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The Influence of Cultural Differences on the Neural Mechanisms of Risky Decision-Making

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Abstract. Risky decision-making is an important cognitive process involved in financial, health-related, social and everyday decisions. Previous research suggests that individuals from different cultural backgrounds may differ in risk preference, information processing, and the evaluation of probability and potential outcomes. However, cultural differences cannot be understood solely through behavioral outcomes because similar choices may result from different cognitive and neural processes. This paper reviews research on the relationship between culture, risky decision-making, and the neural systems involved in risk processing. Existing evidence suggests that culture may influence risky decision-making by shaping information processing, self-construal, and the subjective evaluation of probability, reward and loss. These influences may further affect how common neural systems involved in value evaluation, reward processing, uncertainty and cognitive control process information. However, culture should not be viewed as a deterministic factor because substantial individual differences exist within cultural groups. Overall, cultural experience appears to function as an important modulator of the cognitive and neural processes underlying risky decision-making.

Keywords: culture, risky decision-making, risk preference, neuroscience, decision-making

1. Introduction

Risky decision-making is a fundamental component of human cognition and behavior. Many everyday decisions involve uncertainty regarding possible outcomes, including decisions about money, health, education, relationships and future planning. Individuals often need to choose between a relatively certain outcome and an alternative that offers a potentially greater reward but involves greater uncertainty.

Neuroscientific research has demonstrated that risky decision-making depends on multiple interacting brain systems rather than a single decision center. Processes related to value evaluation, reward processing, emotional responses, uncertainty and cognitive control all contribute to decision-making. Neuroimaging meta-analyses have identified both common and distinct neural mechanisms associated with different forms of risky behavior [1-3].

At the same time, decision-making does not occur in a cultural vacuum. Culture influences social learning, values, beliefs, self-construal and patterns of information processing. These factors may shape how individuals attend to information and evaluate possible outcomes. Cross-cultural research

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therefore raises an important question: when people from different cultural environments make risky decisions, do cultural differences influence only their final choices, or do they also influence the cognitive and neural processes used to reach those choices?

This question is important because behavioral outcomes alone cannot always reveal the processes underlying a decision. Two individuals may make the same risky choice while focusing on different information or assigning different subjective values to the available outcomes. Neural measures can therefore provide additional insight into how cultural experiences may influence decision-making.

The purpose of this paper is to examine how cultural differences may influence risky decision-making and the neural mechanisms underlying these differences. It focuses on three questions: what neural systems are generally involved in risky decision-making, how culture may influence risk-related cognition and behavior, and how cultural experiences may modulate the processing of probability, reward, loss and uncertainty.

2. Risky decision-making and its neural basis

2.1. Risk, uncertainty and individual differences

Risky decision-making refers to situations in which individuals make choices involving outcomes that differ in both value and uncertainty. A risky option may offer a greater potential reward while also increasing the possibility of a negative outcome. Decision-makers must therefore weigh potential benefits against potential costs.

A distinction can be made between risk and uncertainty. Risk generally refers to situations in which probabilities are known or can be estimated, whereas uncertainty refers to situations in which probabilities are unknown or difficult to determine.

Individuals also differ in their tendencies toward risk seeking or risk aversion. Risk-seeking behavior involves a greater willingness to choose uncertain options with potentially larger rewards, whereas risk aversion involves a preference for more certain outcomes. Meta-analytic evidence suggests that these tendencies involve both shared and distinct neural mechanisms [2]. Therefore, risk preference should not be viewed as a fixed characteristic. Instead, it may reflect reward sensitivity, emotional processing, cognitive control, and situational factors.

Research comparing adolescents and adults also demonstrates that risk-taking is influenced by multiple biological and developmental factors [3]. Cultural experience may represent another important source of variation.

2.2. Neural systems involved in risky decision-making

Risky decision-making involves several interconnected neural systems. The prefrontal cortex contributes to planning, cognitive control, and the integration of information during complex decisions.

The ventromedial prefrontal cortex (vmPFC) is commonly associated with value-based decision-making. Potential rewards and costs must be integrated into subjective values before individuals choose between different options.

Reward-related systems, including the striatum, are also relevant because risky options often involve the possibility of desirable outcomes. Interactions between reward-related systems and prefrontal control systems may influence whether a potential reward is pursued despite uncertainty.

Other regions, including the anterior insula and anterior cingulate cortex (ACC), have been associated with processes related to uncertainty, salience, conflict monitoring, and behavioral

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adjustment. Together, these findings support the view that risky decision-making depends on distributed neural networks involving value evaluation, reward processing, emotional responses, and cognitive control [1-3].

