

# Creative self-beliefs and critical thinking disposition: A network analysis approach

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## ABSTRACT

This study examined the relationship between creative self-beliefs and critical thinking disposition using a network analysis approach. The sample comprised 672 final-year undergraduates who completed the Short Scale of Creative Self (SSCS) and the Critical Thinking Disposition Scale (CTDS). A regularized partial correlation network estimated via EBICglasso revealed that the two domains were largely organized into distinct but weakly connected communities. Although cross-construct associations were generally small, bridge centrality analyses identified specific items—particularly those reflecting openness to new ideas and perceived capacity to cope with complex situations—as key connectors between the two systems. Classical centrality indices further indicated that creative personal identity constituted the structural core of the creative self-beliefs network, whereas reflective self-monitoring emerged as central within critical thinking disposition. Community detection analysis further supported a two-community structure consistent with partial segregation between constructs. Overall, the findings suggest that creative self-beliefs and critical thinking disposition function as relatively differentiated yet selectively integrated systems. These results highlight the importance of targeting specific bridge processes when designing educational interventions aimed at fostering both creative and critical thinking in higher education.

## 1. Introduction

There is now a broad consensus over the need to promote the skills of critical and creative thinking in education (Murphy, Murphy, & Swain, 2024). However, while both sets of skills are now explicitly targeted by contemporary education systems (Thornhill-Miller et al., 2023; Wechsler et al., 2018), debate continues over how to characterize these modes of thinking and how best to promote their development (Leibovitch et al., 2024; Murphy et al., 2024).

Being able to think critically and creatively is essential to both effective problem solving and students' overall intellectual development (Paul & Elder, 2006). Moreover, the two processes are closely related: critical thinking implies the ability to critically evaluate information; while creative thinking requires imagination in order to consider new perspectives (Glassner & Schwarz, 2007). It has similarly been suggested that these processes are interdependent; insofar as critical thinking enhances and is enhanced by creative thinking; and vice-versa (Alghafri & Ismail, 2014).

Notwithstanding this recognition of the intrinsic inter-relationship between critical and creative thinking, the two constructs have often

been treated in the literature as independent, with critical thinking being seen as convergent and linear, while creative thinking is regarded as divergent and associative (Baker, Rudd, & Pomeroy, 2001; Beyer, 1987; Halpern, 2014). However, more recent studies (Akpur, 2020; Zhang, Bian, Wu, Tang, & Li, 2023) consider the two processes to be inseparable. Although divergent reasoning facilitates originality, the ability to switch between the creative generation and critical evaluation of ideas is essential for achieving innovative outcomes in real-life contexts (Zhang et al., 2023). Furthermore, studies such as that by Tsai (2019) have found positive relationships between the two modes of thinking; although the nature and strength of these associations vary across factors such as age; gender; and socioeconomic status. Research in higher education has shown that critical; reflective; and creative thinking are positively related and significantly predict academic performance (Akpur, 2020). This reinforces the idea that, aside from being complementary; critical and creative thinking are more effective when they are integrated within education (Murphy et al., 2024).

Although critical and creative thinking skills have now been incorporated into the official curricula of various countries (Murphy et al., 2024; Taylor & Kaufman, 2020), it has been argued that a more in-depth

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understanding of the factors that facilitate their development is required so as to design effective teaching and learning strategies (Bezanilla, Galindo-Domínguez, & Poblete, 2021; Murphy et al., 2024; Wechsler et al., 2018). In this context, creative self-beliefs and the disposition toward critical thinking have both been identified as key elements in the development of these skills.

Critical thinking, while widely acknowledged to be a core competence, requires an individual disposition if it is to be applied effectively (Chen, Liu, Zhou, & Tang, 2020). Similarly; creative self-beliefs; understood as a person's perception of and confidence in their ability to be creative (Karwowski & Beghetto, 2018); act as a driver of creative behavior; fostering engagement; effort; and perseverance in creative tasks. In education; a strong disposition toward critical thinking may therefore promote the generation and evaluation of creative ideas; while confidence in one's creative ability can encourage students to engage in critical and reflective processes. This relationship between critical thinking disposition and creative self-beliefs has been demonstrated across different educational contexts; including higher education students (Álvarez-Huerta, Muela, & Larrea, 2022); vocational high school students (Lee, Hung, Liau, & Tsai, 2026); and teachers (Mangion, Camilleri, & Vella, 2024). In addition; a recent study involving Chinese university students (Wang, Huang, & Zhou, 2024) found that perceived self-efficacy had a positive effect on their problem solving disposition that was mediated through critical thinking disposition. Among prospective teachers; academic self-efficacy has been identified as a predictor of their disposition toward critical thinking (Kozikoğlu, 2019).

Although these studies have advanced our understanding of the relationship between creative self-beliefs and critical thinking disposition, they have approached it through aggregate-level methods such as correlations, regression models, and structural equation modeling with mediation, leaving the internal structure of this relationship unknown. Both correlational methods and latent variable models treat constructs as unified aggregates, the latter assuming that the covariation among indicators reflects a single underlying common cause and that indicators are locally independent and essentially interchangeable (Guyon, Falisard, & Kop, 2017). Moreover; these approaches summarize individual differences without explaining why broader constructs emerge from their components; and obscure the specific pathways through which individual components of one construct relate to individual components of the other (Briganti et al., 2024). Network analysis offers a theoretically grounded alternative (Borsboom et al., 2021; Epskamp & Fried, 2018). It conceptualizes psychological phenomena not as manifestations of underlying latent variables, but as systems of directly interacting components in which broader constructs emerge from these interactions. The structure of relationships among components is itself theoretically meaningful: centrality indices indicate which components exert the most influence within a construct (Epskamp, Borsboom, & Fried, 2018); while bridge nodes identify the elements through which distinct constructs interact (Jones, Ma, & McNally, 2021). In addition; community detection algorithms can be used to identify groups of densely connected nodes within psychological networks; thereby revealing the meso-level organization of complex systems (Fortunato, 2010). This approach allows the examination of whether components cluster in ways that reflect theoretically meaningful substructures. The present study, therefore, extends this line of research by adopting a network perspective, with implications for the design of pedagogical interventions aimed at fostering both capacities.

