



Temporal Organization of Intellectual Virtues among University Students: A Longitudinal Exploratory Study

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Abstract

Intellectual virtues—such as curiosity, attentiveness, carefulness, open-mindedness, and autonomy—are recognized as contributors to academic flourishing and character development in higher education. However, longitudinal evidence on how these virtues interact over time remains scarce. This study examined the temporal dynamics and interrelations of five intellectual virtues in 521 Argentine university students (58.5% female; ages 18–45) across two measurement waves using the Virtuous Intellectual Character Scale (VICS). Exploratory cross-lagged panel models were applied to investigate both contemporaneous associations and prospective relationships. Results indicated moderate to high temporal stability and positive associations among the virtues. Cross-lagged analyses revealed tentative evidence of a probabilistic developmental sequence, with curiosity as a potential foundational trait, attentiveness as a possible mediator, and open-mindedness, carefulness, and autonomy as downstream traits. Effect sizes were modest, suggesting these patterns reflect exploratory trends rather than strong causal pathways. The study contributes preliminary longitudinal evidence to the understanding of intellectual character and its temporal organization, providing a basis for future research with additional waves and diverse populations to clarify developmental trajectories and examine the generalizability of these tentative patterns.

Keywords Intellectual virtues · Character education · Longitudinal study · University students · Positive psychology · Cross-lagged panel analysis

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1 Introduction

In recent years, increasing attention has been given to the role of intellectual virtues in higher education, particularly in relation to students' holistic development and character formation (Lechner et al., 2025; Pritchard, 2023). Virtues such as intellectual humility, curiosity, and open-mindedness are central not only to academic excellence but also to the broader educational mission of universities aimed at fostering morally and intellectually flourishing people (Case & VanderWeele, 2025; Faizah et al., 2024; Mesurado & Vanney, 2025). This emphasis aligns with an expanding body of literature on character education at the university level, which highlights the responsibility of higher education institutions to cultivate character alongside disciplinary knowledge (Arthur, 2024; Brant et al., 2022; Brooks et al., 2024). Recent reviews have further emphasized the growing relevance of intellectual virtues within higher education contexts and their connection to broader educational aims related to reflective inquiry, epistemic responsibility, and flourishing (Kuntz & Taylor, 2021). Within this context, understanding the trends in the development of intellectual virtues during the university years is especially relevant, as this understanding can inform educational practices that promote reflective, self-directed, and autonomous learners.

Intellectual virtues are commonly understood as stable traits of character that dispose individuals to think well, particularly in the pursuit of knowledge and understanding. Although there is broad agreement on their importance, there is no fixed or definitive account of which virtues such a framework should include. Accordingly, existing approaches emphasize the open-ended and nonexhaustive nature of any proposed list. For example, Roberts and Wood (2007) focus on virtues such as love of knowledge, intellectual courage and caution, humility, autonomy, generosity, firmness, and practical wisdom. Other scholars have offered overlapping but distinct classifications. Dow (2013) identifies seven core intellectual virtues—including curiosity, honesty, fair-mindedness, courage, carefulness, tenacity, and humility—whereas King (2021) expands this account by highlighting the importance of intellectual autonomy and open-mindedness. Similarly, Baehr (2021) proposes a set of nine central intellectual virtues that foreground qualities such as attentiveness and thoroughness rather than honesty and fair-mindedness. Overall, these accounts reflect sustained efforts to articulate intellectual virtues with explicit attention to educational aims and pedagogical implications. These theoretical accounts have increasingly motivated efforts to operationalize and assess intellectual virtues empirically in educational contexts.

Recent advances in the assessment of intellectual virtues have yielded a range of instruments that target specific virtues. In particular, psychological research has produced validated scales for individual traits—for example, measures of intellectual humility (Leary et al., 2017), curiosity (Bluemke et al., 2023), and open-mindedness (Dolbier et al., 2025)—that help capture discrete aspects of intellectual character. More recently, Mesurado and Vanney (2024) developed the *Virtuous Intellectual Character Scale (VICS)* to facilitate a more holistic assessment of virtuous intellectual functioning as a unified construct, comprising curiosity, attentiveness, open-mindedness, carefulness, and intellectual autonomy.

On the basis of Baehr's conceptualization of intellectual virtues (Baehr, 2021), curiosity is understood as "a disposition to wonder, ponder, and ask why—a thirst for understanding and a desire to explore" (p. 195). Attentiveness is defined as "a readiness to be *personally present* in the learning process," involving keeping distractions at bay and noticing important details (p. 195). Carefulness refers to "a disposition to notice and avoid intellectual pitfalls and mistakes" (p. 195). Open-mindedness is characterized as "an ability to think outside the box" and to give "a fair and honest hearing to competing perspectives" (p. 196). Finally, intellectual autonomy is described as an "ability to think and reason for oneself" (p. 125).

