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The Development of a Methodology Based on Neurosciences Applied to Innovation, Entrepreneurship, and Creativity

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1. Introduction

Entrepreneurship and innovation stand out in the contemporary economy, serving as synonyms for technological progress, national development, and business success. According to the literature, creativity is the starting point of the innovative process within entrepreneurship, enabling entrepreneurs to identify opportunities and develop solutions that enhance business performance and economic growth [1-4].
In the field of innovation, entrepreneurship, and creativity, neuroscience has contributed to understanding how entrepreneurs integrate unrelated information to conceive products, mobilize resources, and analyze opportunities for decision-making. By addressing both conscious and unconscious human behavior, this neuroscientific approach offers valuable insights into the entrepreneurial profile. Additionally, chronobiology has demonstrated the influence of chronotypes on personality traits and cognitive aspects, such as decision-making, creativity, and mental flexibility [5-14].
Based on these considerations, this work presents the preliminary steps of a neuroscience-based methodology aimed at identifying and measuring explicit (conscious) and implicit (unconscious) associations regarding entrepreneurship, innovation, and creativity, as well as analyzing their correlations with individual chronotype.

2. Methodology

Traditional research in innovation and entrepreneurship has focused on identifying entrepreneurial characteristics, personality traits, and the impact of environmental and cultural factors on behavior. However, to the best of our knowledge, no study in the neuroentrepreneurship or cognitive psychology literature has quantitatively compared approaches that simultaneously assess implicit and explicit associations using customized instruments specifically designed for entrepreneurial behavior evaluation. Existing methodologies fail to integrate and contrast implicit (unconscious) attitudes with explicit (conscious) ones within innovative entrepreneurial behavior. Concurrently, no empirical framework correlates chronotypes with these distinct cognitive dimensions. To address this gap, this study introduces the preliminary development of a novel, dual-layer methodology that provides a deeper, integrative understanding of both conscious and unconscious human behavior related to entrepreneurship. The steps of this neuroscience-based approach are presented below.

2.1 Step 1: Selection and customization of the Implicit Association Test (IAT)

Traditional questionnaires and inventories effectively assess explicit (conscious) concepts of innovation and entrepreneurship; however, implicit (unconscious) concepts can only be captured through instruments designed to access implicit memory [15-16].
Consequently, the first step of this neuroscience-based methodology involved selecting an appropriate tool for identifying implicit associations. The Implicit Association Test (IAT) was selected because it is a reliable, computer-based method that utilizes reaction times to measure the strength of automatic, unconscious associations (implicit biases) between concepts [17-20].

Customizing and administering the IAT requires specialized software. In this study, the Portuguese version of FreeIAT was utilized. It is a free, open-source, highly customizable, and validated software program designed to administer the IAT in Portuguese [21].
The IAT paradigm requires the classification of items representing four distinct categories: two attributes and two target concepts. For this research, the two attributes were designated as "good" and "bad," while the two target concepts were "innovative" and "conservative." The stimuli representing the "good" attribute comprised: *well-being, joy, fulfillment, safety, peace, happiness, courage, and success*. Conversely, the "bad" attribute included: *threat, danger, cowardice, failure, sadness, distress, bankruptcy, and scarcity*. For the "innovative" concept, the words were: *innovation, to innovate, innovative, to transform, modern, novelty, to change, and new*. Finally, the words for the "conservative" category were: *conservation, to conserve, conservative, conserved, tradition, traditional, to maintain, and traditionalism*.
The initial IAT instruction screen delineates the task parameters, directing participants to quickly sort words into categories displayed on the left- and right-hand sides of the computer screen. Specifically, participants are instructed to press the “e” key if the word belongs to the category on the left, and the “i” key if it belongs to the category on the right [18, 21].
Upon task completion, the system immediately tabulates response times and error rates to evaluate the strength of the implicit associations. Faster reaction times to specific pairings indicate stronger automatic/implicit associations [18].

2.2 Step 2: Development of a Likert-type scale questionnaire

The second step consisted of designing an instrument to identify explicit (conscious) concepts about innovative entrepreneurial behavior. Titled the *Entrepreneurship, Innovation, and Creativity Questionnaire*, this 24-question instrument was designed using a 6-point Likert-type scale, where 1 indicates ‘strongly disagree’ and 6 indicates ‘strongly agree’.

