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Analysis of the necessary conditions of mood states for the development of learning strategies in university students

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Keywords

Needs analysis
Adequacy analysis
Motivation
Learning strategies

Abstract

Moods, unlike emotions, are more enduring, diffuse, and lack a specific stimulus, modulating the degree of application of cognitive learning strategies. This research aims to analyse the interaction between mood states and learning strategies from the necessary conditions analytic perspective, differentiating this approach from traditional probabilistic models. A total of 270 university students enrolled in the Primary Education Degree programs at the University of Jaén (Andalusia, Spain) participated in the study. Accessibility and convenience sampling was carried out. The *Mood Rating Scale* and the *Cognitive Strategies for Learning and Study Questionnaire* were used. The results showed that the dimensions of learning strategies interact variably with specific mood states, such as joy, hostility, anxiety, and depression. From the logic of necessity, certain strategies are essential to achieve moderate levels of mood states such as joy, while other strategies, such as depressive mood, reveal the inherent complexity of the concept. In parallel, the sufficiency-based approach highlights how positive states facilitate the selection of the process, while the depressive state limits its effectiveness, reaffirming the differential value. We conclude by highlighting the importance of the necessary conditions analytic in identifying those mood states whose influence determines the development of learning strategies.

Análisis de las condiciones necesarias de los estados de ánimo para el desarrollo de estrategias de aprendizaje en estudiantes universitarios

Palabras clave

Análisis de necesidad
Análisis de suficiencia
Ánimo
Estrategias de aprendizaje

Resumen

Los estados de ánimo, a diferencia de las emociones, son más duraderos, difusos y carecen de un estímulo específico, modulando el grado de aplicación de estrategias cognitivas de aprendizaje. Esta investigación tiene como objetivo analizar la interacción entre estados de ánimo y estrategias de aprendizaje desde la perspectiva analítica de las condiciones necesarias, diferenciando este enfoque de los modelos probabilísticos tradicionales. Participaron 270 estudiantes universitarios del Grado de Educación Primaria de la Universidad de Jaén (Andalucía, España). Se realizó un muestreo de accesibilidad y conveniencia. Se utilizaron la *Escala de Valoración del Estado de Ánimo* y el *Cuestionario de Estrategias Cognitivas para el Aprendizaje y el Estudio*. Los resultados mostraron que las dimensiones de las estrategias de aprendizaje interactúan de manera variable con los estados de ánimo específicos, como alegría, hostilidad, ansiedad y depresión. Desde la lógica de la necesidad, ciertas estrategias resultan esenciales para alcanzar niveles moderados de estados de ánimo como alegría, mientras que otras estrategias, como el caso del estado de ánimo depresivo, revelan complejidad inherente al concepto. Paralelamente, el enfoque basado en suficiencia destaca cómo estados positivos facilitan la selección del proceso, mientras que el estado depresivo limita su efectividad, reafirmando el valor diferencial. Se concluye destacando la importancia del análisis de las condiciones necesarias en la identificación de aquellos estados de ánimo cuya injerencia determina el desarrollo de las estrategias de aprendizaje.

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The underlying complexity of learning processes, linked to academic performance, motivation, self-regulation in learning, as well as student mood states, among other interpersonal and intrapersonal factors, has aroused scientific interest for decades. However, the disparity of criteria when establishing adequate theories that configure a connection between how mood states influence the sequential process (phases that must occur in a pre-established order) of learning strategies (selection, organisation, elaboration, and memorisation) has blurred the balance among the importance of the learning process to which the subject is exposed and the adaptive capacity, tempered by their mood (Schuch et al., 2017). Specifically, mood, as the most stable and diffuse component of affect, plays a modulating role in how students organise, process, and consolidate information during their learning process (Obergriesser & Stoeger, 2020; Palmer, 2017). This temporal stability acts as a regulatory framework for cognitive processing, which runs through all phases of the learning sequence. While emotion may momentarily alter attention or memory, a sustained mood has a cumulative and global effect, more consistently affecting academic performance and the use of learning strategies. Despite its relevance, empirical research has tended to focus on the construct of emotion, leaving the impact of moods on the structural sequence of learning, which includes the phases of selection, organisation, elaboration and memorisation, in the background (Schweder & Raufelder, 2019). This sequence, far from being equitable, responds to a processual model that requires both cognitive and affective preconditions for its optimal development (Ausubel et al., 1986; Miller, 1956). Each phase involves mental operations that can be facilitated or inhibited by the student's mood. For example, happiness has been associated with greater creativity, cognitive flexibility and integrative processing (Isen et al., 1987), which favours both the selection and elaboration phases of content. Conversely, states of anxiety, stress, or hostility tend to restrict attention, reduce motivation, and hinder working memory (Grzankowski & Textor, 2022), particularly compromising the organisation and retention phases of information.

Although the scientific literature has identified these effects in university contexts, most studies have not clearly differentiated between the concepts of emotion and mood, using them arbitrarily (Hufendiek, 2018; Meyers & Tamir, 2024). This disparity in criteria has limited the development of a solid explanatory framework that would allow for the establishment of specific conditions necessary for a particular mood to facilitate, or conversely limit, the proper development of learning strategies. From this perspective, traditional quantitative methods have shown limitations in accurately capturing the diffuse and prolonged nature of mood, compared to emotion (Brady, 2018; Zambrano-Vélez et al., 2023).