Baehr has argued that different intellectual virtues play distinct roles at various stages of the learning process (Baehr, 2021). Some virtues—including curiosity, intellectual autonomy, and intellectual humility—are especially important for initiating learning. Others—such as attentiveness, intellectual carefulness, and intellectual thoroughness—are required to sustain and appropriately regulate learning once it is underway. Finally, certain virtues—including open-mindedness, courage, and tenacity—are particularly salient for overcoming common obstacles encountered during learning.

Although the theoretical literature generally assumes that intellectual virtues are interrelated and that the development of one virtue may facilitate the development of others, there is, to our knowledge, no empirical evidence clarifying whether these virtues emerge in a sequential order over time. This lack of empirical clarity represents an important gap in the literature, particularly given that, from a positive psychology perspective, intellectual virtues may be conceived as character-based psychological resources that contribute to academic flourishing (Mesurado & Vanney, 2025). The present study aims to address this gap by examining the temporal ordering and interrelations of intellectual virtues among university students.

Intellectual virtues are conceptualized in the present study as acquired traits of character—relatively stable dispositional tendencies oriented toward epistemic goods such as truth, understanding, and responsible inquiry. Within virtue epistemology, such virtues are understood not as transient psychological states but as cultivated dispositions that tend to exhibit continuity across contexts and over time. Empirical research on character strengths provides converging support for this dispositional perspective. Longitudinal investigations of VIA character strengths have shown that these traits tend to remain relatively stable across extended periods of time. In a large-scale study spanning up to 3.5 years, Gander et al. (2019) found substantial rank-order consistency in character strengths, suggesting that individuals tend to maintain their relative standing over time while still allowing for modest mean-level change. These findings indicate that character dispositions typically display probabilistic stability while remaining open to contextual influence and developmental refinement. Taken together, this empirical pattern supports the theoretical expectation that intellectual virtues, understood as traits of character rather than transient psychological states, should exhibit meaningful temporal continuity in emerging adult populations, thereby justifying the examination of their longitudinal organization.

1.1 Present Study

Building on the theoretical and empirical gaps in the literature, the present study aims to preliminarily examine the temporal dynamics and interrelations among five intellectual virtues—curiosity, attentiveness, carefulness, open-mindedness, and autonomy—in a sample of university students. On the basis of prior theory and research, we formulate the following exploratory hypotheses to investigate both the concurrent associations and the longitudinal ordering of these five virtues.

H1: Intellectual virtues are expected to show positive associations at each time point, which is consistent with their conceptualization as interrelated but distinguishable traits.

H2: Some virtues are expected to exhibit probabilistic temporal precedence over others such that earlier levels of certain traits may be associated with relative changes in others over time.

2 Methods

This study employed a longitudinal panel design, with data collected at two time points.

The study protocol was approved by the Ethics Committee of Austral University (CIE N° P24-003), and written informed consent was obtained from all of the student participants prior to their involvement.

2.1 Participants

The study sample included 521 university students from Argentina, including 305 females (58.5%), 190 males (36.5%), and 26 participants (5%) who preferred not to disclose their gender. Ages ranged from 18 to 45 years ($M=19.13$, $SD=1.74$). Although the full age range was broad, the vast majority of the sample (99.2%) was between 18 and 25 years old, indicating that the sample was highly concentrated in late adolescence and early emerging adulthood.

2.2 Measures

To assess intellectual virtues, we used the five subscales of the 23-item VICS (Mesurado & Vanney, 2024), which is based on the *Virtue-Oriented Self-Report Measures* proposed by Baehr (2021). The participants rated each item on a five-point Likert-type scale ranging from 1 (“not at all like me”) to 5 (“very much like me”), and mean scores were calculated for each subscale, with higher scores reflecting stronger virtuous intellectual character.

The reliability of the five subscales was as follows: the 5-item curiosity subscale (e.g., “The world is a fascinating place to discover.”) had Cronbach’s α values of 0.75 at T1 and 0.70 at T2; the 5-item attentiveness subscale (e.g., “I enjoy paying attention.”) had α values of 0.63 at T1 and 0.63 at T2; the 5-item carefulness subscale (e.g., “I check my work for errors before turning it in.”) had α values of 0.62 at T1

and 0.63 at T2; the 5-item open-mindedness subscale (e.g., “I like to hear different perspectives.”) had α values of 0.72 at T1 and 0.73 at T2; and the 3-item intellectual autonomy subscale (e.g., “When someone gives me advice, I like to think it through for myself.”) had α values of 0.40 at T1 and 0.48 at T2. Owing to the modest reliability of the autonomy subscale, the findings involving this virtue should be interpreted cautiously, particularly with respect to predictive analyses.

