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Executive Functions and Their Relation to Academic Performance in University Students

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Academic performance, dropout rates, and low graduation rates constitute an area of concern in Latin American universities that has been the topic of various studies. Certain researchers suggest that some differences in academic performance could arise from interindividual variations in self-regulation mechanisms such as executive functions. Therefore, this study aimed to contribute to the investigation of the relationships between university performance and executive functions, specifically working memory, inhibition, and shifting. The study involved 196 students who completed the Reading Span Task, the Five Digits Test, and the Finger Task. Working memory, inhibition, and shifting exhibited a weak significant relationship with performance. Furthermore, additionally to age, socioeconomic status, and student work hours, inhibition and shifting accounted for 38% of the variance in academic performance. The findings provide a contribution to the understanding of this topic and to the discussion of previous contradictory findings.

Funciones ejecutivas y su relación con el rendimiento académico en estudiantes universitarios

Palabras clave:
Funciones ejecutivas
Autorregulación
Memoria de trabajo
Inhibición
Alternancia
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R E S U M E N

El rendimiento académico universitario, el rezago y las bajas tasas de egreso suponen un área de preocupación en las universidades latinoamericanas que ha sido objeto de diferentes investigaciones. Algunos investigadores sugieren que determinadas diferencias en dicho rendimiento podrían surgir de diferencias interindividuales en distintos mecanismos de autorregulación, como las funciones ejecutivas. Por ello, este trabajo se propuso contribuir al estudio de las relaciones entre el rendimiento universitario y las funciones ejecutivas, específicamente la memoria de trabajo, la inhibición y la flexibilidad cognitiva. Se trabajó con 196 estudiantes que completaron la Tarea de Amplitud de Lectura, el Test de Cinco Dígitos y la Tarea de los Dedos. La memoria de trabajo, la inhibición y la flexibilidad presentaron una relación significativa baja con el rendimiento. Además, junto con edad, nivel socioeconómico y horas que trabaja el estudiante, la inhibición y la flexibilidad cognitiva, permitieron explicar el 38% de la varianza del rendimiento. Los resultados suponen un aporte al conocimiento de esta temática y a la discusión de los hallazgos contradictorios previos.

In the last few decades, there has been a significant increase in the number of enrollments in Ibero-American universities. However, despite the growth in the number of enrollees, low academic performance (AP), repetition, dropout rates, and low graduation rates remain areas of concern. This is due to the small proportion of students who manage to complete their university careers (Fernández Hileman et al., 2014; Plotno, 2009), and even fewer who do so within the theoretical time frames stipulated by the curricula (Martinengo & Caretta, 2017; Ríos, 2007). As a result, the study of the university population has been a highly relevant objective in the agenda of public and institutional policies in Latin America for several years (Centro Interuniversitario de Desarrollo, 2006).

Thus, AP and dropout rates represent areas of relevance and concern that have been the focus of various studies (e.g., Gallegos et al., 2018; Munizaga et al., 2018; Naves Mamede et al., 2015). The Center for Argentine Education Studies (Guadagni et al., 2019) highlights that Argentina has a higher proportion of university students compared to other countries in the region such as Brazil or Chile. However, there are fewer graduates in Argentina than in these countries due to a higher dropout rate, making this phenomenon of great importance in local studies (Viale Tudela, 2014). García de Fanelli (2014) reported that only 22% of students who enroll in Argentine national universities graduate. Similar data were provided in the Statistical Yearbook of the Argentine Republic (Instituto Nacional de Estadísticas y Censos,

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2019), with estimates that may vary and be even lower for certain careers or universities.

Given that AP is a complex and multidetermined variable, it should continue to be explored. Many studies in this field are limited to the analysis of sociodemographic variables, such as gender or socioeconomic status (e.g., Coschiza et al., 2016; Soza Mora, 2021). In addition to these, certain researchers (e.g., Baumeister & Monroe, 2014; Duckworth & Carlson, 2013) suggest that some differences in AP may arise from interindividual differences in various self-regulation mechanisms, such as executive functions (EF) (Carver & Scheier, 1982; Hofmann et al., 2012).

