 16.90	0.22	3.98	0.001

Note. B = Unstandardized regression coefficients; β = Standardized regression coefficients. n = 352

The overall model results revealed that, after the Bonferroni adjustment to statistical significance, the following models reached significance: *sensitivity* in vocabulary, $F(5, 346) = 4.13$, $p = 0.001$, $R^2 = 0.21$; *specificity* in vocabulary, $F(5, 346) = 3.65$, $p = 0.002$, $R^2 = 0.19$; *sensitivity* in probabilities, $F(5, 346) = 3.28$, $p = 0.002$, $R^2 = 0.15$; *specificity* in probabilities, $F(5, 346) = 15.01$, $p < 0.001$, $R^2 = 0.25$; MAI knowledge of cognition, $F(5, 346) = 20.02$, $p < 0.001$, $R^2 = 0.29$; and MIA regulation of cognition, $F(5,346) = 20.14$, $p < 0.001$, $R^2 = 0.30$. None of the other omnibus models reached statistical significance, all p-values ≥ 0.11.

The predictive pattern of personality characteristics was relatively consistent. Conscientiousness and openness were significant positive predictors of *sensitivity* and *specificity* as well as subjective knowledge and regulation of cognition. As the association patterns previously discussed indicated, no significant personality-factor predictors emerged for either *sensitivity* or *specificity* in paper folding. Finally, the predictive effects of personality factors on subjective metacognitive knowledge and regulation of cognition were slightly higher than for the objective monitoring variables, as the effect sizes were larger for these two regression models.

Gender Differences in Objective and Subjective Measures of Metacognition Controlling for University Type and Perceived Academic Performance

Results of the one-way MANCOVA evaluating the effect of gender on the cell raw frequencies by domain were statistically significant even after controlling for the effect of university type and perceived academic performance, multivariate $F(9, 339) = 3.81$, $p < 0.001$, $\eta^2_p = 0.09$. Given the statistically significant multivariate omnibus findings, univariate results were interpreted next. Interestingly, univariate results were only significant for probabilities correct performance judged to be correct, $F(1, 347) = 15.34$, $p < 0.001$, $\eta^2_p = 0.06$, and probabilities incorrect performance judged to be correct or overconfidence, $F(1, 347) = 25.28$, $p < 0.001$, $\eta^2_p = 0.09$. In the case of probabilities correct performance judged to be correct, males were, on average, more accurate than females whereas in the case of probabilities incorrect performance judged to be correct, females were, on average, more overconfident than males. None of the other cell raw frequency results reached statistical significance, all p-values ≥ 0.04.

The one-way MANCOVA examining the effect of gender on the subjective metacognition variables of knowledge and regulation of cognition revealed statistically significant findings even after accounting for university type and perceived academic performance, multivariate $F(2, 346) = 6.80$, $p < 0.001$, $\eta^2_p = 0.04$. The individual univariate analyses indicated that results were significant for both knowledge of cognition, $F(1, 347) = 13.44$, $p < 0.001$, $\eta^2_p = 0.04$, and regulation of cognition, $F(1, 347) = 11.47$, $p = 0.001$, $\eta^2_p = 0.04$. Adjusted means revealed that males reported significantly higher knowledge and regulation of cognition when compared to females. Table 5 displays the initial (unadjusted) means and the adjusted means (after partialling out the effect of university type and perceived academic performance).

Table 5
Initial and Adjusted Means for Significant Findings of the Effect of Gender on Objective and Subjective Metacognitive Variables

Variable	Male		Female	
	M	M_a	*M*	M_a
Probabilities Cell *a*	5.07	5.66	4.99	4.09
Probabilities Cell *b*	2.01	2.75	5.01	4.18
MAI knowledge	67.11	71.23	67.68	65.70
MAI regulation	65.14	69.20	67.01	64.39

Note. Only statistically significant findings are included for the sake of parsimony. Key: *M* = Initial (unadjusted mean); M_a = Adjusted mean, after controlling for the effect of university type (private, public) and perceived academic performance (high, low); Cell *a* = correct performance judged to be correct; Cell *b* = incorrect performance judged to be correct. $n = 352$ (Males, $n = 120$; Females, $n = 232$).