The instrument was designed for use in educational contexts and can be administered efficiently in classroom settings through self-report procedures requiring minimal administrator training.

2.3 Procedures

Directors of an Argentine university were initially contacted and informed about the study’s objectives. After granting approval, they facilitated communication with the heads of the institution’s academic programs. A member of the research team visited the classrooms during regular class hours to present the study objectives, explain the informed consent procedure, and invite students to participate. Students who agreed to participate provided written informed consent before data collection. The questionnaires were then completed immediately during the same class session using an online survey platform. The administration of the questionnaire was supervised by the course instructor, as the instrument does not require specialized clinical or psychometric training for administration. Completion time was approximately 10 min.

All of the constructs were measured using self-report instruments. All of the responses were collected anonymously to ensure confidentiality and reduce social desirability bias.

2.4 Statistical Analysis

Descriptive statistics for all of the study variables were computed using SPSS 29.0. Additionally, Kolmogorov–Smirnov tests were carried out to evaluate whether the sample distributions deviated from normality.

In a preliminary stage, confirmatory factor analyses (CFA) were conducted in Mplus 9 (2025) at Time 1 (T1) to test the factorial structure of the instrument.

To address Hypotheses 1 and 2, cross-lagged panel analyses were conducted in Mplus 9 (2025) using maximum likelihood estimation with robust standard errors (MLR) to examine the bidirectional predictive relationships across the two time points (Little et al., 2012). Ten models were estimated to cover all of the pairwise combinations of virtues, each including autoregressive effects (the effect of each virtue on itself measured one year later), cross-lagged effects (the effect of one virtue on another virtue measured one year later), correlations at Time 1, and residual correlations at Time 2. Pairwise models were estimated to reduce model complexity and avoid overparameterization relative to the sample size and the number of potential cross-lagged paths. In the Results section, these residual correlations are reported separately to illustrate concurrent associations while controlling for temporal stability and prospective effects, providing complementary evidence for Hypothesis 1. Although limited to two waves, this design allows an examination of initial temporal trends among virtues.

3 Results

3.1 Descriptive Statistics

Descriptive statistics for all of the study variables at T1 are summarized in Table 1.

The results of the Kolmogorov–Smirnov tests suggested that the distributions of all of the study variables at T1 deviated from normality (attentiveness: $D(520) = 0.085$, $p < .001$; open-mindedness: $D(520) = 0.085$, $p < .001$; curiosity: $D(520) = 0.095$, $p < .001$; carefulness: $D(520) = 0.089$, $p < .001$; autonomy: $D(520) = 0.143$, $p < .001$). Given the large sample size, statistical significance in the normality tests was expected; therefore, robust estimation (MLR) was employed.

3.2 Preliminary Analysis

As a preliminary analysis, a confirmatory factor analysis (CFA) was conducted for the VICS at T1. The fit indices indicated an adequate model fit to the data ($\chi^2(207) = 435.30$, $p < .001$, CFI = 0.943, TLI = 0.930, RMSEA = 0.046 (90% CI [0.040, 0.052]), SRMR = 0.046). As expected, given the sample size, the chi-square test was statistically significant. The fit indices were evaluated using MLR.

3.3 Exploratory Cross-Lagged Panel Models

Cross-lagged panel models were used to examine (1) the stability of individual differences in a virtue between one measurement and the next, and (2) prospective associations among virtues across the two time points. A series of 10 exploratory cross-lagged panel models was estimated covering all of the possible pairwise combinations between pairs of virtues. The following patterns provide preliminary evidence of probabilistic temporal precedence among traits rather than causal effects.

The temporal stability of the five intellectual virtues was examined using autoregressive paths in the cross-lagged panel models (see Table 2). The autoregressive paths reflect temporal stability within each virtue. All of the virtues demonstrated moderate to high levels of stability across the two time points, suggesting that individual differences tend to be preserved over time and providing a tentative basis for examining the cross-lagged effects and potential temporal precedence.

The standardized autoregressive coefficients ranged from 0.506 for autonomy to 0.565 for attentiveness, and all of them were statistically significant ($p < .001$).