While there are various definitions of EF, most proposals converge in highlighting central characteristics, including (1) a set of processes or mechanisms that (2) enabling controlled and flexible top-down processing of information, (3) exerting control and regulation over other processes, and (4) being oriented towards achieving goals related to adaptation and valuable to the individual (Gioia et al., 2001; Hofmann et al., 2011; Schmeichel & Tang, 2015). One of the primary debates surrounding EF is the determination of their structure and organization (Introzzi, 2016). In particular, the debate presents two possibilities. The first considers executive processes as independent from each other (a multidimensional approach) due to the unique and differential variance found in various tasks that explore these processes (Brocki & Bohlin, 2004; Godefroy et al., 1999). The second viewpoint posits that executive functioning should be understood as a unified mechanism (a unitary approach) represented by a general executive component (Cohen & Servan-Schreiber, 1992; Duncan et al., 1996). Nevertheless, most of the current research is based on an intermediate stance, suggesting that EF should be considered as separate and distinguishable components but related to each other (Collette et al., 2005; Miyake & Friedman, 2012). This integrative approach is commonly referred to as the model of “unity and diversity” of EF (Friedman & Miyake, 2017; Miyake et al., 2000). Thus, despite the existence of a common factor in tasks requiring executive control, there are also specific subcomponents that are primarily involved in certain specific tasks.

Furthermore, there are different models regarding the structure and components of EF (e.g., Roebers, 2017; Tirapu-Ustarroz et al., 2018; Zelazo & Carlson, 2012). However, one of the most widely discussed and disseminated models is the one proposed by Miyake et al. (2000). The model suggests that working memory, inhibition, and shifting constitute the core EF upon which higher-order ones like planning or problem-solving are built (Diamond, 2013).

“Working memory” is a complex general system with limited capacity that enables the maintenance of relevant information within attentional focus for executing complex tasks (Engle et al., 1999). It can be conceptualized as a mental space for retaining information, but its role is not limited to temporary storage alone. It also involves the dynamic updating and manipulation of this information to respond to environmental demands (Baddeley, 2012; Diamond, 2013). Individuals use working memory whenever they perform cognitive operations that involve actively working with information (manipulating, organizing, modifying, updating, or using it in some way; Canet-Juric & Burín, 2016).

“Inhibition” is the capacity for halting, attenuating, or overriding a mental process to exclude irrelevant information, thoughts, emotions, or actions for the performance of an ongoing task (Hulbert & Anderson, 2008). It engages in conflict situations where inappropriate prepotent responses (conflicting with the task objectives) generate interference and must be suppressed for the person to adapt better to the environment (Friedman & Miyake, 2004; Hofmann et al., 2012). Inhibitory control allows people to pause and reflect before acting, enabling them to make decisions beyond emerging impulses or automatic reactions.

“Shifting” refers to the capacity to switch between goals, thoughts, strategies, or actions depending on changes in situational demands (Dajani & Uddin, 2015; Ionescu, 2012). This ability enables people to cognitively disengage from a previous task, reconfigure new responses, and implement them to adaptively address contextual demands (Genet et al., 2013). Efficiently and swiftly shifting in response to substantial demands constitutes a crucial aspect of adaptive and goal-directed behavior (Ionescu, 2012). Although shifting is considered one of the three core EF along with working memory and inhibition, the former relies on the latter two for its functioning (Diamond, 2013). To execute a flexible change, individuals must be capable of holding different rules or perspectives in focus, actively inhibiting previous actions or goals (which were previously suitable but now need modification) and updating or activating the new rule to provide an appropriate response (Dajani & Uddin, 2015). In this manner, working memory plays a role in retaining rules and updating goals in the face of situational changes, while inhibition comes into play by suppressing automatic responses (Davidson et al., 2006; Ionescu, 2012).