### 1.1. Disposition toward critical thinking

Critical thinking has become an important goal within education (Facione, 2011); and it is recognized as being a key skill for academic; personal; and professional success (Hart, Da Costa, D'Souza, Kimpton, & Ljubicic, 2021). In a world characterized by increasing information overload; fostering students' ability to think critically is essential if they are to be capable of making a reasoned and thorough evaluation of their

everyday reality (Orhan, 2023). It is recognized; however; that developing critical thinking skills in educational settings poses a number of challenges (Janssen et al., 2019); and strategies for promoting it and barriers to its development have been explored by several authors (Bezanilla et al., 2021; Wason, 2025).

Critical thinking encompasses both cognitive skills and a personal disposition, that is to say, an individual willingness to apply these skills when there is a problem to be solved or a decision to be made (Sosu, 2013). Notably; one of the conclusions of recent research (Chen, Wang, & Zheng, 2024) is that evaluating and fostering this disposition is potentially more important than is the development of the associated cognitive skills; especially during pre-university stages of education. It is argued that the emphasis during these stages should be on cultivating perceptions; attitudes; and habits that favor the development of critical thinking among learners (Chen et al., 2024).

One of the most widely used tools for exploring people's willingness to think critically is the Critical Thinking Disposition Scale (CTDS; Sosu, 2013). This instrument assesses two dimensions: *critical openness*; defined as a tendency to be open to new ideas; to evaluate them critically; and to be prepared to modify one's own views in light of the evidence; and *reflective skepticism*; which refers to a willingness to learn from past experience and to question the evidence (Sosu, 2013). Research in the higher education context has provided support for the unidimensional structure and psychometric properties of the CTDS; showing it to be a suitable tool for assessing students' willingness to think critically (Bravo, Galiana, Rodrigo, Navarro-Pérez, & Oliver, 2020).

### 1.2. Creative self-beliefs

Recent decades have seen a growing interest in creativity due to its impact in areas such as mental health, quality of life, problem solving, and social and technological innovation (Acar & Runco, 2024). Creativity not only favors individual development but is also essential for collective progress; contributing significantly to education; culture; and the economy (Acar & Runco, 2024). As a result, it has become a key component of various educational assessment frameworks internationally. For example, the Partnership for 21st Century Learning (P21) identifies creativity as a fundamental skill, while the OECD's PISA framework considers it to be a key competence, underlining its importance for preparing citizens to face contemporary challenges.

A recent line of research within the educational context focuses on creative self-beliefs, a construct distinct from creative performance and which encompasses aspects such as creative identity and creative confidence beliefs (Runco, 2024). Creative self-beliefs may be considered as playing an intermediary role between a person's creative potential and their actual creative behavior. A growing body of research (Mathisen & Bronnick, 2009; Payne & Whitworth, 2022; Runco, 2024; Vally et al., 2019) suggests that these beliefs, together with actual creative behavior, may be cultivated through specific pedagogical strategies and enriching learning experiences, and as such their analysis is crucial.

The most widely used tool for assessing creative self-beliefs is the Short Scale of Creative Self (SSCS; Karwowski, Lebudá, & Wiśniewska, 2018). This instrument was designed to measure two key components of creative self-concept: creative self-efficacy, which refers to an individual's belief in their ability to solve problems or perform tasks that require creative thinking; and creative personal identity, which reflects the extent to which a person considers creativity to be an important part of who they are and how they function. Applied in an educational context, this tool can provide insight into how students perceive their creative potential, thus contributing to the design of pedagogical strategies for developing their creativity, which is crucial for a more innovative and effective education.

### 1.3. The present study

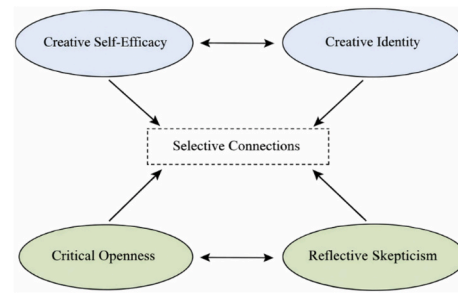
Although they have traditionally been treated as independent skills, critical and creative thinking are increasingly regarded as complementary and inter-related processes (Akpur, 2020; Zhang et al., 2023). Indeed, the ability to alternate between the generation and evaluation of ideas is considered a factor that underpins both creativity and criticality (Paul & Elder, 2006). The present study analyzes the relationship between students' creative self-beliefs and their willingness to engage in complex cognitive tasks (i.e., those requiring critical thinking). These self-beliefs may be especially important during life stages that require evaluation and judgment, where confidence in one's creative abilities might encourage the questioning of established ideas and the exploration of new perspectives. A disposition toward critical thinking may likewise foster in students a greater openness to experimentation and result in the generation of innovative ideas, both of which are crucial elements of the creative process.

Although neither creative self-beliefs nor critical thinking disposition directly assess cognitive ability, there are theoretical reasons to expect a relationship between them. Both constructs share a motivational and dispositional nature, rather than reflecting fixed cognitive capacities, and both capture the degree to which individuals are inclined to engage in certain ways of thinking. Individuals who perceive themselves as capable of thinking creatively may be more willing to question assumptions, remain open to alternative perspectives, and tolerate ambiguity. Conversely, a disposition toward critical thinking, characterized by open-mindedness and reflective skepticism, may foster positive creative self-beliefs by encouraging individuals to explore and evaluate new ideas without premature closure. Consistent with this reasoning, empirical evidence indicates that students with a greater disposition toward critical thinking also tend to perceive themselves as having a stronger creative self-concept (Álvarez-Huerta et al., 2022); a finding replicated in challenging real-world contexts (Mangion et al., 2024) and confirmed in more recent work showing a positive association between creative self-efficacy and critical thinking disposition (Lee et al., 2026).

As already noted, while the skills of critical and creative thinking have been widely incorporated into educational curricula, a more in-depth understanding of the factors that facilitate their development is required so as to design effective teaching and learning strategies (Murphy et al., 2024; Wechsler et al., 2018). In this respect, although the relationship between critical and creative thinking has been explored by researchers, the specific link between creative self-beliefs and critical thinking disposition in students has not been examined in detail. Investigating this relationship could provide key information for the design of curricula that integrate cognitive skills and personal dispositions in a more cohesive way, thus maximizing their impact on students' learning.

In this context, network analysis provides a particularly suitable framework for examining the interplay between these constructs. Unlike traditional aggregate approaches, network models estimate conditional associations among individual components, thereby revealing the structural organization of complex psychological systems (Borsboom et al., 2021; Guyon et al., 2017). In addition, network analysis enables the identification of central nodes and bridge elements that link distinct domains. This approach offers a more fine-grained understanding of how students' creative self-beliefs interact with their disposition toward critical thinking and may inform the design of more targeted educational interventions aimed at fostering both capacities in higher education.

