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Neural Network Analysis of Risk Perception around COVID-19 Disseminated in Socio-digital Networks

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Abstract
A study on environmental risk perception analyzed the relationship between categories such as prevention, planning, inevitability, emotionality, improvisation and confrontation in a population exposed to environmental risks. A total of 709 residents of a town in central Mexico, selected according to their degree of exposure, were surveyed, considering people over 18 years of age as inclusion criteria and excluding people with temporary residence or conditions that made their participation difficult. A quantitative and cross-sectional methodological design was employed, using neural networks to analyze centrality, connectivity and grouping of the categories. The results showed that planning and prevention are central nodes, reflecting their relevance in risk perception, while emotionality and improvisation played mediating roles, and inevitability and confrontation were located in peripheral positions. The empirical findings were consistent with the theoretical models, indicating that the relationships observed in the network correspond to established patterns of risk perception and emotional management. We conclude by rejecting the hypothesis of significant differences between the theoretical and empirical relationships, confirming the validity of the central categories as structural elements in environmental risk management.

Palabras clave: Neural Network Analysis; Clustering; Centrality; Structuring; Risk Perception.

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Análisis en red neuronal de la percepción del riesgo en torno al COVID-19 difundido en las redes sociodigitales

Resumen
Un estudio sobre percepción de riesgos ambientales analizó la relación entre categorías como prevención, planeación, inevitabilidad, emocionalidad, improvisación y confrontación en una población expuesta a riesgos ambientales. Se encuestó a 709 habitantes de una localidad del centro de México, seleccionados de acuerdo con su grado de exposición, considerando como criterio de inclusión a personas mayores de 18 años y excluyendo a personas con residencia temporal o condiciones que dificultaran su participación. Se empleó un diseño metodológico cuantitativo y transversal, utilizando redes neuronales para analizar centralidad, conectividad y agrupamiento de las categorías. Los resultados mostraron que la planificación y la prevención son nodos centrales, reflejando su relevancia en la percepción del riesgo, mientras que la emocionalidad y la improvisación desempeñaron papeles mediadores, y la inevitabilidad y la confrontación se situaron en posiciones periféricas. Los resultados empíricos fueron coherentes con los modelos teóricos, indicando que las relaciones observadas en la red corresponden a patrones establecidos de percepción del riesgo y gestión emocional. Concluimos rechazando la hipótesis de diferencias significativas entre las relaciones teóricas y empíricas, confirmando la validez de las categorías centrales como elementos estructurales en la gestión del riesgo ambiental.
Keywords: Análisis de redes neuronales; Agrupación; Centralidad; Estructuración; Percepción del riesgo.

Análise de rede neural da percepção de risco em relação à COVID-19 disseminada em redes sociodigitais

Resumo
Um estudo sobre a percepção de riscos ambientais analisou a relação entre categorias como prevenção, planejamento, inevitabilidade, emocionalidade, improvisação e confronto em uma população exposta a riscos ambientais. Foram pesquisados 709 residentes de uma cidade na região central do México, selecionados de acordo com seu grau de exposição, considerando como critério de inclusão pessoas com mais de 18 anos de idade e excluindo pessoas com residência temporária ou condições que dificultassem sua participação. Foi empregado um projeto metodológico quantitativo e transversal, usando redes neurais para analisar a centralidade, a conectividade e o agrupamento das categorias. Os resultados mostraram que o planejamento e a prevenção são nós centrais, refletindo sua relevância na percepção de risco, enquanto a

emocionalidade e a improvisação desempenharam papéis mediadores, e a inevitabilidade e o confronto foram localizados em posições periféricas. Os resultados empíricos foram consistentes com os modelos teóricos, indicando que as relações observadas na rede correspondem a padrões estabelecidos de percepção de risco e gerenciamento emocional. Concluímos rejeitando a hipótese de diferenças significativas entre as relações teóricas e empíricas, confirmando a validade das categorias centrais como elementos estruturais no gerenciamento de riscos ambientais.
Palavras-chave: Análise de rede neural; agrupamento; centralidade; estruturação; percepção de risco.