EF are critical for adaptation to the environment and goal achievement (Hofmann et al., 2012), suggesting their relevance in various academic facets. Working memory is presumed to be responsible for enabling students to maintain relevant information in their attentional focus, comprehend textual information, retain instructions or guidelines, keep task goals updated, or perform mathematical calculations, among other academic tasks (Arrington et al., 2014; Bergman-Nutley & Klingberg, 2014). Inhibition allows students to resist interference from irrelevant stimuli, suppress automatic representations that may interfere with ongoing tasks, and override prepotent responses that could hinder learning or performance goals (Diamond, 2013; Friedman & Miyake, 2004; Lustig et al., 2007; Montoya et al., 2019). Furthermore, inhibition is strongly associated with self-control, enabling individuals to resist immediate temptations or impulses to achieve long-term objectives (Baumeister, 2014; Nigg, 2017). Shifting would enable students to dynamically adapt to various learning contexts, reconfigure their responses in the face of changing demands, adjust their objectives, and approach a problem from different strategies or perspectives (Dajani & Uddin, 2015; Ionescu, 2012).

Despite the literature documenting numerous studies on the relationship between EF and AP in children and adolescents (e.g., Ahmed et al., 2019; McClelland et al., 2007), there is less research at the university level, and the findings reported therein are contradictory (García Berbén et al., 2017; Gareau et al., 2019; Jiménez-Puig et al., 2019). Furthermore, many studies focusing on this population do not employ direct indicators of AP but instead concentrate on various learning-associated behaviors, such as the number of study hours or the use of learning strategies. For instance, Rabin et al. (2011) found a relationship between some EF (initiative, planning, organization, inhibition, self-monitoring, working memory, task control, organization of materials) and academic procrastination. Similar results have been reported by other authors regarding procrastination in this population (e.g., Bolden et al., 2020; Rinaldi et al., 2021; Sabri et al., 2016).

Regarding AP specifically, Gropper and Tannock (2009) and Gareau et al. (2019) restricted their analysis to working memory (but not other EF), and their findings confirmed that this capacity is associated with students’ mean grade scores. However, two other studies (Figueroa et al., 2018; Zapata et al., 2009) that also examined the role of working memory did not find significant relationships between it and academic averages in this population.

Regarding other EF, García Berbén et al. (2017) assessed inhibitory capacity, shifting, working memory, verbal fluency, and attention in university students. They found that, except for verbal working memory, performance on the rest of the tests distinguished students with low grades from those with high grades. However, other studies that examined EF in university students arrived at different results: Jiménez-Puig et al. (2019) did not find differences in the working memory capacity among students with low, medium, and high performance, nor did they find differences in inhibition or shifting. On the other hand, Barceló Martínez et al. (2006) did not find differences in inhibition and shifting between students with low and high AP, although they did find differences in verbal fluency.

Given these discrepancies, further evidence is necessary to clarify the relationships between these variables. Deepening knowledge about EF and their relationship with AP is of interest to analyze strengths and deficits in university students. Also, this could guide the design of interventions aimed at optimizing learning and teaching processes in the university. In the long term, this research topic can contribute to improving the AP of the university population and preventing attrition (Gallegos et al., 2018; Munizaga et al., 2018). Based on the above, this study aimed at contributing to the study of the relationships between EF and the AP of university students. Building on the theoretical proposals in the literature, the main hypothesis was that EF, particularly working memory, inhibition, and shifting, are associated with AP in university students, in such a way that EF allow discriminating between students with low and high AP and explaining the variance of AP (beyond the sociodemographic variables of age, socioeconomic status, or hours worked by the student). Thus, students who score higher on tasks assessing working memory, inhibition, and shifting are likely to demonstrate better AP.