To facilitate conceptual clarity, Fig. 1 presents a non-causal schematic overview of the potential relationships among the focal domains examined in this study.



**Fig. 1.** Conceptual overview of potential relationships between creative self-efficacy, creative identity, critical openness, and reflective skepticism. The diagram is intended as a non-causal heuristic to support interpretation of the network results.

## 2. Method

### 2.1. Participants

The sample for this study comprised 672 undergraduates ( $M_{\text{age}} = 21.70$  years,  $SD = 1.23$ ; 60.7% female, 38.1% male, 1.2% non-binary) who were enrolled in the final year of their respective degree programs at a Spanish university. The largest groups were Primary Education (32.0%), Business Administration and Management (20.1%), and Early Childhood Education (18.6%). Smaller proportions of students were enrolled in Entrepreneurial Leadership and Innovation (4.9%) and Business Data Analytics (4.5%), while the remaining participants were distributed across several engineering and specialized programs (combined <10%). Information on degree program was missing for 7.9% of the sample. Degree program was included for descriptive purposes only and was not used as a covariate in the network models.

### 2.2. Instruments

#### 2.2.1. Creative self-beliefs

Creative self-beliefs were measured with the Short Scale of Creative Self (SSCS; Karwowski et al., 2018), an 11-item scale that explores both creative self-efficacy (e.g., "I know I can efficiently solve even complicated problems") and creative personal identity (e.g., "I think I am a creative person"). Each item is rated on a 5-point Likert-type scale (from 1 = *Definitely not* to 5 = *Definitely yes*), and around five minutes are needed to complete the scale. Internal consistency of scale scores in the present sample was 0.91 (McDonald's omega) and 0.90 (Cronbach's alpha).

#### 2.2.2. Disposition toward critical thinking

The disposition toward critical thinking was assessed using the Critical Thinking Disposition Scale (CTDS; Sosu, 2013; Spanish adaptation by Bravo et al., 2020). The CTDS comprises 11 items that measure critical openness (e.g., "I usually try to think about the bigger picture during a discussion") and reflective skepticism (e.g., "I often re-evaluate my experiences so that I can learn from them"), two components of the disposition toward critical thinking. Each item is rated on a 5-point Likert-type scale (1 = *Totally disagree*, 5 = *Totally agree*) and around four minutes are needed to complete the scale. Internal consistency of scale scores in the present sample was 0.83 (both McDonald's omega and Cronbach's alpha).

Although the present study focused on item-level network estimation rather than composite scale scores, internal consistency indices are reported to document the reliability of the original instruments in the current sample.

### 2.3. Procedure

The aforementioned instruments were hosted online in the form of a questionnaire. Students were first informed about the nature and purpose of the study, and how to access the questionnaire. It was made clear that participation was entirely voluntary and that all information collected would remain confidential, in accordance with existing data protection legislation in Spain. All students who agreed to take part signed informed consent prior to data collection. The study protocol was reviewed and approved by the Research Ethics Committee of xxx University (masked for review).

### 2.4. Data analysis

The network of indicators of critical thinking disposition and creative self-beliefs was estimated using a graphical Gaussian model (GGM), in which edges represent regularized partial correlations between nodes after controlling for all other variables in the network. The model was regularized using the graphical LASSO algorithm (gLASSO; Friedman, Hastie, Tibshirani, & Tibshirani, 2015) in combination with the extended Bayesian information criterion (EBIC); which promotes sparse and interpretable network structures. Each item of the CTDS and SSCS was modeled as a node in the network. Because the CTDS and SSCS items were measured using Likert-type response scales; correlations were estimated using the `cor_auto` function from the `qgraph` package (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012). This procedure automatically detects ordinal variables and computes polychoric correlations when appropriate (Epskamp & Fried, 2018). Accordingly, the regularized partial correlation network was estimated based on a polychoric correlation matrix using the EBICglasso procedure rather than treating Likert items as continuous.

To evaluate node importance, we computed centrality indices, focusing on node strength and expected influence. Strength represents the sum of the absolute edge weights connected to a node, whereas expected influence preserves the sign of the edges. These indices were selected because they have demonstrated greater stability and interpretability in psychological networks, whereas indices such as betweenness and closeness are often unstable and difficult to interpret in cross-sectional GGM models (Bringmann et al., 2019; Epskamp et al., 2018). In addition, bridge centrality indices (bridge strength and bridge expected influence) were computed to quantify the extent to which nodes connect the two theoretical communities (critical thinking disposition and creative self-beliefs) (Jones et al., 2021).

Network robustness was examined by estimating the accuracy of edge weights and the stability of centrality indices (Epskamp et al., 2018). Edge-weight accuracy was evaluated via non-parametric bootstrapping (1000 iterations) to obtain 95% confidence intervals. Stability of centrality estimates was assessed using case-dropping subset bootstrap (1000 iterations) and quantified through the correlation stability (CS) coefficient. Values above 0.25 are considered acceptable and values above 0.50 indicate good stability (Epskamp et al., 2018). To examine the meso-level organization of the network; a community-detection analysis was conducted using the Walktrap algorithm (Pons & Latapy, 2006).

Although traditional a-priori power analyses are not straightforward for regularized GGMs, the present sample size ( $N = 672$ ) is adequate for estimating an item-level network with 22 nodes. The ratio of cases to nodes ( $\approx 30:1$ ) exceeds commonly used practical guidelines for psychological network estimation under EBICglasso regularization. Empirically, the case-dropping bootstrap indicated good stability of centrality estimates (CS = 0.59 for strength; CS = 0.67 for expected influence), and non-parametric bootstrapping showed acceptable precision of edge-weight estimates (see Fig. 4). Together, these results suggest that the network was estimated with sufficient stability and accuracy.

Missing responses in the network items were modest at the cell level

(4.6% of all item responses). Approximately 22.2% of participants had at least one missing response across the 22 items, with the highest missingness observed for CT6. Consistent with standard practice in psychological network analysis, the GGM was estimated using pairwise complete observations so that all available data contributed to estimation. Given the low overall proportion of missing data, substantial bias due to missingness is unlikely; however, results involving CT6 should be interpreted with appropriate caution.