Cultural influences may therefore affect risky decisions not by creating entirely different neural systems, but by shaping how information is processed within common decision-making networks.

3. Cultural differences in risky decision-making

3.1. Culture and risk perception

Culture may influence how individuals understand and respond to risk. Cultural environments provide patterns of social learning, values, norms, and expectations that can shape beliefs about desirable or appropriate behavior. Consequently, the same risky choice may have different psychological meanings in different cultural contexts.

Research on cultural approaches to risk emphasizes that perceptions of risk are influenced by social and cultural frameworks rather than objective information alone [4]. People may interpret the same possible outcome differently depending on their values, social environment, and expectations. Risk perception therefore cannot be understood solely as a response to numerical probability.

However, cultural differences should not be reduced to the assumption that one cultural group is generally more risk-seeking while another is more risk-averse. Cultural groups are heterogeneous, and individuals within the same group do not necessarily share identical risk preferences. For instance, an individual may exhibit risk aversion in financial matters while demonstrating a willingness to embrace social or professional risks.

Therefore, culture may influence the specific processes used to evaluate risk rather than producing a fixed tendency toward risk seeking or risk avoidance. This shifts attention from the question of which group takes more risks to the question of how risk is interpreted and evaluated.

3.2. Information processing and cultural orientation

One possible explanation for cultural differences in risky decision-making is variation in information processing. Cross-cultural psychology has frequently examined relatively analytic and relatively holistic patterns of cognition. Analytic processing tends to focus more strongly on focal objects and individual attributes, whereas holistic processing gives greater attention to relationships, context, and interactions among multiple factors.

These differences may be relevant to risky decision-making because risk information often includes several components, such as probability, reward magnitude, potential loss, and contextual consequences. Individuals who focus primarily on numerical probability may process a risky option differently from individuals who give greater attention to relationships or broader contextual consequences.

Cultural neuroscience provides evidence that cultural experience can be associated with differences in neural processing. Han and Ma's quantitative meta-analysis identified cultural differences in human brain activity across multiple cognitive domains [5]. These findings do not imply that every member of a cultural group processes information in the same way, but they support the relevance of cultural context to the study of the brain.

Self-construal may also influence risky decision-making. Independent self-construal emphasizes personal autonomy and individual goals, whereas interdependent self-construal places greater

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emphasis on relationships and social roles. These orientations may influence which consequences are considered important during risky decisions.

Importantly, self-construal should not be treated as identical to nationality. Individuals within the same country may differ substantially in cultural orientation. For this reason, research based only on national group membership may overlook important individual differences.

4. Neural mechanisms of cultural differences in risky decision-making

4.1. Probability and value processing

Probability processing is a central component of risky decision-making. Individuals must estimate the likelihood of possible outcomes and integrate this information with potential gains and losses. Cultural differences in attention and information processing may therefore influence how probability contributes to value-based decisions.

Chuang, Su and Goh [6] examined culture-related differences in the neural processing of probability during mixed lottery value-based decision-making. This research is particularly important because it moves beyond comparisons of final behavioral choices and examines how probability information is processed during the decision itself.

Cultural experiences may influence the subjective importance assigned to outcomes. Because value-based decisions integrate probability, rewards and losses, cultural values may affect how these outcomes are processed within common neural systems.

Neural measures can therefore reveal processes that are not visible through behavioral outcomes alone.

4.2. Cognitive control, emotion and uncertainty

Risky decision-making requires interactions between cognitive control and affective processes. Prefrontal systems contribute to the regulation and integration of information, while other neural systems contribute to responses related to reward, uncertainty and potentially negative outcomes.

Culture may influence the balance among these processes by shaping the meaning of rewards, losses, and social consequences. For example, an uncertain outcome may be evaluated primarily in terms of individual gain in one context but may also be considered in relation to family, social responsibility, or interpersonal consequences in another context.

These differences may influence the information that receives the greatest weight during decision-making. However, cultural neuroscience does not support the idea that different cultural groups possess completely separate decision-making systems. Instead, cultural experiences may influence how common neural mechanisms are recruited and what information is emphasized during cognitive processing.

This interpretation is consistent with broader evidence showing that culture can be associated with differences in neural activity during cognitive and social tasks [5].

4.3. Reward and risk networks

Reward processing is another possible pathway through which culture may influence risky decision-making. Risky choices are often attractive because they offer the possibility of obtaining a valuable reward. However, the subjective meaning of a reward may differ according to personal goals, social norms, and cultural expectations.

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The striatum plays an important role in reward-related processing, while prefrontal systems contribute to integrating reward information with goals and other considerations. Cultural influences on goals and values may therefore affect how reward-related information is evaluated during risky decisions.