From a constructivist approach, learning is configured as an active and intentional process that requires autonomy, self-regulation, and decision-making on the part of the student (Bahamón-Muñetón et al., 2013). These decisions do not occur in an emotional vacuum; that is, mood could act as a filter that affects not only the interpretation of the task but also the choice of cognitive and metacognitive strategies (Guterman & Neuman, 2021; Ratcliffe, 2016). In this sense, needs analysis, unlike a purely correlational or predictive approach, could make it possible to identify whether the presence of certain moods acts as an essential condition for the effective development of each sequential phase of learning (Dul et al., 2020).

Thus, this research aims to analyse the relationship between learning strategies as a sequential process and moods, depending on the space-time moment in which the situation occurs (Gallegos, 2023). This approach could contribute to clarifying the affective-cognitive mechanisms involved in autonomous learning for the design of educational environments that consider the affective climate as a structural variable.

Learning strategies: definition and procedural sequence

Learning strategies have been defined as a structured, conscious, and intentional set of mental, cognitive, and metacognitive operations that enable students to organise information, monitor their progress, and adjust their behaviour towards a learning goal (Guterman & Neuman, 2021; Schweder & Raufelder, 2019). These strategies are usually developed sequentially across four phases (selection, organisation, elaboration and memorisation), involving differentiated processes at the cognitive level (Ausubel et al., 1986; Miller, 1956). It should be noted that, while there has been some consensus in the study of these strategies, less attention has been paid to the role that moods (basic affective components) play as facilitators or limiters of the proper development of these phases (Obergriesser & Stoeger, 2020). This shortcoming is tempered by the frequent conceptual confusion between emotion and mood, two affective phenomena that differ in duration, intensity, and causal nature (Gross, 2014; Lazarus, 1991).

Conceptual distinction between emotion and mood state

Emotions are usually brief, intense, and linked to specific stimuli. Mood states, on the other hand, are more diffuse, prolonged, and not necessarily triggered by specific events (Brady, 2018; Hufendiek, 2018). Similarly, while emotions tend to manifest themselves more visibly and can trigger immediate responses, mood states are temporary and subjective phenomena that can subjugate a person's consciousness and are composed of affective, cognitive, physiological, and motivational components (Palmer, 2017). They tend to be less intense but can persist for prolonged periods, influencing in complex and uneven ways the ability to make decisions, take action, solve problems, and sequence the learning process in an orderly manner (Obergriesser & Stoeger, 2020; Palmer, 2017; Sekhon & Gupta, 2023). This distinction is crucial when approaching learning from an affective-cognitive perspective, as different mood states can act as *sine qua non* conditions for activating or blocking certain strategies. From this perspective, a cheerful mood state could temper the repertoire of thoughts, favour semantic connections and enhance cognitive flexibility, particularly facilitating the elaboration and organisation phases (Gallegos, 2023; Isen, 1987). Conversely, states such as stress, anxiety, or hostility

could interfere with selective attention, reduce working memory retrieval capacity, and generate blockages in the information selection or retention phase (Grzankowski & Textor, 2022; Park, 2002). The proposed approach responds to the logic that mood states, being diffuse and prolonged phenomena, can also be understood as the result of the learning process. In university contexts, where students are required to have a high degree of autonomy and self-regulation, these fluctuations in mood states could have significant effects on the ability to select information appropriately, organise mental schemas, make prior connections and memorise in the long term (Bahamón-Muñetón et al., 2013; Ratcliffe, 2016). Therefore, the distinction between mood states and emotion would be fundamental to understanding how, when, and why the affective component impacts the sequential development of learning strategies. However, research such as that by Zambrano-Vélez et al. (2023) has pointed out that emotion and mood are often still treated as synonyms, which would limit the theoretical and methodological accuracy of studies.

Another relevant aspect would be determined by traditional methods of analysis, which present difficulties in capturing the prolonged and subtle nature of moods (Meyers and Tamir, 2024). This limitation contributes to most scientific evidence on affect and learning being based on the assessment of immediate emotions rather than stable moods that can act as bottlenecks in the sequential development of learning (Dul et al., 2020).

Necessary Condition Analysis (NCA)

From an affective-cognitive approach, learning cannot be understood exclusively from a linear (cause-effect) or statistical correlation perspective. Various studies have pointed out that complex processes require valid methodological tools that allow us to identify not only predictive variables but also dimensions that are essential for others to be activated or fully developed (Dul et al., 2020; Richter & Hauff, 2022). From this perspective, the present research adopts the NCA as a complementary methodological tool, allowing us to establish whether certain moods (X) are indispensable for a learning strategy (Y) to be deployed properly.

Therefore, the number of related studies on mood, emotion and/or their impact on learning strategies was previously considered in the PubMed, Web of Science (WoS), ScienceDirect and LILACS databases, including studies published in the last five years. This search process was carried out by the authors for this research. A total of 848 studies were found that established the relationship between emotion and learning strategies. Only eight studies addressed this relationship with mood states. In many cases, they treated mood and emotion in the same way (Frausto Martín del Campo et al., 2021), which could hinder the theoretical understanding of these two constructs (Hufendiek, 2018; Meyers & Tamir, 2024). Secondly, we analysed whether most research in higher education followed a traditional quantitative logic, focused on predictive or sufficient relationships, which, although useful, could provide biased information about the complexity of sequential learning processes. From this approach, the use of the NCA methodology was considered, as it allows us to establish whether certain conditions (learning sequences) could be present for a certain state of mind to occur, which would not imply their sufficiency, but rather their necessity (Dul et al., 2020). These learning sequences would form the cognitive scaffolding on which autonomous learning in higher education is built. Effective questioning in each of these phases could be a necessary condition for maintaining or promoting certain states of mind during the learning process (Ausubel et al., 1986; Zimmerman, 2013). Therefore, moods would not be considered as a cause of learning, but rather as a result variable, that is, as an affective response modulated by the quality of the learning process carried out. This aspect has been considered in previous studies, which would corroborate that when students organise information well and consolidate knowledge, they tend to experience positive and stable moods (Gallegos, 2023; Zimmerman, 2013). In other words, the correct selection and organisation of information could reduce cognitive load, thereby reducing the likelihood of experiencing anxiety or stress (Kong, 2021). Similarly, the memorisation phase, by promoting the consolidation of knowledge, could generate greater self-concept, favouring states such as joy.