All analyses were conducted in R (version 4.5.2) using the packages `bootnet` (Epskamp et al., 2018); `qgraph` (Epskamp et al., 2012); `networktools` (Jones et al., 2021); and `igraph` (Csárdi et al., 2026).

## 3. Results

Table 1 shows descriptive statistics for scale items included in the analysis. Values of skewness and kurtosis were generally within acceptable limits, indicating no significant problems related to distribution of the variables.

### 3.1. Network structure and centrality measures

To examine the relationships between critical thinking disposition and creative self-beliefs, we estimated a regularized partial correlation network and subsequently computed centrality indices (node strength and expected influence) (Fig. 2).

### 3.2. Network structure

Inspection of the estimated network indicated that connections between critical thinking disposition and creative self-beliefs were generally weak and sparse (Fig. 2). Consistent with this visual pattern, the average absolute edge weight within constructs was substantially larger than that between constructs (mean  $|\text{within}| = 0.084$ ; mean  $|\text{between}| = 0.011$ ). Together, these results suggest that the two constructs function as relatively distinct but weakly connected domains in the present sample. Nevertheless, several positive cross-construct associations were observed. The strongest cross-domain edges included the associations between CT4 and CS11, between CT8 and CS6, and between CT6 and CS6, although their magnitudes remained modest compared with within-construct connections.

The strongest relationships overall were observed among items belonging to the same construct, reflecting the internal coherence of each construct. Within the critical thinking dimension, the most prominent edges connected CT6 with CT7 and CT2 with CT4. Within the creative self-beliefs dimension, strong associations were observed between CS1 and CS2, between CS2 and CS7, and between CS3 and CS6. Some negative relationships were also observed, although their magnitude was small. For instance, negative edges emerged between CT6 and CS5, and between CS3 and CS10. Given their small magnitude, these negative associations should be interpreted cautiously.

### 3.3. Centrality (standardized indices)

Centrality indices were standardized (z-scores) to facilitate comparison across nodes. Following common practice, nodes with z-scores greater than 1 were considered highly central. For expected influence, the most central node was CS10 ( $z = 2.01$ ), followed by CT11 ( $z = 1.39$ ), CT4 ( $z = 1.33$ ), and CS8 ( $z = 1.32$ ). Regarding node strength, CS10 again emerged as the most central node ( $z = 2.34$ ), with CS1 ( $z = 1.52$ ) and CS3 ( $z = 1.09$ ) also exceeding the  $z > 1$  criterion (Fig. 3).

Overall, the most central nodes reflected key aspects of creative identity and self-belief (particularly CS10 and CS1), together with reflective improvement and openness-related dispositions within critical thinking (CT11, CT4). Notably, CS8 showed high expected influence but not strength, indicating a strong net influence despite more moderate overall connectivity. Inspection of the network topology further

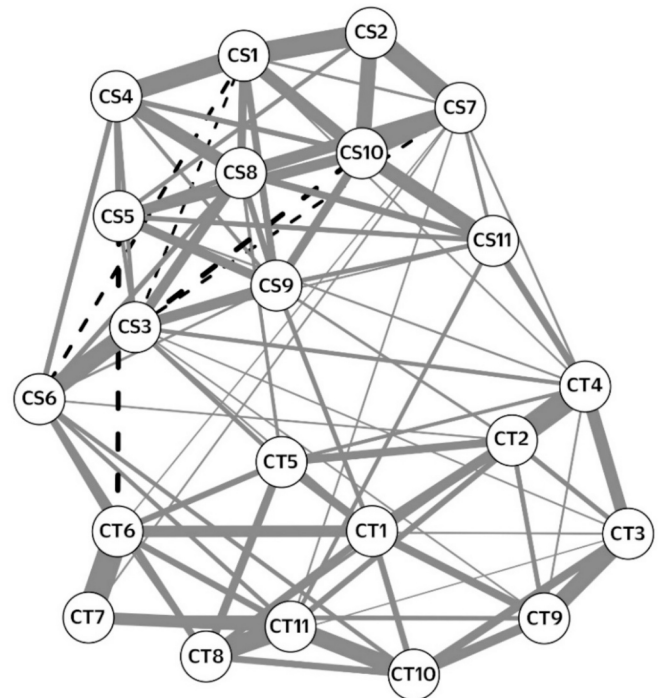
**Table 1**  
Means, standard deviations, skewness, and kurtosis for item scores on disposition to critical thinking (CTDS) and creative self-beliefs (SSCS).

Item/Node	Item wording	Dimension to which item refers	M	SD	Skewness	Kurtosis
CT1	I usually try to think about the bigger picture during a discussion.	Critical openness	3.93	0.74	-0.34	-0.11
CT2	I often use new ideas to shape (modify) the way I do things	Critical openness	3.62	0.77	-0.03	-0.17
CT3	I use more than one source to find out information for myself	Critical openness	3.89	0.86	-0.43	-0.38
CT4	I am often on the lookout for new ideas	Critical openness	3.61	0.88	-0.17	-0.46
CT5	I sometimes find a good argument that challenges some of my firmly held beliefs	Critical openness	3.46	0.92	-0.26	-0.22
CT6	It's important to understand other people's viewpoint on an issue	Critical openness	4.49	0.69	-1.34	1.90
CT7	It is important to justify the choices I make	Critical openness	4.04	0.83	-0.67	0.43
CT8	I often re-evaluate my experiences so that I can learn from them	Reflective skepticism	3.81	0.84	-0.29	-0.44
CT9	I usually check the credibility of the source of information before making judgements	Reflective skepticism	3.57	0.81	-0.30	-0.15
CT10	I usually think about the wider implications of a decision before taking action	Reflective skepticism	3.79	0.82	-0.25	-0.38
CT11	I often think about my actions to see whether I could improve them	Reflective skepticism	4.03	0.72	-0.24	-0.47
CS1	I think I am a creative person	Creative personal identity	3.68	0.89	-0.46	0.05
CS2	My creativity is important for who I am	Creative personal identity	3.71	0.97	-0.39	-0.48
CS3	I know I can efficiently solve even complicated problems	Creative self-efficacy	3.79	0.76	-0.22	-0.17
CS4	I trust my creative abilities	Creative self-efficacy	3.56	0.91	-0.30	-0.36
CS5	My imagination and ingenuity distinguishes me from my friends	Creative self-efficacy	3.17	0.98	-0.05	-0.44