Table 1 Descriptive statistics for intellectual virtues at time 1 ($N = 521$)

Variable	Minimum	Maximum	M	SD
Attentiveness	1.60	4.80	3.23	0.58
Open-mindedness	2.00	5.00	3.62	0.64
Curiosity	1.80	5.00	3.83	0.62
Carefulness	1.80	5.00	3.64	0.62
Autonomy	1.67	5.00	3.14	0.58

Note. Values represent the minimum, maximum, mean, and standard deviation for each intellectual virtue at Time 1 ($N = 521$). Higher scores indicate stronger expressions of the virtues

Table 2 Autoregressive and cross-lagged paths of intellectual virtues from time 1 to time 2

A. Autoregressive Paths (temporal stability)						
Virtue	Standardized β	SE	p			
Curiosity	0.558	0.036	< 0.001			
Attentiveness	0.565	0.037	<0.001			
Carefulness	0.530	0.038	<0.001			
Open-mindedness	0.544	0.040	<0.001			
Autonomy	0.506	0.035	<0.001			
B. Cross-lagged Paths (prospective associations)						
Predictor T1	Outcome T2	Standardized β	SE	p	95% CI Lower	95% CI Upper
Curiosity	Attentiveness	0.094	0.039	0.016	0.016	0.156
Curiosity	Carefulness	0.022	0.041	0.591	−0.058	0.101
Curiosity	Open-mindedness	0.072	0.040	0.071	−0.006	0.151
Curiosity	Autonomy	0.093	0.038	0.013	0.020	0.167
Attentiveness	Curiosity	0.076	0.041	0.061	−0.003	0.154
Attentiveness	Carefulness	0.119	0.038	0.002	0.045	0.192
Attentiveness	Open-mindedness	0.077	0.038	0.045	0.002	0.152
Attentiveness	Autonomy	0.131	0.039	0.001	0.055	0.207
Carefulness	Curiosity	−0.046	0.039	0.239	−0.122	0.030
Carefulness	Attentiveness	0.033	0.035	0.339	−0.035	0.101
Carefulness	Open-mindedness	0.005	0.038	0.904	−0.070	0.079
Carefulness	Autonomy	0.043	0.040	0.286	−0.036	0.121
Open-mindedness	Curiosity	0.021	0.039	0.583	−0.055	0.098
Open-mindedness	Attentiveness	0.051	0.038	0.179	−0.023	0.125
Open-mindedness	Carefulness	0.038	0.039	0.327	−0.038	0.115
Open-mindedness	Autonomy	0.075	0.037	0.045	0.002	0.149
Autonomy	Curiosity	−0.028	0.037	0.449	−0.100	0.044
Autonomy	Attentiveness	0.057	0.039	0.139	−0.019	0.133
Autonomy	Carefulness	−0.016	0.039	0.682	−0.092	0.060
Autonomy	Open-mindedness	0.068	0.038	0.075	−0.007	0.144

Note. Standardized β coefficients, standard errors (SE), and p values are reported. The autoregressive paths indicate the temporal stability of each virtue from Time 1 (T1) to Time 2 (T2). Cross-lagged paths represent prospective associations between different virtues, controlling for prior levels and T1 correlations. The coefficients are representative values from separate pairwise models; all of the autoregressive paths were statistically significant ($p < .001$)

As Selling and Little (2012) indicate, an autoregressive coefficient of considerable magnitude indicates that individuals' relative standings on the construct have changed very little over time. The reported coefficients correspond to one representative model for each virtue; the values were largely consistent across separate cross-lagged models, with minor variations that did not affect substantive interpretation. These results indicate that each virtue exhibits substantial continuity, suggesting that although development and change are possible, individual differences tend to remain relatively consistent over the study period, providing preliminary and exploratory evidence for temporal stability.

To examine potential temporal precedence among the intellectual virtues, cross-lagged paths were estimated from each virtue at T1 to all other virtues at Time 2 (see Table 2). Several notable patterns emerged. Curiosity at T1 predicted relative increases in attentiveness ($\beta=0.094$, $SE = 0.039$, $p = .015$) and autonomy prospectively

($\beta=0.093$, $SE = 0.038$, $p = .013$) at T2, whereas none of the other virtues at T1 predicted subsequent changes in curiosity. This pattern suggests that curiosity may occupy a foundational position within the observed exploratory trends of the developmental sequence. Although effect sizes are modest, they provide evidence for probabilistic temporal precedence (Zyphur et al., 2019) rather than deterministic causal effects.

Attentiveness at T1 also played a central role, predicting subsequent increases in carefulness ($\beta=0.119$, $SE = 0.038$, $p = .002$), open-mindedness ($\beta=0.077$, $SE = 0.038$, $p = .045$), and autonomy ($\beta=0.131$, $SE = 0.039$, $p = .001$). Other cross-lagged paths were generally small and nonsignificant, which may indicate a tentative temporal ordering rather than a fully reciprocal model, in which certain virtues serve as foundational or mediating, whereas others occupy outcome positions.