Method

Participants

Using G*Power software, a minimum sample size of 174 participants was estimated to evaluate moderate effects through various inferential statistical analyses. To facilitate a reliable comparison of AP among participants, it was decided to limit the sample to a single undergraduate program (with all students having the same number of courses per year, the same condition of semester-based courses, the same final exam regimen, the same historical GPA, etc.). Consequently, all students belonged to the Faculty of Psychology. Thus, the 287 students who enrolled in the Cognitive Psychology course (corresponding to the third curricular year of the Bachelor's degree in Psychology at the National University of Mar del Plata) were asked to participate voluntarily in this research. A total of 220 students agreed to collaborate. Exclusion criteria were not being an active regular student in the Bachelor's degree in Psychology, being over 39 years old, presenting neuropsychological pathologies or cognitive deficits. After conducting all evaluations, three people from the Faculty of Humanities (who were taking Cognitive Psychology as an elective subject within the Philosophy program) were removed from the sample. Secondly, 13 students who exceeded the 39-year age limit were excluded. Thirdly, five students were excluded due to problems with the tracking of their academic history. Fourthly, one participant who had difficulty understanding the instructions (interrupted two tasks and asked to restart them, thereby invalidating the assessment) was eliminated. Fifth, one student who indicated having dyscalculia and refused to perform one of the tasks involving numbers was removed. Lastly, one participant with a cognitive deficit was excluded. In total, 24 participants were removed, resulting in a final sample of 196 students from the National University of Mar del Plata, ranging in age from 19 to 37 years (M = 22.63, SD = 3.26). Of the participants, 79.1% (n = 155) identified as female, and 20.9% (n = 41) identified as male. According to Hollingshead's (2011) socioeconomic classification, 7.1% (n = 14) had a low socioeconomic status, 14.3% (n = 28) had a lower-middle socioeconomic status, 24.5% (n = 48) had a middle socioeconomic status, 31.1% (n = 61) had an upper-middle socioeconomic status, and 23.0% (n = 45) had a high socioeconomic status.

Measures

Reading Span Task

To assess working memory, the Argentine adaptation (Barreyro et al., 2009) of the Reading Span Task (Daneman & Carpenter, 1980) was administered. This task involves the computerized presentation of sets of sentences, each consisting of approximately 12 to 15 words (e.g., "In general, the audience that prefers cinema does not attend the theater", "That summer was so cold that many people had to change their plans"). Each set presents two to five sentences one at a time on a black background with white letters. Participants are instructed to read the sentence aloud as it appears on the screen (processing), to retain (storage) the last word of the sentence, and to continue reading the next sentence in the set. At the end of the set, participants are asked to recall the final words of each sentence in the same order in which they were presented (e.g., "theater, plans"). The task consists of one practice set and four experimental sets with increasing levels of complexity (1st experimental set: three trials of two sentences; 2nd set: three trials of three sentences; 3rd set: three trials of four sentences; 4th set: three trials of five sentences). If a participant fails in two or three trials of the same level, the task is interrupted. The Argentine adaptation demonstrated satisfactory internal consistency (α = .95) and evidence of validity. In the current study, the coefficient α was .94. "Working memory" was operationalized as (1) the proportion of correct trials (trial accuracy) and (2) the proportion of words remembered (word accuracy). The number of observed intrusions was also used as an indicator of "inhibition" (Chiappe et al., 2000).

Fingers Task

To assess shifting, the Fingers Task (Introzzi et al., 2019; Richards et al., 2021) was administered. It is based on the task-switching paradigm (Davidson et al., 2006; Monsell, 2003). The task comprises three assessment blocks: congruent- (20 trials), incongruent- (20 trials), and mixed (40 trials) blocks. Each block also includes practice trials. In the congruent block, finger pointing straight down appears on the left or right side of the screen. The participant is required to press the Z or M key depending on the location of the stimulus (Z for stimuli on the left and M for stimuli on the right), giving a congruent response to the stimulus' location. In the incongruent block, the finger points diagonally (at a 45° angle) to the opposite side of its location. The participant must press the key on the side opposite to where the stimulus is presented, following the direction indicated by the finger (M for stimuli on the left and Z for stimuli on the right). Finally, the mixed block combines both types of stimuli from the previous blocks (congruent and incongruent). This requires a rapid shift (switch) between two incompatible rules: pressing the key on the same side of the stimulus or pressing the key on the opposite side of the stimulus. The stimuli are presented sequentially, equidistant from the center of the screen, with a 500-ms interval. Each stimulus remains on the screen for 750-ms or until the participant responds. The task has previously been used in Argentina (e.g., Introzzi et al., 2015; Richards et al., 2017) with demonstrated validity and reliability. In the current study, internal validity was confirmed (participants exhibited lower mean accuracy and longer mean response times [RT] as the task difficulty increased). "Shifting" was operationalized as (1) the proportion of correct responses (accuracy) and (2) the participants' RT.