This study adds to existing methodological reasoning (Sekhon & Gupta, 2023) and aims to identify which phases of the sequential process of learning strategies are a necessary condition for promoting a specific state of mind in university students. Mood states, as prolonged affective phenomena, could be both conditioners of learning and consequences of it (Gallegos, 2023; Zimmerman, 2013). Therefore, the following question was considered: Which phases of the sequential process of learning strategies are necessary conditions for promoting a particular mood state?

This study hypothesises that all phases of the learning process (selection, organisation, elaboration and memorisation) must be present as a necessary condition for influencing a specific state of mind. The absence of a specific phase in the learning sequence could act as a filter, preventing a specific state of mind from being achieved, even if the other phases were present. No single phase would be sufficient on its own (Dul et al., 2020; Richter & Hauff, 2022; Tynan et al., 2020).

Method

Participants

The participants (n = 270) were undergraduate students of the Primary Education Degree at the University of Jaén (Andalusia, Spain). Random and accessibility sampling was used. A total of 192 women (71.1%) and 78 men (28.9%) participated. The age range was between 18 and 32 years, with a mean age of 19.64 years (SD = 2.29). The statistical power (Cohen, 1988) was 95.4%, with a significance level of 5%.

Instruments

The Mood Assessment Scale (EVEA), developed by Sanz (2001), is a 16-item self-report questionnaire designed to assess

the intensity of mood states (anxiety, hostility, depression, and joy). It uses an 11-point Likert scale (from 0 = *Not very intense* to 10 = *Very intense*). Each state consists of four items and has excellent psychometric properties: Cronbach's α between .88 and .93. In the present study, the factorial structure was evaluated using Confirmatory Factor Analysis (CFA), employing the maximum likelihood estimation method (Hair et al., 2022), with CFI = .90; TLI = .88; SRMR = .06; RMSEA = .07. Although the TLI is slightly below the recommended value, it remains close to the acceptable threshold, suggesting a reasonable fit of the model. The reliability of this questionnaire was established at Cronbach's α = .83 and McDonald's ω = .88. The goodness-of-fit test χ^2/df = 2.79.

The Cognitive Strategies for Learning and Studying Questionnaire (CECAE), developed by Valle et al. (2006), aims to assess cognitive learning strategies. The questionnaire consists of 22 items and 4 dimensions that measure frequency: selection strategies (8 items), organisation (6 items), elaboration (4 items) and memorisation of information (4 items). It uses a 5-point Likert scale (from 0 = *Never* to 4 = *Always*). The reliability indices, Cronbach's α, for these factors range from .68 to .83. The factorial structure was evaluated using Confirmatory Factor Analysis (CFA), using the maximum likelihood estimation method, presenting an adequate fit (Hair et al., 2022), with CFI = .93; TLI = .90; SRMR = .07; RMSEA = .07. The reliability of this questionnaire was Cronbach's α = .86 and McDonald's ω = .86. The goodness-of-fit test χ^2/df = 1.76.

Procedure

The research was conducted in strict compliance with national and international ethical guidelines in June 2024. All data was managed in accordance with current regulations, following the provisions of European Union Regulation 2016/679 of 27 April 2016 on the protection of personal data, as well as Organic Law 3/2018 of 5 December, which covers digital rights. Participants were assured that the data collected would be treated anonymously and confidentially, and that all information collected would be used solely for scientific purposes. The research instrument was set up individually using the Google FormsÒ platform. Those responsible explained the purpose of the study and the guidelines for its proper conduct to the students. Relevant data was collected in accordance with ethical principles for the purpose of the research.

Data analysis

Previously, the means and standard deviations were calculated using the Hot-Deck method of multiple entries, taking into account any error bias. A preliminary analysis was performed to assess the validity, reliability, and internal consistency of each instrument using Confirmatory Factor Analysis (CFA) to determine the factor loadings for each item. To verify the normality of the data, a multivariate hypothesis test was performed, which revealed that the distribution was not normal. For the coefficients considered in the study, the χ^2/df ratio (less than 3), the root mean square error of approximation RMSEA (≤ .08 acceptable), and the comparative fit index CFI (≥ .90 acceptable) were used. To assess convergent validity, the average variance extracted AVE (≥ .50) was calculated, following the recommendations of Hair et al. (2022).

This research was based on determining the specific impact of moods on cognitive learning strategies, using regression analysis: tolerance values < .2; Variance Inflation Factor (*VIF*) > 4 and ACN, where four criteria were established as described in Table 1.

