The Role of Emotions in Decision-Making Systems

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Abstract: This article is dedicated to the issue of recognizing the role of emotions in decision-making systems. It has been shown that emotions can play an important role in decision-making, as they have the ability to improve or worsen the decisions made. Emotions are considered a complex event involving both subjective, cognitive, and physiological components. Various discrete mathematical structures are proposed to describe both the decision-making systems themselves and the emotional processes. A method is proposed for embedding the model of emotions into the structure of decision-making systems. This leads to better decisions obtained through the generalized decision-making system. It has been demonstrated that the generalized model and management method automatically take into account the state of emotions. Since there is no unified theory that shows the relationship between emotion and decision-making, this problem is approached by many scientific disciplines such as psychology, neuroscience, cognitive science, and others. It is indicated that dependencies that account for the risk in executing individual decisions can be applied to the developed generalized decision-making model.

Keywords: Emotion, emotional state, emotion management, neuroscience, decision-making.

1. Introduction

Decision-making is part of the fast-paced daily life of individuals. Human emotions play their role and contribute to this process, whether decisions and choices are made correctly, small or large. Decision-making is a conscious or unconscious active action that is influenced by various conditions, expanding

cognitive processes, motivation, social interaction, and, not least, the individual's emotions. More and more researchers are exploring with enthusiasm and depth the role of emotions, tracing the function and interconnectedness of systems in decision-making. The ability to recognize, identify, and regulate emotions is a crucial indicator that influences the choice of any action. Emotions also influence how information in the environment is perceived and interpreted, leading to personalized decision making. This article is devoted to emotions and their influence on the decision-making process.

2. The Essence of Emotion

According to Lazarus [1], emotions are "complex systems of organized emotional experiences, physiological activations, expressive reactions, and changes in interpersonal interactions. This concept emphasizes the importance of emotional experiences, physiological reactions (such as changes in heart rate, breathing, and hormonal activity), expressive behavior, and interpersonal interactions.

Emotions are a fundamental component of human psychology and play an important role in daily life. They help us perceive and react to external events and stimuli, express our desires and aspirations, connect with others, and adapt to changing circumstances. Emotions influence how we make decisions, whether we think creatively, critically, and analytically, and how we relate to others. Mayer and Salovey [2, 3] found that emotions demonstrate individuals' relationships with the world and the people around them, as well as changes in these relationships. Emotional and cognitive knowledge are two separate aspects of mental activity that often collaborate with each other and manifest in tandem.

3. Theories of Emotions

According to Bar-On. [3, 4], emotionally and socially intelligent individuals are able to effectively connect and express their emotions, establish good relationships with others, and succeed in their daily responsibilities and challenges. They effectively cope with stress. This is due to individuals' ability to know themselves, be aware of their strengths and weaknesses. In the social sphere, this includes awareness of one's own and others' emotions, feelings, and needs, and the ability to form and nourish stable, cooperative, constructive, and egalitarian rewarding and satisfying partnerships.

Charles Darwin [5, 6] investigated emotional expressiveness in all its variations, considering it as an adaptation, a developed response by humans to cope with the challenges they encounter and to facilitate communication with others. He focused on emotional expressions such as facial distortions, gestures, body postures, and other forms of communication. In his book "The Expression of the Emotions in Man and Animals" published in 1872, Darwin explores his

discoveries regarding emotional expressiveness and its role in evolution. The book presents situations and illustrations of humans and animals expressing emotions such as pleasure, fear, anger, and others, while providing the reader with information about emotions and their role in human and animal behaviour.

According to the James-Lange theory [7, 8], emotions are not merely subjective experiences but rather the result of physiological reactions to specific stimuli. The theory states that when we encounter a stimulus, our body generates physiological responses such as changes in heart rate, breathing, or muscle tension, and these bodily changes give rise to subjective emotional experiences. In other words, our emotional experiences result from our perception of our bodily reactions to stimuli. The James-Lange theory shifts the focus to the bodily changes accompanying emotions and emphasizes their importance in the overall experience of emotions.