**Table 1 (continued)**

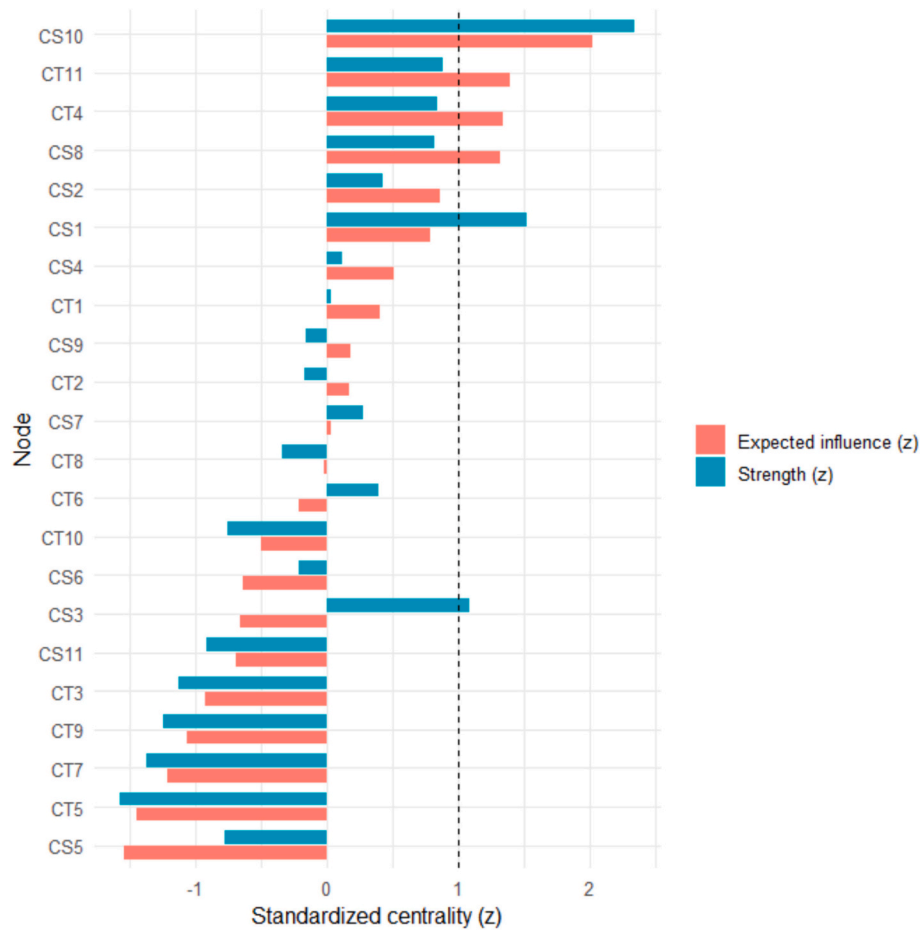
Item/Node	Item wording	Dimension to which item refers	M	SD	Skewness	Kurtosis
CS6	Many times I have proved that I can cope with difficult situations	Creative self-efficacy	3.98	0.83	-0.47	-0.26
CS7	Being a creative person is important to me	Creative personal identity	3.77	0.99	-0.58	-0.18
CS8	I am sure I can deal with problems requiring creative thinking	Creative self-efficacy	3.69	0.80	-0.23	-0.10
CS9	I am good at proposing original solutions to problems	Creative self-efficacy	3.55	0.83	-0.20	-0.15
CS10	Creativity is an important part of myself	Creative personal identity	3.38	1.02	-0.13	-0.66
CS11	Ingenuity is a characteristic which is important to me	Creative personal identity	3.63	0.91	-0.33	-0.26

Note. M = mean; SD = standard deviation; CT = items/nodes referring to critical thinking disposition (measured using the CTDS); CS = items/nodes referring to creative self-beliefs (measured using the SSCS).



**Fig. 2.** Regularized partial correlation network of critical thinking disposition and creative self-beliefs. Note. CT = items/nodes referring to critical thinking disposition (measured using the CTDS); CS = items/nodes referring to creative self-beliefs (measured using the SSCS). Edge thickness represents the magnitude of the regularized partial correlation.

suggested that these centrality patterns were largely driven by within-construct connectivity, with dense clustering among items belonging to the same scale.



**Fig. 3.** Standardized centrality indices (node strength and expected influence) for the regularized partial correlation network of critical thinking disposition and creative self-beliefs. *Note.* CT = items/nodes referring to critical thinking disposition (measured using the CTDS); CS = items/nodes referring to creative self-beliefs (measured using the SSCS). Bars represent z-standardized centrality values. The dashed horizontal line indicates the threshold of  $z = 1$  used to identify highly central nodes.

**3.4. Bridge centrality (cross-construct connectivity)**

To directly quantify cross-construct connectivity, bridge centrality indices were computed (See Table 2). Inspection of the bridge strength values indicated that a small subset of nodes showed clearly higher cross-community connectivity. In particular, the highest bridge strength values were observed for CS6 (0.36), CT4 (0.29), CS11 (0.22), and CS3 (0.22), indicating that these items played the most prominent role in linking creative self-beliefs and critical thinking disposition.

Bridge expected influence (1-step) showed a similar pattern, with

**Table 2**

Bridge centrality indices between critical thinking disposition and creative self-beliefs.

Node	Bridge Strength	Bridge Expected Influence (1-step)
CS6	0.360	0.360
CT4	0.295	0.295
CS11	0.218	0.218
CS3	0.218	0.218
CT6	0.195	0.040
CT11	0.157	0.157
CT5	0.133	0.133
CT8	0.123	0.123
CS9	0.118	0.118
CS7	0.116	0.116

*Note.* Bridge centrality indices quantify the extent to which nodes connect the critical thinking and creative self-beliefs communities. Higher values indicate stronger cross-construct connectivity.

CS6 and CT4 emerging as the strongest cross-construct connectors. Importantly, some nodes with high classical centrality (e.g., CS10) did not appear among the strongest bridge nodes, suggesting that their influence was primarily driven by within-scale associations rather than cross-construct connectivity.