Discussion

The present study attempted to address four research objectives. The first was to examine the overlap between objective measures (*sensitivity* and *specificity*) and subjective measures (knowledge of cognition and regulation of cognition dimensions of the MAI) of metacognition across three domains (vocabulary, probabilities, and paper folding). The second was to relate these objective and subjective measures of metacognition with aspects of the B5PI (agreeableness, emotional stability/neuroticism, conscientiousness/responsibility, extraversion, and openness to experience/intellect/imagination). The third was to ascertain the predictive pattern of these personality factors on objective and subjective measures of metacognition across three intellectual domains (vocabulary, probabilities, and paper folding). The fourth was to explore the influence of gender (male, female) on objective and subjective measures of metacognition across three intellectual domains while controlling for academic performance (high, low) and university type (private, public).

Regarding the first objective, results revealed that there were weak associations between objective measures of metacognitive monitoring and subjective measures of metacognition, with correlation coefficients being slightly higher between objective measures of metacognitive monitoring and the subjective regulation of cognition measures. These findings partially support the hypotheses that there would be weak-to-moderate relationships between objective and subjective measures of metacognition and that objective monitoring measures would relate more strongly with regulatory components of the MAI. These results are congruent with research that reported weak-to-no correlations between objective measures of monitoring and self-report measures of self-regulation (Gutierrez & Schraw, 2015; Schraw et al., 1995) and objective measures of monitoring and subjective measures of metacognition (Gutierrez de Blume et al., 2021; Schraw, 1995; Schraw et al., 1995). Schraw et al. (1995) and Schraw (1995) reported that the relations between objective measures of monitoring accuracy were weakly related to subjective perceptions of metacognitive awareness, with some associations between objective measures of monitoring and aspects of subjective metacognitive awareness being negligible. Likewise, Gutierrez and Schraw (2015) and Gutierrez de Blume (2017) found no significant correlations between an objective absolute monitoring measure and self-report components of the MAI among adults and children, respectively. The most plausible explanation for this lack of moderate-to-strong relations among these measures is the incongruence between theoretical principles and measurement, especially that pertaining to subjective, self-report measures. Indeed, Schraw (2009) argued for stronger alignment between self-report measures of metacognition and theoretical guidelines as a possible avenue for increasing the relation between objective and subjective measures of the same construct. Another plausible explanation may stem from cultural and individual differences, as it is quite possible that the relationships may be stronger depending on the culture in which data are collected and, even within cultures, depending on the individual.

With respect to the second objective, findings suggested that for both the individual cell raw frequencies across domains and *sensitivity* and *specificity* the personality factors of conscientiousness and openness correlated significantly and at a higher magnitude than the other three factors (agreeableness, neuroticism,

and extraversion). Relationships of the cell raw frequencies indicated that for cells *b* (overconfidence) and *c* (underconfidence), the correlations were inverse with conscientiousness and openness whereas they were positive for cells *a* and *d*. Interestingly, of all three domains, correlations were weakest, with most of them non-significant, among personality factors and paper folding variables and MAI knowledge and regulation of cognition. In addition, correlations between personality factors and subjective measures of metacognition, knowledge and regulation of cognition, were, overall, higher than with either cell raw frequencies or the composite monitoring measures (all of which represent objective measures of metacognition), albeit associations with conscientiousness and openness still remained the highest compared to the other personality factors. These findings provide solid support for the prediction that personality factors would relate more strongly with subjective MAI components than with objective monitoring measures, except for the correlational patterns regarding the paper folding domain. This is in line with research that demonstrates the cognitive skills needed in visual-spatial reasoning tasks, such as paper folding, differ from those needed in other intellectual domains, such as vocabulary and numeracy (Demetriou et al., 2019; Zippert & Rittle-Johnson, 2020). Of special significance, agreeableness had a weak-to-moderate positive correlation with the subjective measures of knowledge of cognition and regulation of cognition. Conversely, its correlation with objective measures of metacognitive monitoring were approaching negligible. Agreeableness is broadly defined as the personality factor that includes traits such as altruism, trust, modesty, and emotional warmth (Goldberg et al., 2006; John et al., 2008). If subjective knowledge of cognition is considered to include skills such as conditional knowledge (when, where, and why to apply strategies, given task demands) and subjective regulation of cognition includes skills such as comprehension monitoring, and information management strategies, this relationship with agreeableness is not as surprising as at first glance. Indeed, this relation aligns with recent findings about the relation between personality and metacognitive skills (Gutierrez-de Blume & Montoya-Londoño, 2020b).