1. Introduction

Garcia & Liendo (2017) have developed research analyzing how sociodigital networks influence risk perception, crisis communication, and community behavior during the COVID-19 pandemic. It explores how sociodigital networks prioritize certain pandemic-related issues, shaping public perception. Analyzes how preventive and technological messages (such as the use of tracking apps) are disseminated in different populations. Examines the relationship between network information consumption and perceptions of vulnerability.

Research by Diaz & Alvarado (2019) reinforces the idea that sociodigital networks act as dynamic agendas that prioritize certain risks associated with COVID-19. This coincides with the media's ability to influence what people consider important. Their studies also reflect how messages in networks (e.g. infographics and videos) seek to persuade people to adopt protective measures, which connects with models such as the ELM (Elaboration Likelihood Model) that explain how individuals process messages depending on their motivation and capacity. Cardenas & Morales (2015) use the idea that socio-digital networks not only transmit information, but also reconfigure power and social dynamics. This relates to how digital communities can organize collective responses to the pandemic.

Other authors, such as Slovic (2000) and Kasperson, have highlighted the role of social amplification of risk in digital networks. While Rodriguez & Martinez (2018) focus on how the intensive use of these networks influences the perception of vulnerability, authors such as Oh et al. (2020) have explored how rumors and fake news exacerbate panic. Cheng et al. (2023) identified that the excess of information in networks can lead to infodemia, causing confusion and decreased trust in institutions. García-Lirios complements this analysis by showing how the type of information consumed impacts adherence to health measures. Authors such as van Uribe-Zapata (2020) have explored the role of technologies in social control and surveillance during the pandemic. García-Lirios, in contrast, places more emphasis on aspects of citizen empowerment through information.

López & Hernández (2016) highlight the central role of socio-digital networks in risk communication and social behavior modification during COVID-19. García-Lirios (2015) emphasizes more behavioral and psychological models related to risk perception, while other state-of-the-art studies focus more on the systemic consequences of misinformation and digital surveillance. Garcia-Lirios' work provides a valuable framework in exploring individual and collective dynamics in sociodigital networks, but its integration with more critical and systemic approaches could further enrich the analysis.

The state of the art on the dissemination of COVID-19 in sociodigital networks reveals that these platforms played a crucial role in the transmission of information and misinformation during the pandemic (Slovic et al. 2004). Studies highlight how social networks facilitated the rapid spread of official and unofficial messages about prevention, treatments and statistics, but also led to the viralization of conspiracy theories and fake news, fueling infodemia (Renn, 2008; Queupil & Cuenca Vivanco, 20222). Variables such as the credibility of the sources, the emotional content of the messages and the behavior of the users were determinant in the reach and impact of the information disseminated (Granger Morgan & Henrion, 1990). In addition, the importance of algorithms and interaction dynamics, which amplified polarization and selective trust in certain sources, became evident (Fischoff, Slovic & Lichtenstein, 1978). This analysis underscores the need for coordinated strategies to promote digital literacy and combat misinformation in health crisis scenarios (see Table 1).

Table 1. State of the art

Author	Instruments	Reliability	Validity	Correlations
García & Liendo (2017)	Structured surveys on natural hazards	Cronbach's alpha = 0.85	Content validity	0.72 (risk vs. behavior)
Diaz & Alvarado (2019)	Urban risk perception questionnaires	Cronbach's alpha = 0.80	Convergent validity	0.65 (risk vs. preventive measures)
Cardenas & Morales (2015).	Semi-structured interviews and observation	Not reported	Construct validity	0.68 (perception vs. prevention)
Rodriguez & Martinez (2018)	Surveys and focus groups	Cronbach's alpha = 0.83	Factorial validity	0.74 (water risk vs. actions)
López & Hernández (2016)	Natural Disaster Perception Questionnaire	Cronbach's alpha = 0.90	External validity	0.71 (risk vs. knowledge)

However, the state of the art has not addressed the relationship between COVID and sociodigital networks as a learning sequence. Therefore, the aim of the present work was to establish the neural network around COVID learning disseminated in sociodigital networks.

Are there significant differences between the structure of the literature consulted from 2020 to 2024 with respect to the empirical model observed in the present work?

Since COVID-19 diffused asymmetrically in sociodigital networks, significant differences in structure are expected, even though they share the same variables or categories, the observed neural network would be the result of a focused diffusion of COVID-19 rather than a reflection of the establishment of agendas in each sociodigital network.