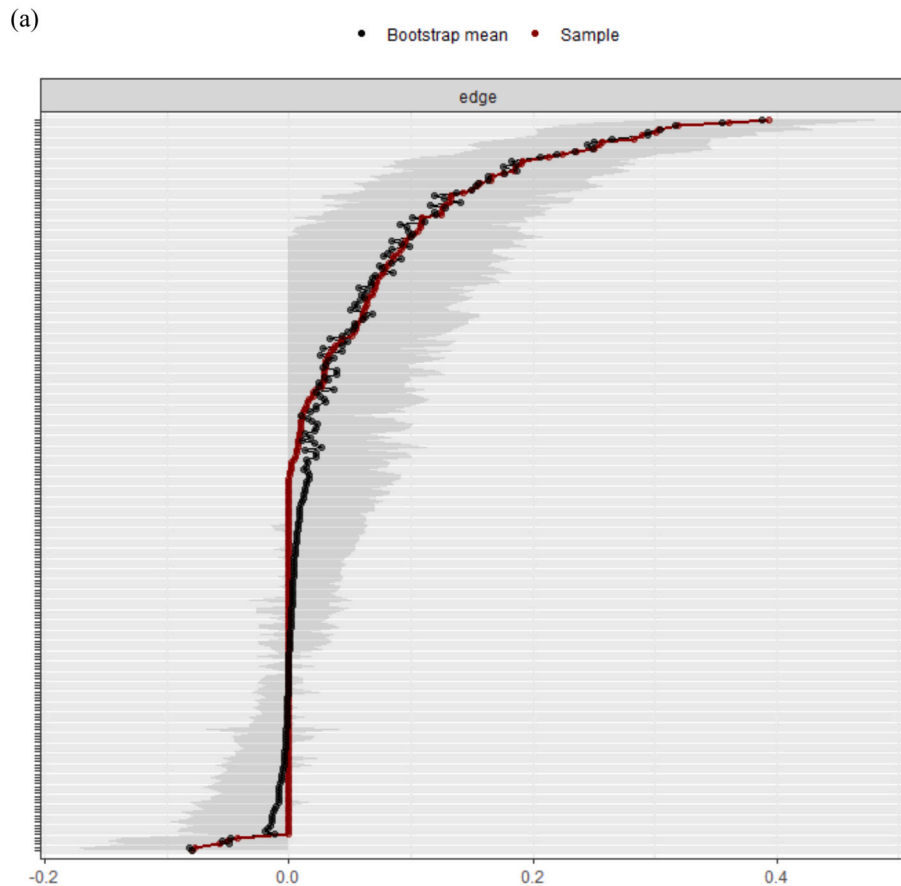
Taken together, these results indicate that although the two domains are weakly connected through specific bridge nodes, the overall network structure is characterized by relatively strong within-construct clustering and limited cross-construct integration.

**3.5. Community-detection analysis**

To further examine the meso-level organization of the network, a community-detection analysis was conducted using the Walktrap algorithm. The algorithm identified a clear two-community structure ( $k = 2$ ) that perfectly mapped onto the two theoretical constructs (modularity  $Q = 0.38$ ). All creative self-belief items (CS1–CS11) clustered within one community, whereas all critical thinking disposition items (CT1–CT11) clustered within the other. This segregated community structure provides additional evidence that the two domains operate as relatively distinct systems in the present sample, with limited cross-construct integration.

**3.6. Network accuracy and stability**

Network accuracy was examined by estimating nonparametric bootstrap confidence intervals for edge weights (Fig. 4a). The relatively



**Fig. 4.** Plot of network accuracy and stability. *Note.* (a) Bootstrapped 95% confidence intervals (CIs) of estimated edge weights for the estimated network. The red line indicates the sample values and the gray area represents the bootstrapped CIs. Each horizontal line represents one edge of the network, ordered from highest edge weight to lowest edge weight; (b) Case-dropping bootstrap for the network. The x-axis indicates the percentage of cases used in the analysis. The y-axis represents the average correlations between the estimated centrality indices (strength and expected influence) of the original network and the centrality indices from re-estimated networks after dropping increasing percentages of cases. The lines represent the correlations of the centrality indices. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

narrow confidence intervals indicated acceptable precision of the estimated edges.

Stability of the centrality indices was assessed using case-dropping subset bootstrapping (Fig. 4b). The correlation stability coefficients indicated good stability for both node strength (CS = 0.59) and expected influence (CS = 0.67), exceeding the recommended threshold of 0.50.

#### 4. Discussion

This study examined the component-level connections between creative self-beliefs and critical thinking disposition in higher education students using network analysis, with the aim of identifying key nodes to inform educational interventions targeting both capacities. Overall, the findings indicate that, although the two domains are conceptually related, they function as partially segregated but weakly interconnected systems. Across complementary indicators (edge patterns, bridge centrality, and community detection), the network showed stronger within-construct clustering than cross-construct integration.

This pattern is consistent with theoretical perspectives that view creative and critical thinking as complementary yet distinguishable processes (Baker et al., 2001; Halpern, 2014). Rather than forming a single unified motivational system, the present results suggest that creative self-beliefs and critical thinking disposition may operate through relatively specialized sub-systems that maintain only modest direct coupling at the dispositional level. This pattern may partly reflect

a methodological difference with prior studies. Research reporting associations between critical and creative thinking (Álvarez-Huerta et al., 2022; Lee et al., 2026; Tsai, 2019; Zhang et al., 2023) has typically relied on aggregate-level approaches that capture overall associations between the constructs. When the relationship is examined at the component level, as network analysis allows, the two domains appear as partially segregated systems with stronger within-construct clustering than cross-construct integration. This suggests that the degree of coupling between creative self-beliefs and critical thinking disposition may depend on the level of analysis, and that aggregate associations may obscure a more complex pattern of selective connections between specific components of each construct.

Several limitations should be kept in mind when interpreting these findings. The cross-sectional design precludes causal inference and prevents establishing the temporal ordering of the observed associations. The sample was drawn from a single university, and the item-level distributional characteristics of some variables may have influenced the magnitude of the estimated connections. Finally, while network analysis provides a powerful framework for examining interrelations among psychological variables, the present results do not permit conclusions about directionality or causal mechanisms. These limitations are discussed in detail in the final section of this paper.