The correlations at T1 represent observed bivariate associations among virtues, whereas the residual correlations at Time 2 represent concurrent associations after controlling for autoregressive and cross-lagged effects. These observed correlations provide preliminary support for H1 regarding positive interrelations among the virtues.

Table 3 Observed and residual correlations of intellectual virtues across time

A. Observed Bivariate Correlations at T1					
Variable 1	Variable 2	Correlation (r)	95% CI Lower	95% CI Upper	
Curiosity	Attentiveness	0.526	0.465	0.586	
Curiosity	Carefulness	0.314	0.228	0.401	
Curiosity	Open-mindedness	0.368	0.294	0.441	
Curiosity	Autonomy	0.244	0.168	0.319	
Attentiveness	Carefulness	0.297	0.210	0.384	
Attentiveness	Open-mindedness	0.289	0.205	0.373	
Attentiveness	Autonomy	0.232	0.150	0.313	
Carefulness	Open-mindedness	0.157	0.068	0.247	
Carefulness	Autonomy	0.047	-0.038	0.132	
Open-mindedness	Autonomy	0.207	0.117	0.296	
B. Residual Correlations at T2					
Variable 1	Variable 2	Residual Correlation (standardized)	95% CI Lower	95% CI Upper	
Curiosity	Attentiveness	0.288	0.195	0.381	
Curiosity	Carefulness	0.240	0.152	0.328	
Curiosity	Open-mindedness	0.257	0.172	0.342	
Curiosity	Autonomy	0.185	0.101	0.269	
Attentiveness	Carefulness	0.185	0.087	0.282	
Attentiveness	Open-mindedness	0.156	0.068	0.243	
Attentiveness	Autonomy	0.135	0.035	0.236	
Carefulness	Open-mindedness	0.184	0.097	0.272	
Carefulness	Autonomy	0.132	0.043	0.221	
Open-mindedness	Autonomy	0.016	-0.068	0.101	

Note. Section A presents the observed bivariate correlations at Time 1 (T1). Section B presents the residual correlations at Time 2 (T2), controlling for autoregressive and cross-lagged effects. Values are standardized; higher absolute values indicate stronger associations between virtues

Strong correlations were observed between curiosity and attentiveness ($r = .526$), whereas several moderate correlations were found, including curiosity with open-mindedness ($r = .368$), curiosity with carefulness ($r = .314$), and attentiveness with carefulness ($r = .297$). Smaller correlations were observed among other pairs, such as open-mindedness and autonomy ($r = .207$). These results are consistent with the literature on correlated but distinct intellectual virtues (Baehr, 2021; Mesurado & Vanney, 2024) and provide a baseline for evaluating longitudinal relationships.

Table 3 presents residual correlations at Time 2 among the five intellectual virtues. The observed correlations represent associations at the first measurement occasion, whereas the residual correlations at Time 2 reflect contemporaneous associations after accounting for the prior levels (autoregressive paths) and the prospective cross-lagged effects.

Taken together, the cross-lagged panel correlations provide information about temporal stability, prospective associations, and residual contemporaneous associations among intellectual virtues.

4 Discussion

As highlighted in the introduction, although universities aim to foster both academic excellence and character development, little is known about how intellectual virtues may unfold over time. The present study provides preliminary evidence on the temporal organization and interrelations of five key intellectual virtues—curiosity, attentiveness, carefulness, open-mindedness, and autonomy—and highlights exploratory trends in how intellectual virtues may relate over time. The present findings also contribute to the broader scientific literature on positive traits, character strengths, and virtues within positive psychology. By examining the temporal organization of intellectual virtues in a university population, this study offers preliminary longitudinal evidence on how epistemically oriented character traits may develop and interact over time. In doing so, it extends existing work on character strengths by highlighting the dynamic relationships among virtues associated with intellectual character and responsible inquiry.

Taken together, the cross-lagged analyses allow us to hypothesize a developmental sequence of intellectual virtues, conceptualized in Fig. 1. Within this exploratory model, curiosity appears as a foundational virtue; attentiveness, as a central mediator; and open-mindedness, autonomy, and carefulness, as downstream traits, reflecting probabilistic tendencies rather than deterministic developmental paths.

All five intellectual virtues—curiosity, attentiveness, carefulness, open-mindedness, and autonomy—demonstrate moderate to high levels of stability over time, as reflected in the autoregressive paths of the cross-lagged panel models. Contemporaneous associations among the virtues were consistently positive at both measurement times, supporting H1: higher levels of one virtue tended to co-occur with higher levels of others. The cross-lagged paths revealed exploratory temporal trends suggestive of probabilistic associations, which is consistent with H2.