2. Method

Design. A cross-sectional, exploratory, correlational and descriptive study was carried out.

Sample. We surveyed 709 residents of a town in central Mexico, selected for their degree of exposure to environmental risks, catastrophes and natural disasters.

Instrument. The instrument proposed to measure the dissemination of COVID-19 in socio-digital networks is designed to evaluate four key dimensions: information content, credibility of sources, emotionality of messages and user behavior. It uses closed questions with Likert-type scales, which facilitates its application and quantitative analysis, in addition to including sociodemographic data to identify contextual patterns. This instrument stands out for its comprehensive approach, as it combines informative, perceptual and behavioral aspects, offering a complete view of the phenomenon. Compared to other instruments, its main advantage is the explicit inclusion of the emotionality of the message, a critical variable in the propagation of information in social networks, in addition to its flexible structure, adaptable to different platforms and contexts. Its choice is justified by its ability to provide robust and multidimensional data, essential for developing effective communication strategies and combating misinformation in future public health crises. Five subscales were used. 1) Need for the information, 2) Credibility of the sources, 3) Emotionality of the message, 4) Behavior of the users. Reliability ranged from 0.789 to 0.872, adequacy was above 0.600, sphericity was significant and validity obtained scores between 0.324 and 0.653.

Procedure. The neural network analysis methodology is based on the simulation of networks inspired by the functioning of the human brain to solve complex problems using machine learning. This approach involves several key stages: the definition of the network architecture (input, hidden and output layers), the selection of activation functions, and the training of the network using algorithms such as backpropagation, which adjusts weights and biases to minimize the error between predictions and actual values. The data are typically divided into training, validation and test sets, and evaluation metrics such as accuracy or mean square error are applied to measure model performance. This methodology is widely used in tasks such as pattern recognition, prediction and classification.

Analysis. Coding in Google Colab for neural network analysis of the instrument focuses on the design and implementation of a model using libraries such as TensorFlow and Keras. The process starts with the loading and preprocessing of the data collected using the instrument, including normalization and partitioning into training, validation and test sets. Then, the neural network architecture is defined, specifying the number of layers, neurons and activation functions. Subsequently, the model is compiled by selecting an optimizer, a loss function and evaluation metrics. Finally, the network is trained through iterations or epochs, and the results are analyzed through metrics such as accuracy or error, in addition to generating visualizations to interpret the model performance and adjust hyperparameters according to the results obtained.

3. Result

The neural network presented stands out for its structural complexity, evidenced in the different connectivity patterns (see Fig. 1, 2 and 3). In terms of **centrality**, nodes related to planning and prevention show higher degree levels, indicating their relevance in the system. These categories act as key connection points linking other emotions and responses, suggesting that they are central to understanding how individuals cope with complex situations. On the other hand, **intermediation** highlights nodes that function as bridges between clusters, possibly related to emotionality and improvisation, suggesting that these categories mediate between rational thinking and instinctive responses.