With respect to classical centrality, the creative self-concept item “Creativity is an important part of myself” (CS10) emerged as the most central node in the entire network, both in terms of expected influence

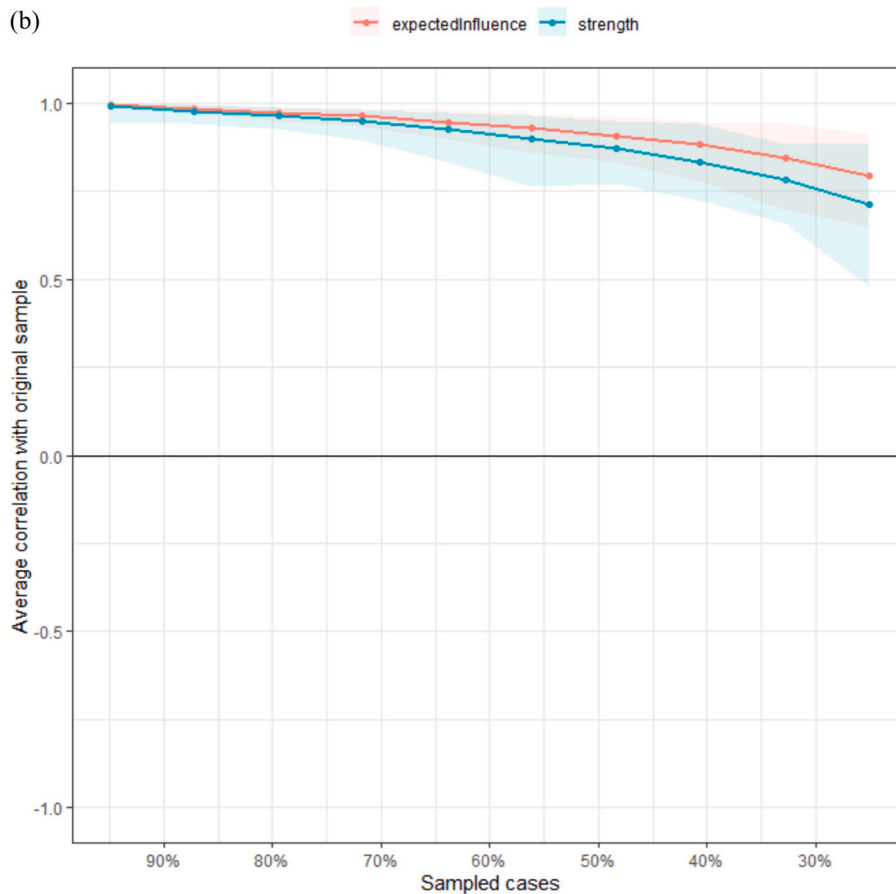


Fig. 4. (continued).

and strength. This item reflects a nuclear component of creative personal identity, linked to the definition of the creative self and the internalization of creativity as a core trait of creative self-concept. This suggests that the creative self-beliefs network is fundamentally organized around creative personal identity. Consistently, the item “I think I am a creative person” (CS1) also showed high centrality values, particularly in strength, indicating strong structural connectivity within the system of creative beliefs. The joint prominence of these two items points to the existence of a creative personal identity core, in which the global self-perception of creativity and the importance attributed to this dimension configure the organizing axis of the system.

Alongside this identity core, the creative self-concept item “I know I can efficiently solve even complicated problems” (CS3) also exceeded the high centrality threshold in terms of strength, while “I am sure I can deal with problems requiring creative thinking” (CS8) was particularly prominent in expected influence. Together, this suggests that the structure of creative self-beliefs may be conceptualized in at least two functional layers: a creative personal identity layer and a creative self-efficacy layer. This differentiation is consistent with theoretical models that distinguish between the extent to which creativity is treated as an important part of an individual's identity and confidence in one's capacity to act creatively (Karwowski et al., 2018).

Regarding critical thinking disposition, the item “I often think about my actions to see whether I could improve them” (CT11) emerged as the most central node within this domain. This item captures processes of reflective skepticism, suggesting that the core of critical thinking disposition in the network is articulated around the tendency to learn from past experiences and question evidence. Within the critical openness subdimension, “I am often on the lookout for new ideas” (CT4) showed a particularly relevant profile, combining high classical

centrality with elevated bridge centrality. This dual position makes it a theoretical hinge node, potentially key for the articulation between critical thinking disposition and creative self-beliefs. Conceptually, this result reinforces the idea that the active search for novelty and cognitive openness may constitute one of the main mechanisms of integration between the two domains.

Importantly, the bridge centrality analysis revealed that cross-construct connectivity was concentrated in a small subset of nodes. This finding suggests that the interplay between creative self-beliefs and critical thinking disposition may not be globally distributed across all indicators but instead may depend on specific psychological components that serve as local integration points between the two domains. Among the nodes with the strongest bridge role, the creative self-concept item “Many times I have proved that I can cope with difficult situations” (CS6) emerged as the most prominent cross-construct connector. Notably, this item does not measure creativity in a strict sense but rather reflects resilience, general self-efficacy, and coping competence in the face of difficulty. This result suggests that the connection between creative self-beliefs and critical thinking disposition may operate through beliefs about one's capacity to handle challenging situations. This interpretation is theoretically plausible, as both critical thinking disposition and this item share an underlying component of adaptive competence. This finding is also consistent with evidence from Mangion et al. (2024), who found that the relationship between creative self-efficacy and critical thinking disposition was positive and suggested that both constructs convey a sense of agency and forward-looking orientation. Taken together, these results point to adaptive competence and the belief in one's capacity to cope with challenging situations as a key psychological mechanism underlying the connection between creative self-beliefs and critical thinking disposition.

The item “I am often on the lookout for new ideas” (CT4), from the critical openness aspect of critical thinking disposition, also emerged as one of the main bridge nodes. This item reflects active curiosity, cognitive exploration, and openness to novelty. These characteristics constitute a natural point of contact between critical thinking disposition and creative self-beliefs, as the active search for new ideas may facilitate the transfer between the two psychological systems.

Similarly, the item “Ingenuity is important to me” (CS11) showed a relevant role in cross-construct connectivity. This creative self-concept item appears to capture an attitudinal valuation of ingenuity primarily. Its position as a bridge node suggests that the importance attributed to ingenuity may be associated with an exploratory mindset that favors the connection between creative self-beliefs and critical thinking dispositions. Likewise, the creative self-efficacy item “I know I can efficiently solve even complicated problems” (CS3) played an important role as a linking node. This finding is conceptually plausible, as critical thinking disposition involves the analysis of complex situations, while this item reflects confidence in one's ability to generate effective solutions under complexity. Both components therefore share a common basis of creative confidence, which may explain their integrative function within the network.