Predictive analysis was developed to understand how independent variables affect the dependent variable by making predictions, identifying patterns, and estimating the magnitude of the effects. However, regression does not claim that a specific variable is absolutely necessary for the outcome to occur, only that it has an average influence on it, as established by the analysis of necessary conditions. Therefore, the CR-FDH (Ceiling Regression-Free Disposal Hull) and CE-FDH (Ceiling Envelopment-Free Disposal Hull) procedures were considered, according to the criteria of Sharma et al. (2022) and the bottleneck table, with the purpose of identifying the critical conditions necessary to achieve a given result (Bokrantz & Dul, 2023). The CE-FDH line, structured in a series of steps, is especially recommended for discrete data or observation patterns that behave non-linearly in proximity to the ceiling line. Similarly, the CR-FDH line is a trend curve through the CE-FDH, and its use is more appropriate in cases of continuous data or when observation patterns close to the ceiling line follow an approxi-

Table 1

Research criteria

Criteria	Description
Necessity vs. sufficiency	NCA points out that certain phases of learning (selection, organisation, elaboration and memorisation) could be necessary conditions, but not sufficient ones, for achieving certain states of mind.
Application	The strategic phases that must be present as minimum requirements in the relationship between moods and learning would be considered, complementing predictive methods.
Comparison with traditional methodologies	Unlike regression, which would explain average and additive causal relationships, NCA reveals bottlenecks, i.e., without a specific phase, the desired state of mind cannot be achieved, even if the others are present.
Practical implication	It allows you to identify the critical learning stages that must be completed in order to promote positive states and prevent negative ones, guiding decision-making.

mately linear distribution. These ceiling lines can help establish the level of condition X necessary to achieve a specific level of outcome Y. The size effect in NCA is quantified from the empty space formed above these ceiling lines (Dul et al., 2020).

Results

To analyse the reliability of the model (see Table 2), composite reliability, the rho_A coefficient and the Average Variance Extracted (AVE) were calculated beforehand.

The summary of the model for the variable joy (see Table 3) indicated that only the dimension of learning strategy selection was included, with the rest of the dimensions excluded, explaining 7.6% of the variance (R = .27; corrected R^2 = .05; F = 2.55 p < .05), with a statistically significant t-value. Similarly, the summary of the model for the depression variable indicated that only the selection dimension was included, explaining 7% of the variance (R = .26; corrected R^2 = .04; F = -2.820 p < .01), with a statistically significant and negative t-value. The hostility and anxiety dimensions were not included in the regression model as they did not have a significant effect on the criterion variable.

To specify each of the results of the dimensions of learning strategies: elaboration, memorisation, organisation, and selection, using the NCA methodology, significant ($d \geq .1$; $p < .05$) for each of the mood states (see Table 4), the following parameters were established: For the joy dimension, the conditions that

Table 2

Resulting validity and reliability of data

	α	Compound reliability (rho A)	Compound reliability	Average Variance Extracted (AVE)
Anxiety	0.81	1.15	0.87	0.7
Elaboration	0.7	0.73	0.82	0.53
Memorisation	0.65	0.66	0.76	0.52
Organisation	0.76	0.76	0.83	0.5
Selection	0.77	0.77	0.83	0.42
Elaboration	0.7	0.72	0.82	0.53
Joy	0.86	0.9	0.9	0.71
Memorisation	0.65	0.66	0.76	0.52
Organisation	0.75	0.76	0.83	0.5
Selection	0.76	0.77	0.83	0.42
Elaboration	0.71	0.72	0.82	0.53
Memorisation	0.65	0.66	0.76	0.52
Organisation	0.75	0.76	0.83	0.5
Selection	0.76	0.77	0.83	0.42
Depression	0.87	0.93	0.91	0.72
Elaboration	0.71	0.71	0.82	0.53
Hostility	0.91	0.92	0.94	0.79
Memorisation	0.65	0.66	0.76	0.52
Organisation	0.76	0.76	0.83	0.5
Selection	0.76	0.77	0.83	0.42

Table 3

Linear regression analysis for the criterion variable mood states and the dimensions of learning strategies

Criterion variable	R	R^2	R^2 Corrected	F	Predictor variables	*Beta*	*t*
Joy	.27	.08	.05	2.67			
					Selection	.34	2.55*
Depression	.26	.07	.04	2.46			
					Selection	-.37	-2.82**
Hostility	.20	.04	.01	1.36			
Anxiety	.12	.02	.02	0.48			

**p < .01; *= p < .05.

showed the greatest effect were: elaboration (d = .12; p < .01) and memorisation (d = .11; p < .01). For the depression dimension, the necessary condition that showed the greatest effect was memorisation (d = .17; p < .01). For the hostility dimension, the necessary condition that showed the greatest effect was memorisation (d = .11; p < .01). Finally, for the anxiety dimension, the conditions that showed the greatest effect were memorisation (d = .25; p < .01) and organisation (d = .11; p < .05), indicating a medium effect size (.1 ≤ d ≤ .3), according to the criteria of Dul et al. (2020).

Below the scatter plot is presented, where empty spaces are displayed in the upper left corner and the relationship between learning strategies and mood states is established.

With regard to the joy dimension (Figure 1), we started from a level of 90% of the observed range, which is a fairly high reference value. The results were: 20.74 for elaboration; 2.96 for memorisation; 17.78 for organisation; and 5.93 for selection, on a scale of 0 to 100. In other words, to achieve a level of joy of 90%, we would need an observed range level of 20.74% for elaboration, which is our highest value.

In relation to the hostility dimension (Figure 2), with a level of 90%, the results were: 3.70 for elaboration; 2.96 for memorisation; 0.74 for organisation; and 0.74 for selection, on a scale of 0 to 100.

In relation to the depression dimension (Figure 3), with a level of 90%, the results were: 3.70 for elaboration; 31.11 for memorisation; and 31.11 for selection, on a scale of 0 to 100. The organisation dimension would not be a necessary condition for depression at any of the levels (scale of 0 to 100).