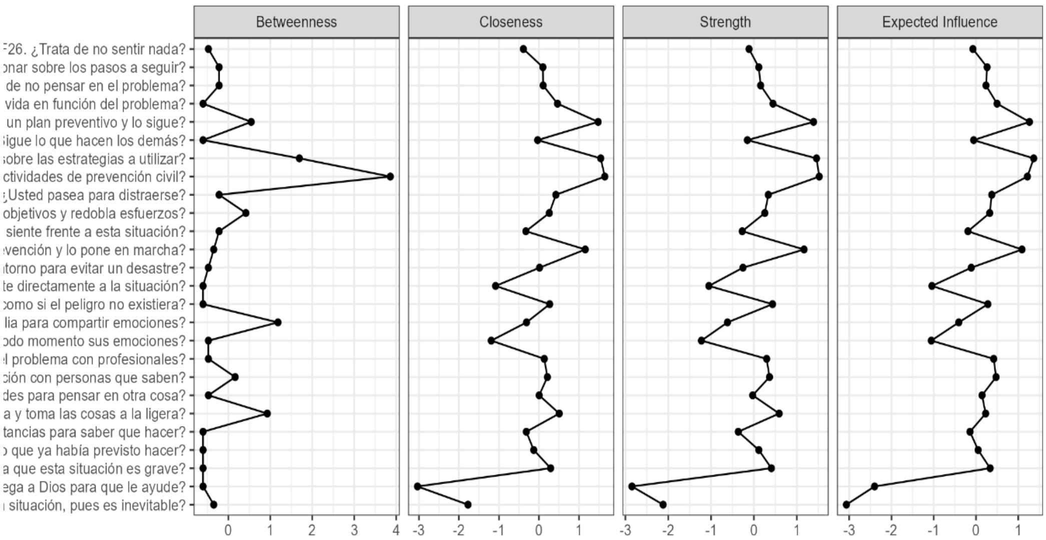

Fig. 1. Centrality of the perception of risk

In terms of clustering, the network appears to be organized into defined clusters, with inevitability and confrontation showing some structural independence. This suggests that these categories function autonomously in certain perceptual dynamics. The overall connectivity of the network is moderate, indicating that, although there is significant interaction between categories, not all nodes are directly linked, which could reflect a hierarchical cognitive process.