A particularly relevant finding of the present study is that the item from the creative self-concept scale, “Creativity is an important part of myself” (CS10), despite being the most central node according to classical centrality indices, did not emerge as a prominent bridge node. This pattern suggests that creative personal identity plays a fundamental organizing role within the creative self-beliefs system, but does not constitute the primary mechanism of integration with critical thinking disposition. From a theoretical perspective, this result points to a possible functional decoupling between the two domains: perceiving oneself as creative does not necessarily imply greater disposition toward critical thinking processes. This distinction is particularly relevant within the framework of psychological network approaches, as it suggests that creative personal identity may operate as a relatively autonomous intra-construct core, while the connection between creativity and critical thinking appears to depend more on beliefs related to adaptive competence and openness.

The community-detection results provide an additional level of convergent evidence regarding the organization of the system. The algorithm identified a well-defined two-community structure that mapped exactly onto the two theoretical constructs, reinforcing the interpretation that critical thinking disposition and creative self-beliefs constitute distinguishable but weakly coupled psychological systems in the present sample. Taken together, the low magnitude of cross-construct connections, the bridge centrality patterns, and the clear community segregation consistently indicate that, despite their theoretical complementarity, both domains maintain a relatively autonomous internal organization, connecting with each other through a limited number of specific bridge nodes rather than forming a single integrated system.

From an applied perspective, these results suggest that educational interventions aimed at simultaneously promoting creative and critical thinking could benefit from focusing on the identified bridge processes, particularly the active search for new ideas and the perceived capacity to cope with complex situations, rather than focusing exclusively on strengthening creative personal identity. Introducing productive friction into learning environments, for instance through tasks that require students to confront ambiguity, challenge assumptions, or generate solutions under uncertainty, may simultaneously activate both bridge processes identified in the network (Kapur, 2016). Building students' confidence in their capacity to handle such challenging situations is equally important, as perceived coping competence appears to be a key mechanism linking the two domains. Drawing on Bandura (1997) self-efficacy theory, this confidence can be fostered through four main sources: experiences that provide direct evidence of competence, vicarious learning through observation of peers managing complex

tasks, verbal persuasion in the form of encouragement and constructive feedback, and attention to students' physiological and emotional states during challenging activities. Instructional designs that deliberately incorporate these sources of efficacy information may therefore help strengthen the bridge between creative self-beliefs and critical thinking disposition identified in the present network.

Although the present analysis provides valuable information about the relationship between creative self-beliefs and critical thinking disposition in higher education students, several limitations should be considered when interpreting the findings. First, the cross-sectional design precludes causal inference, as data were collected at a single time point. Consequently, the temporal ordering and potential reciprocal influences between creative self-beliefs and critical thinking disposition cannot be established. Longitudinal research is therefore needed to examine how these constructs co-develop over time. Second, the cultural context of the sample warrants consideration. Cross-cultural research has shown that response styles such as acquiescence or extreme responding can vary across national contexts (Harzing, 2006), and it is possible that such tendencies introduced some degree of variance in the self-report measures used here. Replication with samples from other cultural contexts would help clarify the generalizability of the present network structure. Third, although specific cross-construct connections were identified, the overall pattern suggested relatively weak interconnections between creative self-beliefs and critical thinking disposition. This underscores the importance of examining potential moderating or mediating variables, such as creative mindset, self-regulation capacity, learning context, or instructional practices, that may shape the relationship between these domains.

Several methodological considerations specific to item-level network analysis also warrant attention. Item heterogeneity and the original scale structure may inherently promote stronger within-scale clustering relative to cross-construct connectivity. In addition, distributional characteristics of certain items, particularly the observed skewness in CT6 (“Many times I have proved that I can cope with difficult situations”), may attenuate partial correlations and thus reduce apparent cross-construct associations. Beyond these psychometric concerns, a potential source of weak cross-construct connectivity lies in measurement misalignment. The SSCS and the CTDS were developed within distinct theoretical traditions: the former targets self-beliefs about creativity, whereas the latter assesses broad dispositional tendencies toward critical inquiry. As a consequence, the constructs as operationalized may share limited conceptual overlap at the item level, which could suppress edge weights independently of any true psychological separation between the two domains. Accordingly, the relative separation observed between the two domains should be interpreted cautiously and not as evidence of complete independence. An additional methodological consideration concerns the operationalization of creative self-beliefs. Because partial correlations in Gaussian graphical models are conditional on the set of variables included in the network, the selection of indicators may influence the magnitude and configuration of the estimated edges. Future research could examine whether the connectivity patterns identified in the present study are robust across different operationalizations of creative self-beliefs, including instruments that capture a broader range of creative self-belief dimensions. This would help to establish the generalizability of the present network structure and to identify whether additional components of creative self-beliefs show stronger cross-construct connectivity with critical thinking disposition.

Finally, although network analysis provides a powerful framework for examining complex interrelations among psychological variables, the present results remain based on cross-sectional correlational data and therefore do not permit conclusions about directionality or causal mechanisms. Future work integrating network models with longitudinal, experimental, or multilevel approaches would help to provide a more comprehensive understanding of the interplay between creativity and critical thinking.

## 5. Conclusions

This study has used network analysis to examine the relationship between creative self-beliefs and critical thinking disposition in higher education students. The results suggest that, while the two constructs are conceptually related, they function as partially segregated but weakly interconnected systems. The network analysis identified creative personal identity as the organizing core of creative self-beliefs, and metacognitive self-monitoring as the central component of critical thinking disposition. Crucially, however, the bridge centrality analysis revealed that cross-construct connectivity depends not on creative personal identity but on beliefs related to coping competence and openness to new ideas. In terms of their pedagogical implications, the present results highlight the importance of designing interventions that target the identified bridge processes, fostering both openness and confidence in one's capacity to cope with complexity.

### 5.1. Compliance with ethical standards

**Disclosure of potential conflicts of interest** - The authors declare that there are no conflicts of interest regarding the publication of this research paper. The research was conducted in an unbiased manner, and there are no financial or personal relationships that could have influenced the findings or interpretations presented herein.

**Research involving human participants and/or animals** - All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** - Informed consent was obtained from all individual participants included in the study.

### CRedit authorship contribution statement

**Paula Álvarez-Huerta:** Methodology, Data curation, Conceptualization, Writing – original draft. **Alexander Muela:** Formal analysis, Writing – review & editing. **Inaki Larrea:** Data curation, Writing – review & editing.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.intell.2026.102021>.

### Data availability

Data will be made available on request.

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