Finally, with regard to the anxiety dimension (Figure 4), with a level of 90%, the results were: 24.44 for elaboration; 36.30 for memorisation; 73.33 for organisation; and 45.93 for selection, on a scale of 0 to 100.

As indicated by the effect size values, the results obtained suggest that the necessary conditions with the greatest effect, in order, are: joy (selection), depression (elaboration) and anxiety (selection) at a level of 50%, to explain the result. However, for all mood states to be reflected in the necessity analysis in each of the dimensions of learning strategies, a level of 90% will be necessary. This pattern establishes that, for higher degrees of mood states, the necessary condition must be in line with each of the elements in the development of learning strategies (see Table 5).

Discussion

The purpose of this research was to understand and analyse the relationship between moods and the sequential process of learning strategies, confirming that certain strategic phases may constitute necessary conditions for the expression of certain states such as joy, anxiety, depression or hostility. To analyse this relationship, it was necessary to first establish the difference between emotions and moods, understanding that emotions tend to be less lasting and are linked to a specific stimulus. Moods, on the other hand, lack an immediate

Table 4

NCA effect size

Joy	CE-FDH	CR-FDH	*p*
Elaboration	.12	.09	.007
Memorisation	.11	.10	.002
Organisation	.16	.14	.499
Selection	.19	.23	.291
Depression	CE-FDH	CR-FDH	*p*
Elaboration	.16	.12	.057
Memorisation	.17	.14	.001
Organisation	0	0	.216
Selection	.14	.13	.337
Hostility	CE-FDH	CR-FDH	*p*
Elaboration	.05	.02	.088
Memorisation	.11	.04	.002
Organisation	0	0	.182
Selection	.06	.05	.303
Anxiety	CE-FDH	CR-FDH	*p*
Elaboration	.13	.12	.14
Memorisation	.25	.23	.001
Organisation	.14	.12	.011
Selection	.11	.13	.338