In extension to this objective, the predictive pattern of the factors of the B5PI on objective and subjective measures of metacognition was explored. Concerning the third objective, the findings of the OLS regressions largely supported the third hypothesis that conscientiousness and openness would be better predictors of subjective measures of the MAI than objective monitoring measures, insofar as conscientiousness and openness were the only significant predictors. Further, subjective measures of metacognitive awareness were more strongly predictive than objective monitoring measures. However, the predictive models were not remotely significant for *sensitivity* or *specificity* within the paper folding domain.

Even though the B5PI factors show consistency across languages and cultures (Costa Jr. et al., 2001; Maltby et al., 2017; Sánchez & Ledesma, 2013), the relationship between personality factors and cognitive variables is not yet well understood. Nevertheless, emerging research exists that shows that personality characteristics are related to learning approach (superficial or deep), locus of control (external and internal), epistemological beliefs, and learning styles (e.g., Batteson et al., 2014; Gutierrez de Blume & Montoya Londoño, 2020a, 2020b; Komarraju et al., 2011). In the present investigation, the finding that conscientiousness and openness were the best predictors of metacognitive skill, especially subjective perceptions of metacognition, are partially supported by a recent study from Latin America in which conscientiousness and openness predicted subjective perceptions of metacognitive skills among in-service teachers (Gutierrez de Blume & Montoya Londoño, 2020a). Similarly, these findings are consistent with a recent study that found that people who are imaginative, open, and creative are more likely to have enhanced metacognitive awareness of their regulatory skills and the use of strategies when participating in a teaching or learning activity (Öz, 2016). It is noteworthy that this sample of university students reported relatively low values on extraversion. This may be due to cultural norms and expectations in the country from which this specific sample was recruited. Nevertheless, more research is needed to disentangle the complex and dynamic relationships between metacognition and personality.

The results of the final research objective indicated that males were more accurate than females and that females were more overconfident than males, but only in the probabilities domain. This provides mixed support for the hypothesis that this pattern would hold across all three intellectual domains, which it did not. However, regarding the expectation that males would self-report higher levels of knowledge of cognition and regulation of cognition compared to females, the results fully supported it. These findings converge with those of previous research that shows that males tend to be more accurate than females (e.g., Gutierrez & Price, 2017; Gutierrez & Schraw, 2015; Gutierrez de Blume, 2017; Sharma & Bewes, 2011). The present findings differ from previous work that has found the tendency of females to be underconfident in their performance judgments compared to males (e.g., Ackerman et al., 2011; Chiu & Klassen, 2010; Gutierrez &

Price, 2017; Gutierrez & Schraw, 2015; Gutierrez de Blume, 2017; Sheldrake et al., 2014). Again, this may be partially influenced by cultural norms and expectations. Research from Europe and North America demonstrates that males tend to be overconfident, females tend to be underconfident, and that males tend to be more accurate in their monitoring (Gutierrez & Price, 2017; Gutierrez & Schraw, 2015; Gutierrez de Blume, 2017; Sharma & Bewes, 2011). Nevertheless, this sample of Latin American students reported results that differed slightly from this pattern, suggesting that culture may play a role in how individuals perceive and experience metacognition.

Implications Theory, Research, and Learning

To understand the dynamic intersection between "cold" learning factors, such as metacognition, and those considered "warm", such as personality, is important for researchers and practitioners. Consequently, research on the intersection between metacognition and personality has never been more pressing. These exploratory findings tentatively suggest that individuals' metacognitive skills may be influenced, although slightly, by the personality traits of conscientiousness and openness. This is of monumental importance to researchers in both fields as well as to educators. The findings of the present study pave the way for further explorations on how personality (a "warm" construct) and metacognition (a "cold" construct) interact. They can also help explain discrepancies and inconsistencies in previous findings on the effects of cognitive strategy training on metacognitive monitoring and learning outcomes. What if personality characteristics somehow determine how students receive these educational interventions? What if these previously general interventions could be adapted to be more interesting to people based on personality profiles? Could these personality profiles be used in conjunction with metacognitive profiles to better meet the learning needs of individuals (i.e., be more attuned to individual differences in learning versus a greater emphasis on group norms and standardized assessments)?