Five Digits Test

To assess inhibition and shifting, the Five Digits Test (5DT; Sedó, 2007) was administered. The test consists of four lists, each containing 50 items. The items are square frames containing different quantities of the same number (except for List 2, which contains asterisks and not numbers), for example, the number "2" written three times. List 1 assess reading speed: the number written is congruent with the quantity of times that the same number appears (e.g., in the squares with the number 2, the number appears two times: "2 2"). List 2 consists of squares with asterisks (and not numbers), where participants must count the number of asterisks in each square. In List 3, the number written in the square is incongruent with the number of times the number appears (e.g., the number 2 written four times: "2 2 2 2"). The participant must verbally state how many numbers are in each square, inhibiting the automatic response of reading them. List 4 consists of items similar to those in List 3, with the difference that some of them have a thicker border. In these items, the participant must shift the rule and read the number in the square instead of counting them. While Lists 1 and 2 evaluate simple and automatic processes (reading and counting), Lists 3 and 4 explore the use of deliberate cognitive resources in complex tasks: active inhibition of information that is processed spontaneously but is irrelevant (List 3), and shifting between two different cognitive processes (List 4). The split-half reliability (Spearman-Brown correction) of the lists' ranges between .86 and .98 points in normal adults (Sedó, 2007), and the task shows strong validity evidence. In the current study, the test's reliability was analyzed (split-half with Spearman-Brown correction), resulting in indices between .77 and .89. "Inhibition" was operationalized as (1) the total time to complete List 3 and (2) the number of errors in List 3. "Shifting" was operationalized as (1) the time to complete List 4 and (2) the number of errors in List 4.

Academic Records

To assess AP, data were collected regarding participants' (a) year of enrollment, (b) number of courses taken and passed, (c) number of courses taken but failed, (d) number of courses taken but abandoned, (e) number of final exams passed, (f) number of final exams failed, and (g) GPA (including failures). The proposals of Luque and Sequi (2002) and Devincenzi et al. (2018) were used and adapted to create a comprehensive university AP index. This index considers the approval/disapproval of courses, the approval/disapproval of final exams, the academic GPA, and the students' progress according to the theoretical timeframes established by the curricula.

Sociodemographic Questionnaire

A sociodemographic questionnaire was designed to collect information on (a) age, (b) gender, (c) primary economic provider of the family, (d) highest educational level of the primary economic provider, (e) characteristics of the primary economic provider's occupation, and (f) whether the student was currently employed (and the number of hours worked per week). The number of weekly working hours was recoded as ordinal data for some analysis. The socioeconomic status was calculated using the Hollinghead index (2011), based on the educational scale by Pascual et al. (1993) and the occupational group scale for Argentina by Sautú (1989).

Procedure

The study was conducted as part of a doctoral project approved by the doctoral committee of the National University of Mar del Plata and the National Council for Scientific and Technical Research (CONICET). A non-experimental cross-sectional design was applied. Ethical procedures recommended by the Declaration of Helsinki (World Medical Association [WMA, 2013]) and the American Psychological Association (2010) were strictly adhered to. The students were approached during their classes, where the characteristics of the study were explained to them. Those who agreed to participate were required to sign an informed consent form outlining the study's characteristics and the conditions of their participation. Students attended face-to-face individual appointments at the university's facilities, during which the instruments were administered in a counterbalanced manner. All participants completed all tasks in a single individual session of approximately 40 minutes. The sessions were conducted by the study's principal investigator. As a result, there were no missing data with respect to the administered tasks. The sociodemographic questionnaire was answered using Google Forms, which prevented participants from progressing unless they answered all the questions, ensuring no missing data in this instrument either. AP data were obtained from the university's student information systems.