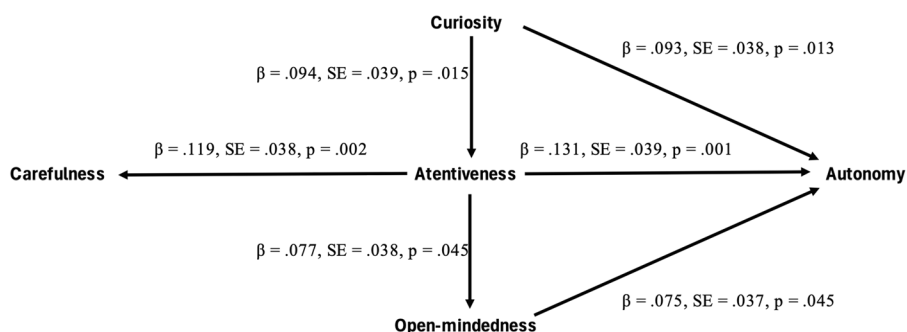


Fig. 1 Exploratory cross-lagged panel model of the hypothesized development of five intellectual virtues. *Note.* Standardized β coefficients are shown for significant paths. Autoregressive paths are also included

The cross-lagged analyses provided preliminary evidence consistent with a potential probabilistic developmental ordering among the intellectual virtues. Curiosity at T1 appeared to be a potential foundational trait, as none of the other virtues predicted its subsequent levels. It prospectively predicted increases in attentiveness and autonomy at T2. Attentiveness functioned as a possible central mediator within this exploratory sequence, predicting increases in carefulness, open-mindedness, and autonomy. These findings support a tentative probabilistic ordering, with curiosity and attentiveness serving as foundational and mediating traits, respectively.

Moreover, the intellectual virtues exhibited moderate concurrent associations at each time point, reflecting their conceptualization as interrelated yet distinguishable dimensions of a broader construct of virtuous intellectual character. This stability and interrelation suggest that intellectual character operates as an integrated system, in which foundational traits may scaffold the development of others while all of the traits remain connected.

4.1 Curiosity as a Foundational Virtue

Curiosity plays an important role in the development of intellectual engagement and cognitive motivation, driving exploration and facilitating reflective learning (Baehr, 2021; Kashdan et al., 2004; Schmitt & Lahroodi, 2008; von Stumm et al., 2011). In our study, curiosity was operationalized as a motivational and epistemic orientation toward the world, characterized by a broad interest in diverse topics, a persistent inclination to explore how things work, and an eagerness to investigate phenomena encountered in daily life and academic contexts (Mesurado & Vanney, 2024).

In the cross-lagged panel models, curiosity at T1 predicted subsequent increases in attentiveness and autonomy at Time 2, whereas none of the other virtues at T1 predicted subsequent changes in curiosity. Within the exploratory trends suggested by the model, curiosity appears to be a possible initiating disposition that may scaffold the later development of other intellectual virtues probabilistically. The effect sizes are modest but consistent, reflecting tendencies rather than deterministic causal effects.

4.2 Attentiveness as a Central Mediating Virtue

Following curiosity, attentiveness emerged as a central virtue within the pattern of longitudinal associations, exerting prospective influence on multiple downstream virtues (see Fig. 1). Conceptually, attentiveness reflects a sustained and detail-oriented mode of cognitive engagement characterized by prolonged focus, sensitivity to relevant information, and the active monitoring of one's cognitive processes. In this exploratory model, attentiveness may act as a central mediator, linking foundational curiosity to later-developing virtues.

Empirically, the cross-lagged analyses indicated that attentiveness predicted several downstream virtues prospectively. Specifically, attentiveness at T1 predicted increases in open-mindedness at Time 2. Open-mindedness was operationalized as an active disposition to consider new evidence, listen to diverse perspectives, maintain cognitive flexibility, and engage with others' reasoning.

These findings align with those of Kaeslin (2023), who argued that a particular form of attentive awareness, "open-minded attention", is necessary for individuals to transcend default cognitive standpoints and engage with perspectives that might otherwise remain unnoticed. Our results provide preliminary evidence consistent with this theoretical link, showing that sustained attentional engagement may facilitate processing and integrating alternative viewpoints, supporting subsequent open-minded intellectual engagement.

Attentiveness also predicted carefulness, defined as a reflective, detail-oriented disposition involving thorough task completion, error monitoring, and avoiding premature conclusions. These results suggest that attentional engagement may contribute to careful cognitive processing and methodical task execution, which is consistent with its role as a mediator in the exploratory model.

Finally, attentiveness predicted autonomy, conceptualized as the disposition to think independently and form reasoned judgments distinct from peers or authority. By supporting focused and critical evaluation, attentiveness helps individuals exercise independent thought, highlighting its role as a possible mediator in the exploratory temporal sequence of intellectual virtues.