The Cannon-Bard theory [8] (also known as the theory of emotional stimulus-response) proposed in 1920 offers an alternative explanation of emotions compared to the James-Lange theory. According to the Cannon-Bard theory, emotional responses occur simultaneously with physiological changes and are independent of them. The Cannon-Bard theory states that emotional stimuli elicit emotional responses and physiological changes simultaneously. This means that, according to this theory, the emotional and physiological aspects of reactions occur in parallel and independently of each other. According to the Cannon-Bard theory, emotional responses and physiological changes represent two independent components of the emotional experience. This means that physiological changes do not cause emotions, and emotions are not the result of physiological changes.

Emotions influence our choices, judgments, and motivations in the context of decision-making. Positive emotions such as happiness, satisfaction, joy, and inspiration can push us to take actions that we perceive as productive. On the other hand, negative emotions such as fear, anger, sadness, dissatisfaction, or irritation can provoke us to avoid actions that we consider dangerous or unproductive.

In Stanley Schachter and Jerome Singer's two-factor theory (1962) [9], both physiological arousal and emotional experience are taken into account. According to their concept, emotions consist of two components: physiological and cognitive. Physiological arousal is interpreted in a context, which then generates emotional experience. The two-factor theory of Stanley Schachter and Jerome Singer is based on physiological experiences, which are a form of cognitive appraisal

The theory of prospect theory by Daniel Kahneman and Amos Tversky (1974) [10]. is crucial for studying decision-making processes in psychology and cognitive science. The idea suggests that there are two distinct pathways for decision-making: a fast and intuitive path and a slower, analytical approach. Emotions can influence both pathways of decision-making, but they have a greater impact on the first one. This theory provides a model for understanding how

people evaluate and make decisions under different conditions of risks and uncertainties

According to Daniel Kahneman and Amos Tversky's theory, decision-making involves two parallel pathways simultaneously. The first one is fast and automatic, based on intuition and emotions. This approach is known as "System 1." The second one is slower and relies on logical reasoning and analysis – "System 2".

"System 1" operates based on associations formed from previous experiences. When we encounter a certain object, "System 1" informs us that it is something we are already familiar with, eliminating the need for further investigation. On the other hand, "System 2" makes a slower and more conscious choice, involving effort and concentration. It is used when performing complex calculations or solving a problem that cannot be solely addressed through intuition.

For example, when calculating the probabilities of a specific event occurring. Although both routes are involved in decision-making, "System 1" takes the lead. This is a result of associative connections and emotions, which can be unreliable or hinder our ability to see the overall perspective.

People regularly rely on "System 1" for decision-making as it is the simplest and quickest approach to deal with problems. However, this method is not always the ideal one, especially when it comes to important choices requiring thoughtful consideration and thorough examination of the situation. They make mistakes due to cognitive biases that limit their processing and assimilation of information and decision-making, as well as incorrect assessment of possibilities.

The concept of the two systems of decision-making has significant implications in the field of psychology and business. Techniques have been developed to enhance professional decision-making and promote communication among individuals in society. Although both pathways are involved in the decision-making process, "System 1" is dominant and often leads to errors in decision-making.

In marketing, companies that focus on the emotional aspects of products often target "System 1" and aim to capture the attention of consumers by appealing to their emotions.

Antonio Damasio is a Portuguese-American neurologist and university professor who developed the theory of somatic markers. Somatic markers consist of emotional and physical reactions that arise when a person is faced with certain situations. These physical reactions can serve as signals and guide us in making decisions.

Damasio's theory of somatic markers [11] emphasizes the connection between emotions and decision-making. According to him, emotions are more than just mental experiences; they also involve physiological reactions in the body known as "somatic markers". These somatic markers act as signals, allowing a

person to assess the situation and make judgments based on their past experiences and preferences. Somatic markers are formed through observations and emotional experiences in specific situations and are linked to the neurological mechanisms responsible for processing our emotions. According to Damasio, the presence or absence of somatic markers can alter the quality of decision-making and adaptability to the environment. The theory of somatic markers is crucial for understanding the relationship between emotions, cognitive processes, and physiological reactions in the human brain This theory has applications in various fields, such as management and marketing. It can help in decision-making related to team management by providing signals on when it is necessary to make risky or conservative decisions. The somatic marker theory is applicable in different areas, including psychology, neurology, and marketing.

4. An Emotional Decision-Making System

With the advent and development of computer technologies, various mathematical models for decision-making in different management systems have emerged. Some models have been created where decisions are determined in a classical manner, and then the influence of emotions is taken into account in the results. In such an approach, a series of heuristics are used to reduce the complexity of the model, which does not guarantee obtaining optimal solutions.