Data Analysis Plan

To analyze the relationships between EF and AP, Pearson's r correlations were computed. To assess the EF's capacity to discriminate between students with low and high AP, discriminant analysis was employed. This multivariate statistical technique was chosen as it has been considered robust in various types of data (Brown & Wicker, 2000; Pohar et al., 2004). Thus, the discriminant function minimizes the probability of misclassifying members of each group (Demagistri, 2016). To accentuate the differences between groups, students were divided into quartiles based on their AP, and the low AP group (1st quartile) and high AP group (4th quartile) were used for discriminant analysis (Stover et al., 2014). As the Box's M test indicated the equality of covariances between groups ($p > .01$), the within-group covariance matrix was used for classification. The Enter method was used. The independent variables entered were (1) sociodemographic factors (age, socioeconomic status, and number of hours worked per week) and (2) EF indicators (two for working memory, three for inhibition, and four for shifting). Gender was not included as a predictor variable since it did not show an effect on AP (no significant differences in AP were observed between men and women using independent samples t-tests; $p < .05$). It is worth noting that, despite having a larger number of female participants, no statistically significant differences ($p > .05$) were observed between men and women for age ($t = -1.9$), socioeconomic status ($t = -0.71$), or the number of hours worked per week ($t = -0.42$).

Once the EF indicators that allowed discrimination between the groups were identified, Z-scores for each participant were computed for these variables. Subsequently, a total working memory variable (Trial Accuracy + Word Accuracy), shifting variable (Fingers Task Accuracy + 5DT Errors), and inhibition variable (Working Memory Intrusions + 5DT Errors) were created using the averages of these indicators. A linear regression analysis was conducted using the Enter method to examine the interaction between the variables. Sociodemographic variables, including age, socioeconomic status, and weekly working hours, were also introduced. The dependent variable was the overall AP without grouping. This analysis included all cases. Collinearity diagnostics indicated appropriate values (VIF < 1.6). The residuals exhibited levels of skewness (0.36) and kurtosis (-0.79) consistent with normal distribution (Field, 2009; George & Mallery, 2016).

Results

Table 1 shows the relationships between EF and AP. The RTs of the EF tests did not present correlations with AP. In contrast, indicators of accuracy showed direct relationships with AP, while indicators of number of errors showed inverse relationships. This indicates a direct, low, and statistically significant relationship between the efficiency of the core three EFs and AP.

Table 1. Correlations between Students' EF and AP

Executive Performance Indicators	Academic Performance
Working Memory - Trial Accuracy	.18**
Working Memory - Word Accuracy	.13*
Shifting – Fingers Task RT	-.04
Shifting - Fingers Task Accuracy	.18**
Shifting - 5DT RT	.04
Shifting – 5DT errors	-.12*
Inhibition – Intrusions in Reading Span Task	-.17**
Inhibition - 5DT RT	.08
Inhibition - 5DT errors	-.15*

Note. 5DT = 5 Digit Test; RT = response time.
**p < .05, **p < .01.

Then, discriminant analysis was employed to assess EF's capacity to distinguish between university students with low and high AP. Independent variables were age, socioeconomic status, working hours, and EF indicators (two for working memory, three for inhibition, four for shifting). As suggested by Wilks' lambda (.44) and the transformation of Lambda to χ^2, $\chi^2_{(15)} = 73.02$, $p < .01$, the multivariate means of the groups differed significantly, indicating statistical differences between low and high AP students. The canonical function indicated that the linear function discriminated between the groups, with an eigenvalue of 1.25. The canonical correlation was .75, demonstrating a high relationship between the function and the AP groups; 86.7% of the cases were correctly assigned. Table 2 presents the results of the contribution of each independent variable to the discriminant function. Wilks' lambda and the significance associated with the *F* statistic (univariate ANOVAs) were used to determine whether each independent variable discriminates between the groups. The variables in Table 2 were ordered in terms of their contribution to the discriminant function (based on the structure coefficients). The variables with the greatest discriminatory power between the groups were sociodemographic variables (age, weekly working hours, and socioeconomic status). Nevertheless, two indicators of working memory, two indicators of shifting, and two indicators of inhibition also contributed to discrimination. Therefore, younger age, fewer weekly working hours, belonging to higher socioeconomic status, greater working memory capacity, greater shifting, and greater inhibitory capacity enable the discrimination of students with better AP.