Importantly, these associations reflect probabilistic tendencies rather than deterministic causal effects, which is consistent with the exploratory nature of a two-wave cross-lagged design. Overall, attentiveness may operate as a central mediator, bridging foundational curiosity with the later emergence of open-mindedness, carefulness, and autonomy.

4.3 Open-Mindedness as a Bridge Virtue

In the developmental sequence suggested by the longitudinal analyses, open-mindedness occupies an intermediate position, functioning both as a likely outcome of attentiveness and as a possible bridge toward autonomy. In this study, open-mindedness was operationalized as an active disposition to consider new evidence, attend to diverse perspectives, maintain cognitive flexibility, and engage seriously with others' reasoning. This operationalization emphasizes the evaluative nature of open-mindedness, helping to interpret its role within the cross-lagged associations observed.

By enabling individuals to consider diverse perspectives and revise their beliefs when appropriate, open-mindedness is associated with broader evaluative engagement and a wider range of considered reasons and alternatives. Within the exploratory model, open-mindedness appears to translate sustained attentional engagement into evaluative openness that supports the emergence of autonomy.

4.4 Autonomy and Carefulness as Outcome Virtues

Autonomy, operationalized as the disposition to think independently—including critically evaluating advice, forming judgments distinct from peers, and disagreeing with authority when warranted—is a virtue that requires reflective engagement with ideas. In the longitudinal models, autonomy at Time 2 was predicted prospectively by attentiveness and by open-mindedness, but it did not exhibit significant prospective associations with other virtues. This pattern suggests that, rather than functioning as an antecedent within the exploratory temporal ordering suggested by the cross-lagged analyses, autonomy is associated with prior attentional engagement and evaluative openness.

The observed pattern highlights contrasting theoretical perspectives regarding intellectual autonomy. Although Baehr (Baehr, 2021) suggests that autonomy can initiate intellectual engagement, recent work in critical thinking education conceptualizes autonomy as a culminating outcome, reflecting the capacity to think independently and protect oneself epistemically in complex environments (Kuntz & Taylor, 2021; McPhee & Cox, 2024). Our empirical findings are more consistent with this latter view, with autonomy being associated prospectively with attentional engagement, and openness to alternative perspectives, although this interpretation should be tempered by the relatively low internal consistency of the autonomy subscale and by the exploratory nature of the cross-lagged analysis.

Carefulness emerged as a later-developing outcome within the observed developmental sequence. It was operationalized as a reflective and detail-oriented disposition involving thorough task completion, monitoring for errors, and avoidance of premature conclusions. In the longitudinal models, carefulness at Time 2 was predicted prospectively by attentiveness at T1, but it did not predict subsequent changes in other virtues. This pattern suggests that carefulness may reflect the consolidation of prior attentional engagement into more precise and disciplined cognitive performance, which is consistent with its operationalization and position in the exploratory temporal ordering.

4.5 Integration and Applied Implications

This study's findings point to a dynamically organized system of intellectual virtues in which motivational, cognitive, and evaluative dispositions are interconnected temporally. Within the limits of a two-wave longitudinal design, the results suggest preliminary and exploratory temporal trends in which curiosity and attentiveness play foundational and mediating roles, respectively, whereas open-mindedness, autonomy, and carefulness may emerge later as downstream dispositions. Rather than operating as isolated traits, intellectual virtues appear to function as interrelated components of

an integrated intellectual character system, combining relative stability with exploratory patterns of temporal association.

Together, these patterns provide preliminary evidence consistent with a probabilistic temporal ordering among intellectual virtues (see Fig. 1), with curiosity and attentiveness functioning as potentially foundational and mediating virtues, respectively, and with carefulness, open-mindedness, and autonomy occupying more intermediate or outcome positions. As such, these patterns should be interpreted as exploratory trends within a two-wave longitudinal design.

Although the effect sizes were generally modest and should be interpreted cautiously given the design limitations, the pattern of predictive paths highlights curiosity and attentiveness as traits of potential central importance, which is consistent with H2.

From an applied perspective, these findings have direct implications for ongoing efforts to foster intellectual character in educational contexts. A growing number of character education initiatives in higher education and related settings aim to promote reflective thinking, epistemic responsibility, and autonomous judgment (López González et al., 2023; Matthews & Lerner, 2024; Orona et al., 2023; Vanney et al., 2025). Our results suggest that if these exploratory temporal patterns are considered, such programs may benefit from initially focusing on potential foundational dispositions, particularly curiosity and attentiveness.