Research has also examined cultural modulation of risky exploration [7]. Cultural factors may influence how this trade-off is evaluated.

Rather than assuming that culture directly changes one specific brain region, it may be more accurate to view cultural influences as affecting interactions among systems involved in reward, uncertainty, value evaluation, and cognitive control.

4.4. Evidence from neuroimaging and electrophysiological research

Cross-cultural neuroimaging studies provide evidence that cultural experiences may be associated with differences in brain activity during complex cognitive tasks. Functional magnetic resonance imaging (fMRI) allows researchers to examine neural activity while participants process probability, reward, loss, or uncertainty.

The study by Chuang et al. [6] is particularly relevant because it examined culture-related differences in neural processing during value-based decisions involving probability. Such research suggests that cultural effects may occur during specific stages of cognitive processing rather than appearing only in final behavioral outcomes.

EEG and event-related potential (ERP) methods provide another useful perspective because of their high temporal resolution. Research has identified cultural differences in neural responses during moral decision-making [8].

Other studies have examined risk-related neural processes in culturally specific contexts. Research has investigated neural correlates associated with advantageous risk-taking in a traditional Chinese medicine context [9]. More recent work has also explored neural oscillations related to the foreign-language effect on risk-taking [10]. Together, these studies suggest that culture and language may influence risk-related cognition through multiple pathways.

However, neuroimaging findings must be interpreted cautiously. Differences in brain activation do not automatically demonstrate that culture directly causes a particular neural response. Education, language, socioeconomic conditions, and other environmental experiences may also contribute to observed differences.

5. Discussion

The evidence reviewed in this paper suggests that culture may influence risky decision-making through several interconnected processes. Cultural experiences may shape how individuals attend to information, interpret social context, and assign subjective value to possible outcomes. These differences may subsequently influence the evaluation of probability, reward, loss, and uncertainty.

A major implication is that cultural differences may be better understood as differences in processing strategies rather than simple differences in the amount of risk-taking. Two groups may show similar behavioral outcomes while relying on different cognitive processes.

Neuroscience methods are therefore valuable because they allow researchers to examine processes that cannot always be identified through behavioral measures alone. Combining behavioral tasks with fMRI or EEG can provide a more complete understanding of how cultural factors relate to decision-making.

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However, culture should be understood as a modulator rather than a deterministic force. Cultural environments influence learning and values, but they do not determine the behavior of every individual. Broad comparisons between cultural populations may identify possible patterns, but these categories contain substantial internal diversity.

Future research should therefore examine both group-level cultural background and individual-level cultural orientation. Measures such as self-construal, cultural values, bilingual experience, and acculturation may provide more precise information than nationality alone. Future studies should also include a wider range of cultural populations.

Current research also has methodological limitations. Studies do not always use the same definition of culture, and risky decision-making tasks vary in probability structures, reward values, and social contexts. Differences between studies may therefore reflect task design as well as cultural variation.

Finally, most neuroimaging studies are correlational. Although fMRI and EEG can identify relationships between cultural factors and neural processing, they cannot independently demonstrate that culture causes a specific neural difference. Longitudinal research may provide stronger evidence regarding causality.

6. Conclusion

Risky decision-making is a complex cognitive process that requires individuals to evaluate uncertainty, probability, potential rewards and possible losses. Existing neuroscience research demonstrates that these decisions depend on interactions among neural systems involved in value evaluation, reward processing, uncertainty, emotional responses and cognitive control.

The evidence reviewed in this paper suggests that culture may influence risky decision-making by shaping the cognitive frameworks used to process and evaluate information. Cultural experiences may influence attention, information integration, self-construal, value judgment and the subjective meaning assigned to rewards and losses. These differences may subsequently affect how common neural systems process information during risky decisions.

Cross-cultural neuroscience research provides evidence that cultural factors can be associated with differences in neural activity during complex cognitive processes, including probability processing and value-based decision-making. However, cultural differences should not be interpreted as evidence that different populations possess completely different decision-making systems. Human beings share common neural mechanisms, while cultural experience may influence how these mechanisms prioritize and integrate information.

Future research should move beyond simple comparisons between broad cultural groups and combine group-level cultural background with individual measures of cultural orientation. Integrating behavioral methods with fMRI, EEG and other neuroscientific approaches may provide a more precise understanding of how cultural experiences influence the brain.

Overall, culture appears to function as an important context in which risky decision-making develops and operates. Rather than creating entirely different neural systems, cultural experiences may shape how shared decision-making networks process and evaluate information. Understanding this relationship may contribute to a more complete account of human cognition that recognizes both biological mechanisms and cultural environments.

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