This paper proposes a method that integrates the decision-making system and the model of emotions into a unified approach. This unified method increases the likelihood of obtaining optimal solutions.

Fig. 1 illustrates a graph, $G(X, U)$ with seven states of the controlled process [12, 13, 14].

$$X = \left\{ x_0, x_1, x_2, x_3, x_4, x_5, x_6 \right\}; \ \left| X \right| = 7; \tag{1}$$

where $|X|$ represents the cardinality of set X.
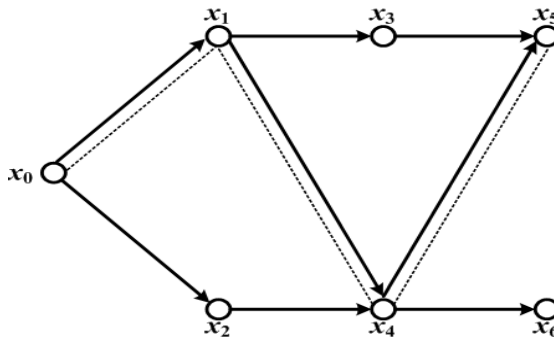
Fig. 1. Abstract decision-making system

And eight edges exist between these states, namely

$$U = \left\{ \left(x_0, x_1 \right), \left(x_0, x_2 \right), \dots, \left(x_3, x_5 \right), \left(x_4, x_6 \right), \left(x_4, x_5 \right) \right\}; \ \left| U \right| = 8; \qquad (2)$$

The arc $x_{ij} = (x_i, x_j)$ indicates the admissible transition of the control process from state x_i to state x_j

The arcs of the decision-making graph $G(X, U)$ and Fig. 1 are defined by the following arc functions and coefficients:

$$\left\{ f_{ij} \right\} = \left\{ f_{ij} \, / \left(x_i, x_j \right) \in U \right\}; \qquad (3)$$

$$\left\{ a_{ij} \right\} = \left\{ a_{ij} \, / \left(x_i, x_j \right) \in U \right\}; \qquad (4)$$

$$\left\{ k_{ij} \right\} = \left\{ k_{ij} \, / \, i \in X \right\}; \qquad (5)$$

where f_{ij} is a flow function on the edges, taking two discrete states $f_{ij} = 0$, representing the path – possibly optimal – and the sequence of decision-making; a_{ij} indicates the non-negative value that should be paid for the transition of the process from state x_i to x_j.

The coefficient k_i; $m \leq k_i \leq 1$; $m > 0$ allows for the adjustment of the multi-stage decision-making process from state x_i while considering the influence of emotions.

Optimizing the multi-stage process enables the selection of the best possible decision from each state $x_i \in X$, taking into account the influence of emotions through the coefficient k_i.

In Fig. 1, the conditionally calculated path G of optimal solutions is represented by dashed lines. This path consists solely of edges with a unitary edge function or value, i.e., $f_{ij} = 1$. The edges outside the path G have zero edge functions $f_{ij} = 0$.

The graph in Fig. 1 is an abstract mathematical structure $G(X, U)$ allows for the search of optimal solutions by interpreting the problem of finding optimal network flow solutions on this graph. The same objective can be achieved by using the problem of finding optimal solutions through the network transportation problem. The structure of the transportation problem, the shortest path problem, and others can also be employed for the same purpose.

5. Conclusions

Based on the proposed model for decision-making with emotional considerations, the following conclusions and recommendations can be drawn. Emotions have

been shown to play a significant role in decision-making processes. They can have both positive and negative influences on these processes, meaning they can either enhance or impair the decisions made. In the former case, they induce fear and anxiety, while in the latter, they assist in making effective decisions.

Assessing emotions, both by the individual and by other specialists, is a crucial step in recognizing and understanding them. Various techniques from psychology can be employed to formulate new and more effective solutions.

A discrete mathematical structure is proposed for describing decision-making systems on one side and emotions on the other. A method has been developed for incorporating the emotional model into the structure of decision-making systems. It is indicated that such a comprehensive model, with appropriate parameter selection, leads to more effective decisions. It is noted that in such a generalized decision-making model, risks associated with different choices can also be introduced. This will enhance the quality of the decisions made.

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