Framing intellectual character development as a gradual and interconnected process highlights the potential value of sequencing or layering educational interventions. In line with these exploratory trends, programs that initially cultivate curiosity and attentional engagement may create favorable conditions for later efforts targeting higher-order reflective dispositions. Recognizing these preliminary temporal associations can help align character education practices with the potential sequential dynamics suggested by the cross-lagged analyses.

More broadly, the present findings raise interesting questions regarding potentially foundational motivational dispositions underlying intellectual virtues. Although curiosity emerged as the most probable initiating virtue within the observed temporal patterns, related constructs such as Need for Cognition (NFC)—defined as the tendency to engage in and enjoy effortful thinking—may also represent important epistemic motivational resources linked to intellectual character development. Previous research has shown consistent associations between NFC and academic achievement (Liu & Nesbit, 2023), suggesting that future studies could examine how motivational dispositions such as curiosity, NFC, and independent thinking jointly contribute to the development and temporal organization of intellectual virtues in higher education contexts.

4.6 Limitations and Future Directions

Several methodological and interpretive limitations of this study should be noted.

First, the two-wave longitudinal design allows for an examination of temporal precedence among intellectual virtues but limits the modeling of more complex developmental trajectories, nonlinear changes, or fully reciprocal relationships. Consequently, the observed cross-lagged associations should be considered exploratory

rather than causal (Hamaker et al., 2015). Future studies with at least three measurement waves are needed to capture developmental patterns better, test reciprocal effects, and validate the temporal ordering of intellectual virtues more robustly.

Second, the autonomy subscale showed low internal consistency, likely due to its limited number of items and broad conceptual scope. Therefore, the results involving autonomy should be interpreted cautiously. Low internal consistency may also reflect the conceptual breadth and multidimensionality of intellectual autonomy, which encompasses several partially distinguishable aspects of independent thinking, including reflective evaluation of information, resistance to undue epistemic dependence, critical judgment, and willingness to disagree with peers or authority when warranted. Capturing these related but heterogeneous facets with a brief three-item subscale may have reduced internal consistency.

Third, our sample consisted solely of Argentine university students, which may limit generalizability. The observed probabilistic temporal ordering could reflect characteristics specific to this cultural and educational context. Replication among diverse populations, educational levels, and cultural settings is needed to evaluate broader applicability.

Fourth, some of the cross-lagged effects were modest, reflecting probabilistic tendencies rather than large or deterministic changes. Researchers and practitioners should consider the nuanced, incremental nature of these developmental associations when interpreting the findings or designing interventions.

Fifth, although the age range of the sample extended into later adulthood, the distribution was highly concentrated around late adolescence and emerging adulthood. Therefore, the present findings should primarily be interpreted as reflecting the temporal organization of intellectual virtues among young university students. Future research with more age-diverse samples could examine whether these temporal patterns vary across developmental stages of adulthood.

Overall, despite these limitations, the present study provides preliminary but valuable exploratory evidence for understanding the temporal organization and interrelations among intellectual virtues. Future research addressing these limitations will help clarify the exploratory dynamics of curiosity, attentiveness, carefulness, open-mindedness, and autonomy and strengthen the evidence for the temporal organization of intellectual character. More broadly, the present findings may contribute to ongoing efforts to better understand the structure and development of positive character traits within positive psychology. Research on character strengths has traditionally focused on identifying and classifying desirable traits, yet comparatively less attention has been devoted to examining how such dispositions are temporally organized and how they dynamically relate to one another over time. By exploring the longitudinal organization of intellectual virtues in a sample of university students, the present study offers preliminary evidence that these epistemic traits may display meaningful patterns of temporal continuity and interrelation during emerging adulthood. In this sense, the findings may help extend current scholarship on positive traits, character strengths, and virtues by highlighting the potential value of longitudinal approaches for investigating the developmental dynamics of intellectual character.

5 Conclusion

This study provides preliminary evidence of exploratory temporal associations among five intellectual virtues among university students. Using a two-wave longitudinal design, the findings support their relative stability and interconnection, with curiosity emerging as a foundational trait; attentiveness, as a potential mediator; and open-mindedness, autonomy, and carefulness, as downstream dispositions.

These results contribute to the literature on intellectual character by offering longitudinal evidence of structured probabilistic temporal ordering. Rather than implying strong causal relations, the results highlight probabilistic tendencies suggesting how motivational, cognitive, and evaluative dispositions may codevelop within an integrated intellectual character system.

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Data Availability The databases are available at OSF: https://osf.io/9vn8a/overview?view_only=b7ce981a3d734239bd240cbcd4ee0972.

Declarations

Ethics Approval and Consent to Participate This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Austral University (CIE N° P24-003). Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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