The findings indicate that learners' metacognition is also influenced by gender. It is, therefore, incumbent on educators to reflect on their own gender identity biases and how subtle shifts in messaging and treatment of male and female students may be contributing to the development of the confidence in performance judgment dilemma (i.e., males' tendency to be more accurate and overconfident whereas females tend to be more underconfident) found in this and previous research (Ackerman et al., 2011; Chiu & Klassen, 2010; Denham et al., 2012; Gutierrez & Price, 2017).

Avenues for Future Research

Although the sample size in the present study was relatively large, future research should replicate this study with similar or larger sample sizes to ensure the results are stable and consistent across multiple samples. The results show the need to conduct multicultural studies to investigate to what extent the results of this study are generalizable to other cultures. This is especially relevant because culture probably has a significant influence on personality development. Some cultures, for example, may value extraversion more than other personality traits, while others may value openness over agreeableness. Cultural and social norms also affect how gender identity is defined and perceived. Additionally, future studies should evaluate a prediction-mediation structural equation model in which personality predicts subjective measures of metacognition that predict objective measures of metacognitive monitoring. Such a model would permit the examination of the mediation effect of subjective measures on the relationship between personality and objective monitoring. Although the present study investigated the relationships between metacognitive skills and personality traits using self-report instruments and objective measures of monitoring, future research should examine how personality, metacognition, gender, and relevant learning outcomes intersect. This may inform the development of not only personality learning profiles that are individually tailored, but also metacognitive profiles that can better guide individuals to optimize learning.

Methodological Reflections and Limitations

First, this study used a non-experimental research design with convenience sampling. This limits the inferences and conclusions that can be drawn from the data and limits the generalizability of the findings. Second, the present investigation used self-report instruments to collect data on personality and subjective metacognitive awareness, which represents a limitation due to the social desirability bias inherent in this type of instruments. This also limits the inferences and conclusions that can be drawn from the results that are presented. Finally, it is important to recognize that the effect sizes for the regression models and some of

the MANCOVA results were modest, and consequently, the reader must interpret the practical significance of the findings presented. Clearly, there are other factors that were not considered in the models that contribute to the variability of these metacognitive variables such as motivational variables like academic emotions, self-efficacy, and autonomy, to name a few.

Conclusion

In the present study, the overlap between objective and subjective measures of metacognition, as well as personality traits and metacognitive abilities, was explored. Further, the influence of gender on subjective and objective measures of metacognition was examined. Results revealed that objective and subjective measures of metacognition are only weakly related, and that personality and metacognition are related along theoretically defensible perspectives. Small-to-moderate correlations were found between most of personality and metacognitive variables, but especially conscientiousness and openness, except for paper folding. In addition, gender significantly influenced subjective and objective measures of metacognition, insofar as males were more accurate than females and that females were more overconfident than males, even after adjusting for the effect of university type and academic performance. Although the present investigation represents an exploratory study combining self-report measures of personality and metacognitive awareness and objective measures of metacognitive monitoring, the study is among the first that systematically investigates these topics in Spanish-speaking populations. While the intersection between gender and metacognition is much better understood than the relation between personality and metacognition, the findings indicate that the association among these phenomena is complex and dynamic. However, further exploration of these topics will help to expand the understanding of the SRL theory and, hence, improve learning outcomes. These initial findings will hopefully stimulate what is expected to be a productive program of study on these topics.

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Anexo A

Sample Vocabulary Item

The word **PROCREATE** means?

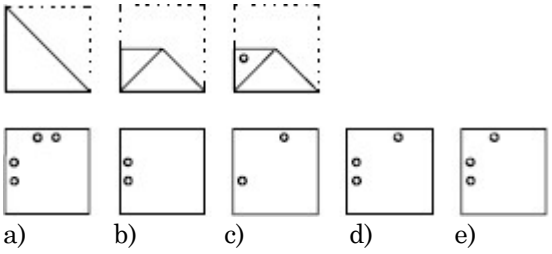
a) inhabit b) beget c) imitate d) encourage

Sample Probabilities Item

The likelihood of a baby being a girl is 50%. What is the likelihood of a couple having four consecutive girls out of four children?

a) 6% b) 12% c) 24% d) 50%

Sample Paper Folding Item



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