Once the EF indicators that allowed discrimination between the groups were identified, a linear regression analysis was conducted to examine the interaction between EF and sociodemographic variables (Table 3). Total variables for working memory (Trial Accuracy + Word Accuracy), shifting (Fingers Task Accuracy + 5DT Errors), and inhibition (Working Memory Intrusions + 5DT Errors) were computed and introduced into the model along with sociodemographic variables (age, socioeconomic status, and weekly working hours). The dependent variable was AP. The model was statistically significant, $F_{(6, 195)} = 19.25$, $p < .01$, and explained 38% of the variance in AP ($r^2 = .379$). The predictor variables were the three introduced sociodemographic variables and, to a lesser extent, inhibition and shifting. Although working memory allowed discrimination between low and high AP students in the discriminant analysis, it did not emerge as a predictor when considering the interaction between the variables.

Discussion

Given the importance of university students' AP in their education, it is valuable to understand the impact of various factors that could affect it, including psychological factors. Initially, although with a low effect, relationships were observed between the three core EF (working memory, inhibition, shifting) and the AP of university students. Thus, with greater EF capacity, AP also tends to be higher. Subsequently, a discriminant analysis was conducted, revealing that working memory, inhibition, and shifting, in addition to age, working hours, and socioeconomic status, enabled the creation of a function that effectively discriminated between the low and high AP groups in 86.7% of the cases. Finally, a linear regression analysis was performed to explore the interaction between EF and sociodemographic variables. The model explained 38% of the variance in AP, with age, socioeconomic status, working hours, and, to a lesser extent, inhibition and shifting emerging as predictors. Although working memory allowed discrimination between low and high AP students in the discriminant analysis, it did not emerge as a predictor when considering the interaction between the variables.

Regarding inhibition and shifting, results from other authors (e.g., Álvarez et al., 2015; García Berbén et al., 2017) also suggest relationships between these EFs and AP at the university. On the one hand, inhibitory capacity would allow students to resist the interference of distracting stimuli when studying or paying attention in class (Friedman & Miyake, 2004; Kavanaugh et al., 2019). It would

Table 2. Contribution of the Independent Variables to the Discriminant Function, and Descriptive Statistics for Each Academic Performance Group

	Low AP		High AP		Structure Coef.	Wilks Lambda	$F_{(1, 96)}$
	M	*SD*	*M*	*SD*			
Age	24.43	2.76	20.59	1.78	.74	.554	66.86**
Working hours per week	16.43	17.49	3.00	7.44	.40	.806	23.04**
Socioeconomic status	37.02	13.09	46.47	14.56	-.23	.930	11.41**
Working Memory - Word Accuracy	0.78	0.07	0.81	0.05	-.21	.939	6.28*
Working Memory - Trial Accuracy	0.59	0.10	0.64	0.08	-.21	.940	6.08*
Shifting - Fingers Task Accuracy	70.66	15.83	77.70	13.89	-.20	.946	5.48*
Inhibition – Intrusions in Reading Span Task	0.23	0.18	0.16	0.16	.19	.949	5.21*
Inhibition - 5DT errors	1.08	0.86	0.71	0.79	.19	.952	4.83*
Shifting – 5DT errors	1.84	1.14	1.33	1.30	.17	.957	4.27*
Inhibition - 5DT RT	33.82	6.14	34.37	5.51	-.04	.998	0.22
Shifting – Fingers Task RT	597.53	38.65	595.00	36.87	.03	.999	0.11
Shifting - 5DT RT	41.60	6.16	42.01	7.34	-.03	.999	0.09

Note. Means and deviations for age, socioeconomic status, and number of working hours per week are presented for the original raw variables without transforming or recoding.
AP = academic performance; RT = response time; 5DT = 5 Digit Test; Structure Coef. = structure coefficients.
*p < .05, **p < .01.

also allow the attenuation or overriding of responses, behaviors, and emotions not appropriate to the task goals for a better adaptation to the academic environment (Friedman & Miyake, 2004; Tangney et al., 2004). On the other hand, students with greater shifting capacity would be better at adjusting their responses according to the characteristics of each academic situation, thus responding to contextual demands in an adaptive manner (Genet et al., 2013; Dajani & Uddin, 2015). Shifting would also allow students to alternate between different study methods or strategies according to the conditions of each subject, teacher, or exam, self-regulate their learning processes, and cognitively or emotionally disengage from previous tasks (Follmer & Sperling, 2016).