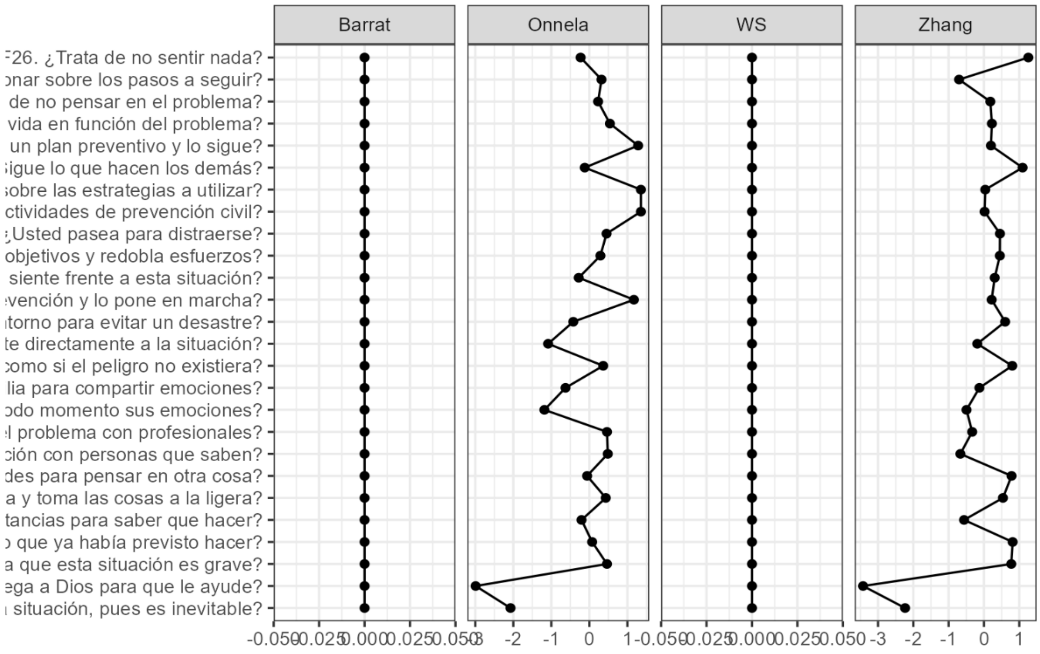

Fig. 2. Clustering of risk perception

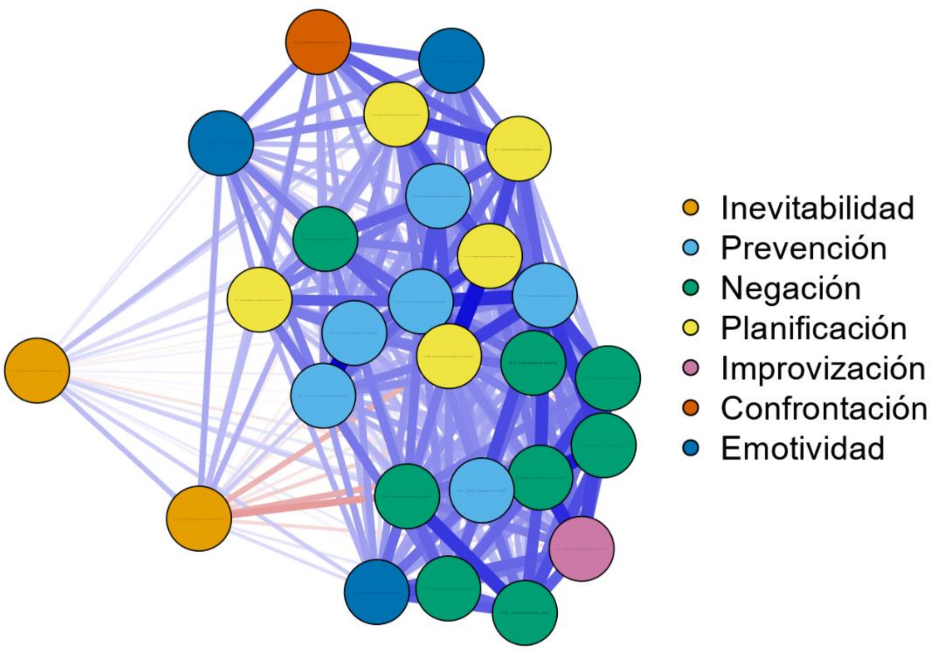

Fig. 3. Structuring the perception of risk

4. Discussion

From a theoretical perspective, the network can be interpreted under the framework of Bandura's (1986) perception theory, which emphasizes the role of previous experiences and self-efficacy in the formation of emotional and behavioral responses. The preponderance of categories such as planning and prevention reinforces the idea that individuals seek control and predictability in the face of uncertain scenarios. Likewise, Festinger's (1957) cognitive dissonance theory explains how confrontation and denial can emerge as responses to internal conflicts when perceived actions do not align with expectations.

Additionally, Watts and Strogatz's (1998) model of small networks and interconnected worlds allows us to explain the structure of the network. The presence of highly mediated nodes indicates the existence of "hubs" or key emotional categories that connect various perceptual dimensions. These patterns are consistent with previous studies on how emotions and thoughts interact in complex systems (Barabási, 2003).

Comparing the results with previous studies, such as those of Slovic et al. (2004) on risk perception, it is observed that categories such as planning and prevention tend to be associated with a greater sense of control and less uncertainty. This is consistent with the network analysis, where these categories stand out as central. Likewise, research on neural networks applied to decision making, such as that of Pessoa (2008), has indicated that emotions such as emotionality and improvisation significantly influence rapid evaluation processes, a finding consistent with the structure observed in this network.

Based on the state of the art and the reported patterns, the hypothesis that the relationships between the categories reported in the state of the art are different from the relationships observed in the neural network is rejected. Previous studies, such as those of Slovic et al. (2004), highlight that categories such as planning and prevention tend to be central in networks related to risk perception, a pattern that is also observed in the analyzed neural network, where these categories have high centrality and mediation. In addition, research such as that of Pessoa (2008) reinforces the importance of emotionality and its connection to rapid decision making, which is also reflected in the network structure. Although there may be slight variations in the specific connectivity or weight of certain categories, the general patterns are consistent with previous findings, indicating a correspondence between the theoretical relationships and those observed in this network. Therefore, the hypothesis should be rejected, as no significant differences are observed that invalidate the established conceptual framework.

The present analysis allows us to identify key emotional and perceptual categories that structure the way in which individuals face challenges. The graphical representation facilitates the understanding of the complex relationships between emotions and thoughts, which can be useful for designing intervention strategies in fields such as education or risk management.

One of the main limits of the analysis is its dependence on the method of network construction. Connections may be influenced by methodological decisions that do not fully reflect reality. In addition, theoretical interpretation requires empirical validation to ensure that the observed patterns are replicated in real contexts.

Future research could focus on analyzing dynamic networks that model how connections change over time or under different interventions. It would also be valuable to incorporate experimental data to validate the categories and relationships observed.

5. Conclusion

The analyzed neural network highlights the importance of categories such as planning and prevention in the structuring of perceptual and emotional processes. From a theoretical interpretation, the role of previous experiences and self-efficacy in decision making is highlighted. Compared to the state of the art, the idea that emotions and thoughts interact in complex ways in highly connected systems is reinforced. While the analysis offers valuable insights, empirical validation and exploration of dynamic networks is recommended for future research.

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