Figure 1

NCA top line chart: Joy

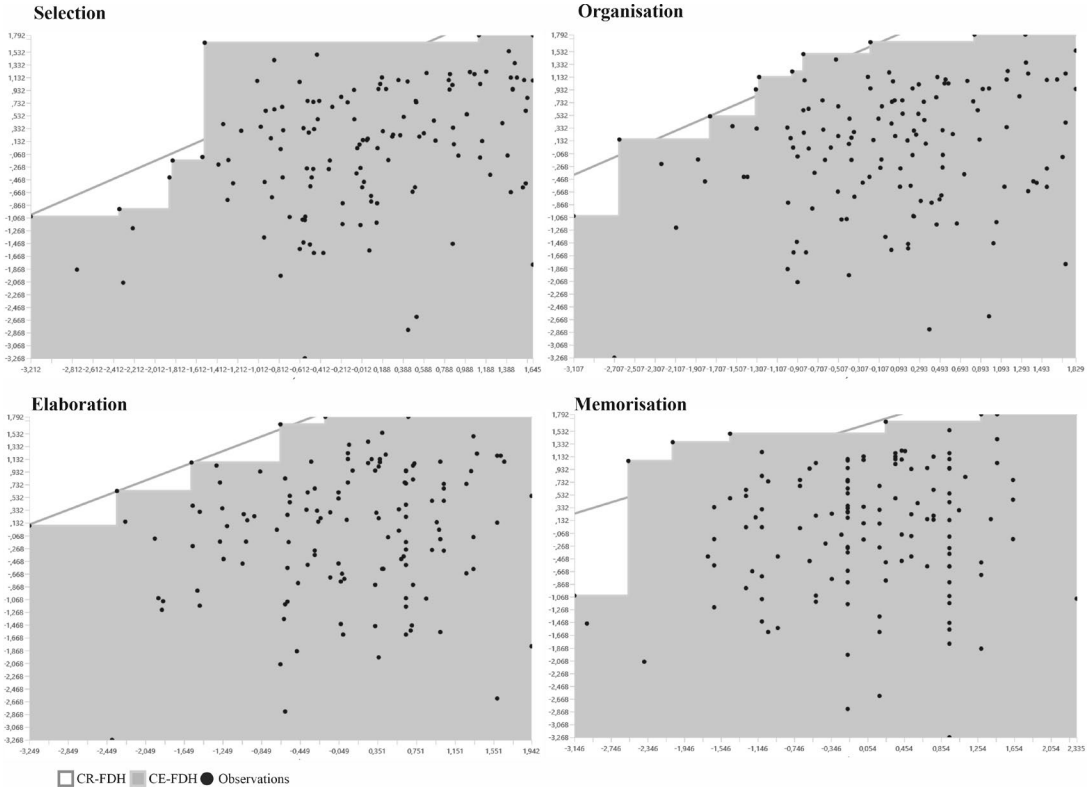

Figure 2

NCA top line chart: Hostility

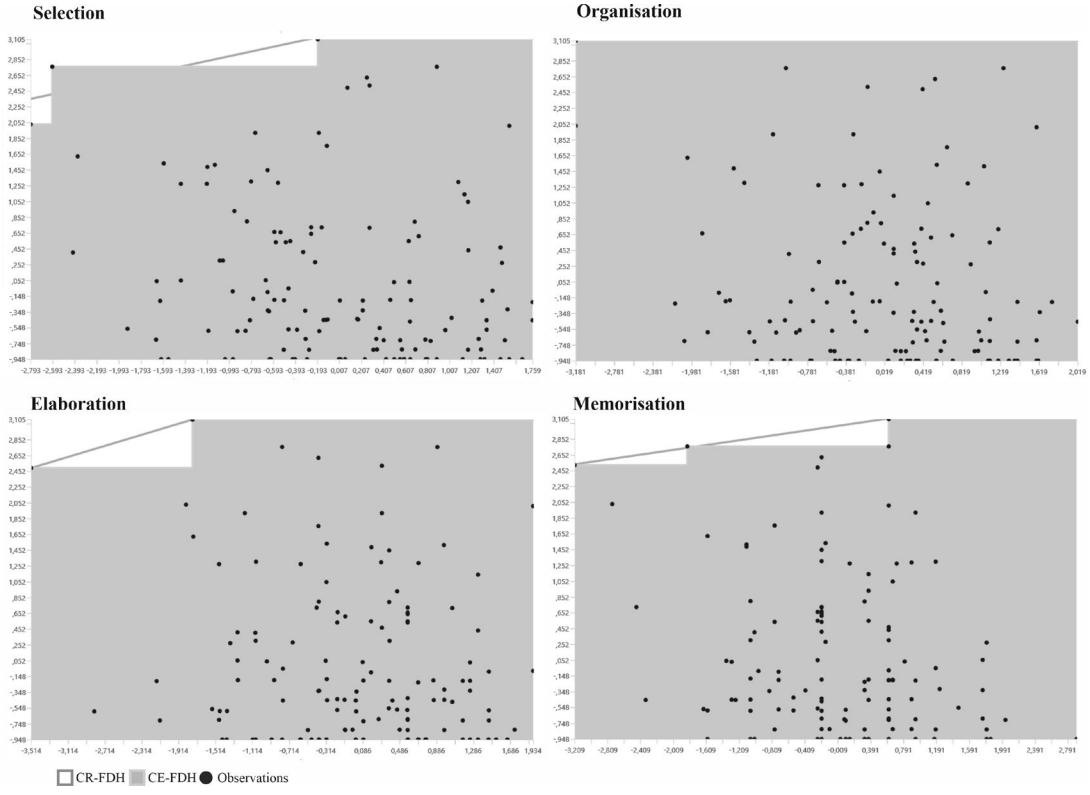

Figure 3

NCA Top Line Chart: Depression

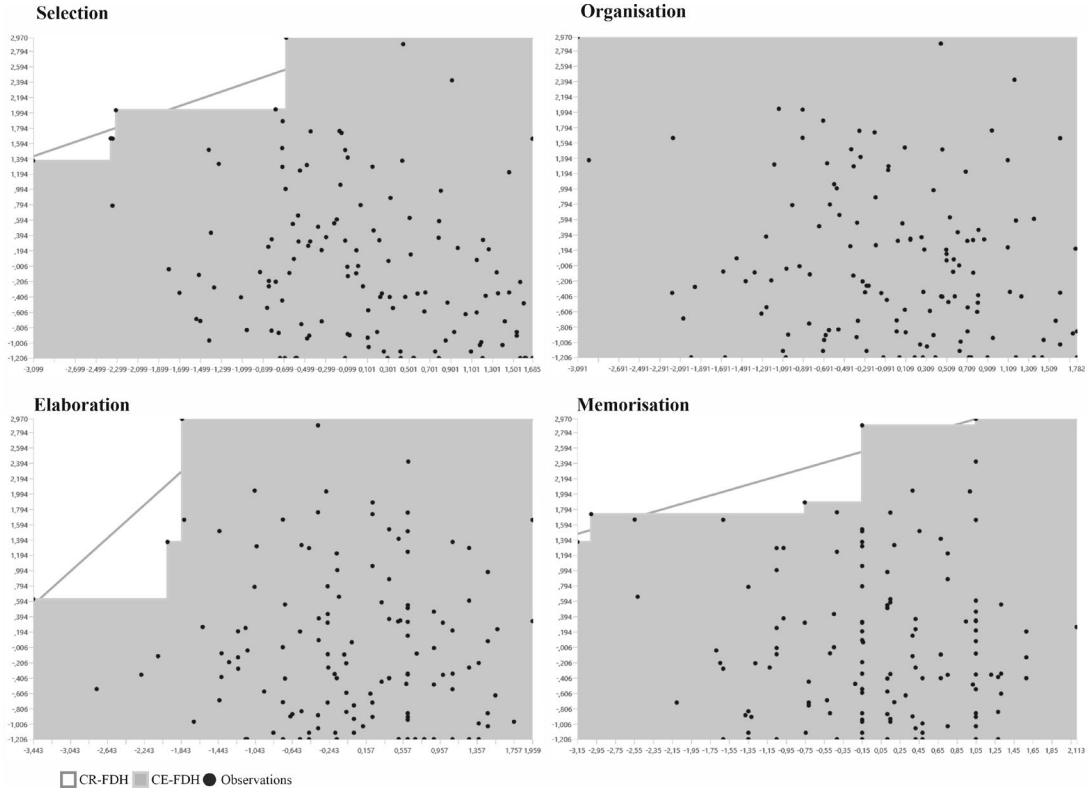

Figure 4

NCA top line graph: Anxiety

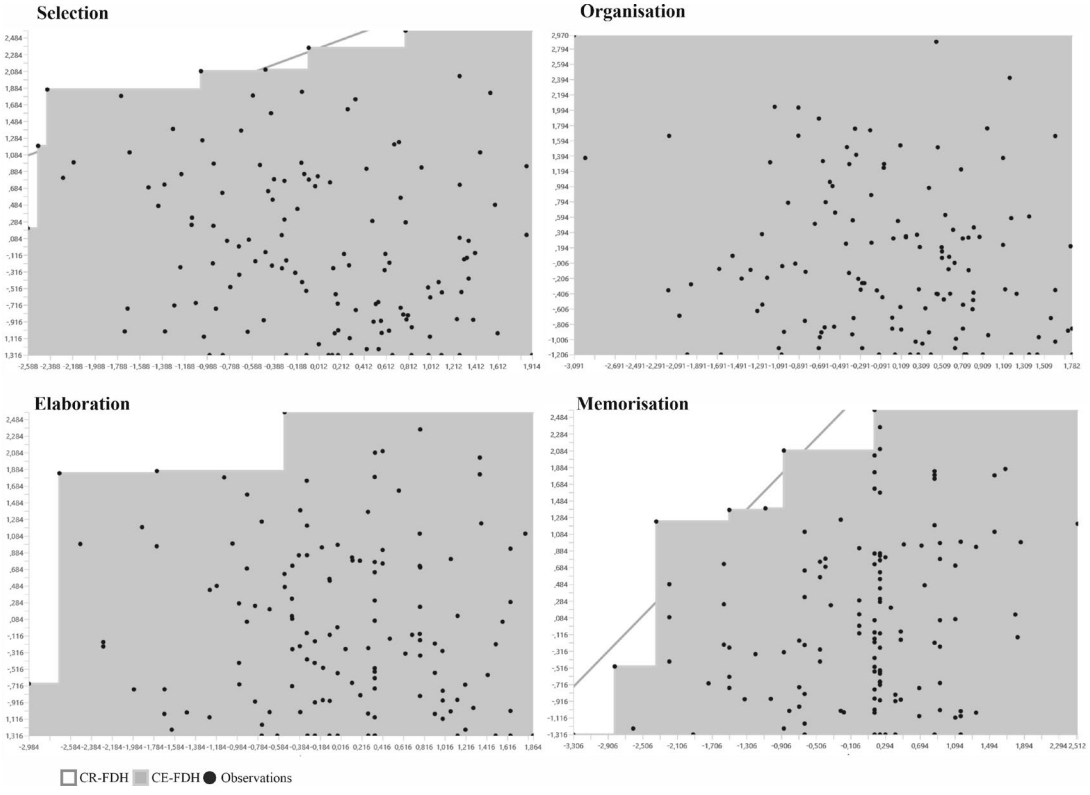

Table 5

Bottleneck table of mood states based on learning strategies

Joy	Elaboration	Memorisation	Organisation	Selection
0%	NN	NN	NN	NN
10%	NN	NN	NN	NN
20%	NN	NN	NN	NN
30%	NN	NN	NN	NN
40%	NN	NN	NN	NN
50%	NN	1.48	1.48	3.7
60%	NN	1.48	1.48	4.44
70%	1.48	1.48	5.18	5.93
80%	5.93	1.48	8.15	5.93
90%	20.74	2.96	17.78	5.93
100%	38.52	91.11	78.52	82.96
Hostility	Elaboration	Memorisation	Organisation	Selection
0%	NN	NN	NN	NN
10%	NN	NN	NN	NN
20%	NN	NN	NN	NN
30%	NN	NN	NN	NN
40%	NN	NN	NN	NN
50%	NN	NN	NN	NN
60%	NN	NN	NN	NN
70%	NN	NN	NN	NN
80%	NN	NN	0.74	0.74
90%	3.70	2.96	0.74	0.74
100%	3.70	64.44	0.74	43.7
Depression	Elaboration	Memorisation	Organisation	Selection
0%	NN	NN	NN	NN
10%	NN	NN	NN	NN
20%	NN	NN	NN	NN
30%	NN	NN	NN	NN
40%	NN	NN	NN	NN
50%	2.96	NN	NN	NN
60%	2.96	NN	NN	NN
70%	3.7	0.74	NN	2.96
80%	3.7	31.11	NN	25.18
90%	3.7	31.11	NN	25.18
100%	3.7	77.04	NN	25.18
Anxiety	Elaboration	Memorisation	Organisation	Selection
0%	NN	NN	NN	NN
10%	NN	0.74	NN	NN
20%	0.74	0.74	NN	NN
30%	0.74	2.22	NN	NN
40%	0.74	2.22	NN	0.74
50%	0.74	2.22	NN	0.74
60%	0.74	2.22	NN	0.74
70%	0.74	14.81	NN	1.48
80%	0.74	14.81	12.59	1.48
90%	24.44	36.3	73.33	45.93
100%	24.44	36.3	73.33	75.56

Note. NN = Condition not required.

object, are more lasting over time and manifest themselves as diffuse experiences (Gross, 2014; Kong & Yuen, 2022). This distinction proved key to understanding the nature of moods, as they could act as a persistent psychological backdrop, exerting a more prolonged influence on the sequential process of learning (Gallegos, 2023), reinforcing the bidirectional nature of the relationship between mood and learning. From this perspective, moods could affect the effectiveness of cognitive processes, and similarly, academic success or failure could condition the moods experienced (Brady, 2018). This interaction would not be homogeneous for all students or for all situations and could be mediated by psychosocial factors (Zambrano-Vélez et al., 2023). In other words, mood states could act as an influential background conditioner throughout the learning process, impacting both the prior affective experience and the subsequent response (Schweder & Raufelder, 2019). Thus, a positive mood such as joy would enhance the adoption and execution of learning strategies, while negative moods such as anxiety or depression would be less prevalent in the development of these strategies (Sekhon & Gupta, 2023), corroborating the results of this research, where mood would articulate the type and effectiveness of the learning strategies selected. A possible underlying explanation for this phenomenon could be due to the differential processing of information depending on mood states (Schuch et al., 2017), as students devote more resources to managing the affective-cognitive load than to deploying effective learning procedures (Becker et al., 2017).