Table 3. Standardized β Coefficients of the Effect of Executive Functions and Sociodemographic Variables on Academic Performance

Executive Functions Indicators	Standardized β
Age	-.39**
Working hours per week	-.15**
Socioeconomic status	.24**
Working memory	-.02
Shifting	.12*
Inhibition	.20**

*$p < .05$, **$p < .01$.

Regarding working memory, studies by Gropper and Tannock (2009), Gareau et al. (2019), and Hong et al. (2012) indicate a relationship between this EF and university students' grades, while other studies such as those by Figueroa et al. (2018) or Hung (2020) report no relationship between working memory and performance in higher education. Like what was found in the present study, Rohde and Thompson (2007) found that the effect of working memory on college performance was low and disappeared when including other cognitive skills in the regression. The contradictory results in the literature may be due to several reasons, such as the interaction between the different factors considered in each study, the characteristics of the population analyzed (career, year of study, etc.) or the consideration of mediating or moderating factors. In this regard, del-Valle, Andrés et al. (2022) suggest a moderating effect of distress tolerance between working memory and AP, such that they report an effect of working memory on AP only among students with high distress tolerance. Further research is still needed to clarify whether working memory is related to AP in the university population (Alloway & Alloway, 2014).

It should also be noted that the effect of EF (inhibition and shifting) was smaller compared to that of age, socioeconomic status, and the number of hours worked by the student. It is possible that the significance of some psychological variables, such as EFs, is greater in earlier educational stages, when these self-regulatory mechanisms are still under development (Best et al., 2011; Huizinga et al., 2006; Müller & Kerns, 2015; Rosselli et al., 2008). In relation to age, this factor presented the clearest associations with college AP compared to the other sociodemographic factors examined. This aligns with what has been previously reported in the academic literature (e.g., Fiori & Ramírez, 2013; Rodríguez Albor et al., 2014) and hints that, as age increases, AP is likely to decrease.

Additionally, students who dedicate more hours to work and those from lower socioeconomic status also presented lower AP. Previous research consistently supports the idea that students' socioeconomic status is directly related to their university performance (Aina et al., 2022; Villamizar Acevedo & Romero Velásquez, 2011). Similarly, an inverse association has been observed between work hours and AP (Coschiza et al., 2016; Lopera Oquendo, 2008). Thus, the additional workload derived from the need for employment may result in difficulties in meeting academic tasks, increased absenteeism, reduced attention, and class participation due to burnout (Carrillo Regalado & Ríos Almodóvar, 2013; Vélez van Meerbeke & Roa González, 2005). Consequently, a younger student, coming from a more favorable socioeconomic background and more likely to be able to devote himself/herself to full-time study without the need to work, tends to exhibit better AP. In contrast, older students, with a lower socioeconomic status, and who must divide their time between studying and working, tend to show lower AP (Barreto Osma et al., 2019; Lopera Oquendo, 2008).

As limitations of the study, several points should be highlighted. Firstly, the study had a high proportion of female participants. While this gender proportion is common in the university population (del-Valle, Zamora et al., 2022; Khalil et al., 2020), a greater representation of male individuals would have been desirable. Secondly, the study focused on AP and did not directly address academic dropout. While low performance is a matter of concern in higher education institutions and a direct cause of dropout (Fernández Hileman et al., 2014; García Ortiz et al., 2014; Uribe-Enciso & Carrillo-García, 2014), academic dropout is of particular importance in Argentine universities. Therefore, it is necessary to conduct studies that directly address academic dropout and analyze whether EF might affect performance to the extent of leading to dropout. Another aspect to consider is that this study employed a cross-sectional design. However, university practice and progression throughout academic courses may involve ongoing training and practice in various cognitive skills that could modulate the relationship examined with AP. Since no previous longitudinal studies on this topic have been found, this could be considered as a future line of research.

In conclusion, this research provides empirical evidence on the relationships between EF and AP in the university population. It is expected that this study serves as a starting point for future research, which should include larger and more diverse samples as well as a greater number of contextual and psychological variables related to learning in the university setting. Findings of this type are of interest in systematically identifying and analyzing strengths and deficits in university students, and can serve as input for designing interventions aimed at optimizing the quality of higher education and the well-being of this population.

Conflict of Interest

The authors of this article declare no conflict of interest.

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