2.3 Step 3: Selection of a Chronotype questionnaire

The third step of the methodology consisted of selecting a chronotype questionnaire to identify potential correlations between individual chronotype and the innovative-creative profile for entrepreneurship. For this work, the Portuguese version of the Chronotype Questionnaire was selected. It is based on the Morningness-Eveningness Questionnaire (MEQ) by Horne and Östberg (1976), translated and validated by the Multidisciplinary Group for Development and Biological Rhythms (GMDRB) [22-23].

2.4 Step 4: Pretest and Sample Characteristics

When a measurement tool is developed for a study, its constituent items should be carefully selected and pretested before conducting the main research [24].
The fourth step of this methodology consisted of administering the complete set of instruments (described in Sections 2.1, 2.2, and 2.3) as a pretest to a sample of 23 participants from the CIETEC (Center for Innovation, Entrepreneurship, and Technology) incubator, located at IPEN (Nuclear and Energy Research Institute). This sample size is methodologically justified since the literature in experimental psychology indicates that a sample of 20 subjects provides sufficient statistical power to robustly demonstrate the IAT effect [18].
The inclusion criteria required participants to be active founders or employees of technology-based startups directly operating in fields related to innovation, entrepreneurship, and creativity. This ensured a homogeneous target profile with practical experience in the core themes of this study. The Statistical Package for the Social Sciences (SPSS), version 22.0, was used to conduct the preliminary reliability analysis [25].

3. Results and Discussion

This research is currently focused on the analysis of its pretest phase, as described in Section 2.4. To date, the completed preliminary statistical analyses demonstrated good internal consistency for both research tools. Cronbach’s alpha coefficients were 0.868 for the customized IAT and 0.794 for the Entrepreneurship, Innovation, and Creativity Questionnaire. Alpha values range from zero (unreliable) to one (perfect reliability), with a threshold of 0.70 or greater generally considered acceptable for research

purposes. The chronotype questionnaire did not undergo reliability testing in this phase, since it is a widely validated and standardized international instrument, described in Section 2.3.

Furthermore, a dimensionality analysis of the Entrepreneurship, Innovation, and Creativity Questionnaire items was conducted using principal component extraction with no rotation, with the number of components determined by the Kaiser criterion (eigenvalues greater than 1), and items were assigned to the component on which they loaded most highly. This analysis revealed four empirically coherent clusters, each demonstrating good internal consistency: Cluster 1 ($\alpha = 0.885$), Cluster 2 ($\alpha = 0.877$), Cluster 3 ($\alpha = 0.809$), and Cluster 4 ($\alpha = 0.801$). Given the pretest nature of the study and the limited sample size ($N = 23$) relative to the 24-item instrument, these findings should be interpreted as preliminary evidence of internal consistency rather than as confirmation of the instrument's factorial structure or construct validity. Additional psychometric analyses, including convergent validity, discriminant validity, and temporal stability have not yet been established; however, they are planned for subsequent stages with larger and more diverse samples.

Regarding limitations, the preliminary results are limited by the current methodological development phase. However, since the primary objective was to demonstrate internal consistency and structural viability, the pretest was designed mainly to pilot the instruments' feasibility and item comprehension. Although this restricts immediate generalizability, it fulfills the methodological requirement to refine the tools before large-scale application.

Consequently, having established the instruments' structural consistency, the collected data will undergo Pearson correlation analysis to examine linear relationships between the variables. In the next phase, the refined instruments will be applied to broader, more diverse groups of current and prospective entrepreneurs.

4. Conclusions

The preliminary results demonstrate the internal consistency of the methodology. The integrated administration of the customized IAT, the Entrepreneurship, Innovation, and Creativity Questionnaire, and the Chronotype Questionnaire establishes a functional framework to capture multiple dimensions of entrepreneurial behavior. Therefore, correlations among implicit measures, explicit measures, and chronotype will be maintained as future analyses until actual statistical results are available. Conclusive statistical data, descriptive data from broader samples, and final inter-variable correlation analyses will be presented in future work. Future studies with larger and more heterogeneous samples will also allow for a comprehensive psychometric validation of the instruments and the generalization of the findings to different entrepreneurial profiles and organizational contexts.

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