Understanding the subsidiary complexity to clarify and understand the relationship between mood states and the sequential process of learning strategies, this research developed a regression model, allowing us to identify whether a set of predictors would explain the variability of a result on average. From this perspective, causality could be understood in terms of sufficient conditions (an antecedent produces a result), but it could not determine which factors are essential for that result to occur, i.e., without the antecedent, the result would not occur (Dul, 2020). Therefore, the NCA methodology in this research could overcome the limitation of the predictive model by detecting the minimum requirements in the relationship between mood states and learning strategies (Dul, 2020). Thus, implementing both methodologies could provide a complementary view, enriching the interpretation of the results.

Linear regression analysis yielded partial results, with only the selection strategy showing significant effects on happiness and depression, with reduced explained variances, respectively. In contrast, hostility and anxiety did not reach statistical significance and were excluded from the model. Under this approach, learning strategies would only explain a very limited proportion of the variability in mood states. The reduced explained variance could be due to the fact that mood states are complex phenomena, influenced not only by learning processes but also by contextual, personal, and social factors (Sekhon & Gupta, 2023).

However, the NCA indicated a progressive increase in the levels necessary in the development of learning strategies to achieve a cheerful mood, reaching its highest levels at 90%. In other words, it would not depend exclusively on the timely activation of a strategy, but on the combination of the strategic repertoire, so that as the 90% threshold is approached, the probability of gaps in the sequential learning process would be reduced, increasing the sense of control and achievement. One of the main implications of this approach would be determined by the function of mood as a mechanism for modulating judgements and evaluations, which would facilitate preferential access to information (Lewis & Critchley, 2003).

This phenomenon would imply that a cheerful mood could affect not only memory and attention, but also selection and organisation as learning strategies (Sekhon & Gupta, 2023). In relation to depressive mood, the bottleneck table indicated that the organisational dimension was not a necessary condition at all levels. Depressive mood is often associated with negative or dysfunctional thinking patterns, which could hinder the establishment of organisational strategies, as attention tends to be diverted towards intrusive thoughts rather than effective organisational structures (Joormann et al., 2010). From this perspective, organisation could not be considered a constant factor in a depressive mood (Becker et al., 2019). In relation to hostile mood, the bottleneck table indicated that to reach an average level in this state (50%), none of the elements of the learning strategies were necessary. To achieve a 90% level of need, the minimum requirement would be 3.7% elaboration, 2.9% memorisation, 0.7% organisation, and 0.7% selection. The contribution of organisation and selection would be minimal (0.7%), respectively, even for high levels (90%) of hostile mood. A possible consequence would be determined by the non-dependence of hostility on structured processes such as learning strategies, associated with less deliberate and impulsive responses (Sekhon & Gupta, 2023).

Finally, the anxious mood state indicated that to reach a level of need of 80%, the minimum requirement was 0.7% elaboration; 14.8% memorisation; 12.5% organisation and 1.4% selection. These results should be understood as minimum requirements without which the anxious mood cannot reach high levels. Various studies have pointed to the effect of moods as a defence mechanism against uncertainty. This phenomenon would imply that an anxious mood would not only affect memory and attention, but also selection and organisation as learning strategies (Guterman & Neuman, 2021). This finding could be determined by a strategic imbalance, where the emphasis on memorisation and organisation acts as a defence mechanism against lack of control (Bokrantz & Dul, 2023).

Practical implications

This research contributes to enriching the theoretical framework by corroborating that moods, specifically positive ones, could significantly condition the sequence of learning strategies. Promoting positive moods in university students could favour the effective application of learning strategies, optimising knowledge acquisition. Similarly, identifying the necessary conditions through NCA could help detect critical factors that must be guaranteed to prevent academic failure.

Limitations

This research also has some limitations. The cross-sectional design of the study prevents us from establishing causal relationships between mood states and learning strategies, limiting us to pointing out associations and necessary conditions at the levels observed. It should be noted that the Tucker-Lewis Index (TLI) on the *Mood Assessment Scale* obtained a value slightly below the recommended threshold, suggesting some caution in interpreting factorial validity, even though the other indicators show an adequate fit. Similarly, the use of self-report questionnaires may have induced biases in the responses, reflecting a possibly more favourable view of the use of learning strategies. Future longitudinal and experimental research would allow for a deeper understanding of this relationship and a more accurate verification of the underlying mechanisms between mood states and learning strategies.

Conclusions

The relationship between moods and learning strategies in university students, considering the NCA approach versus the predictive sufficiency model, has allowed us to establish a fundamental connection between affective and cognitive processes. This research has corroborated that each dimension of learning strategies interacts differentially with mood states. The results obtained showed that joy is related to greater use of strategy selection, while in the case of depressive mood, the same strategy appears to be inversely linked. On the other hand, states such as hostility and anxiety did not show significant effects in the regression model, although NCA showed that at high levels of these variables, minimal requirements for strategies such as elaboration, memorisation, and organisation emerge.

Author contributions

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Conflict of interest

The authors declare that there is no conflict of interest.

Data availability statement

Data supporting the results and conclusions of this study are available upon request from the corresponding author.

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