Study on the Relationship between Working Memory Capacity and Decision Bias in Tennis Players under High-Pressure Situations

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Abstract: Tennis players under high-pressure situations face complex decision contexts, and working memory capacity shows a clear influence on their decision outcomes. High-pressure states increase the mental burden of athletes and may disturb the way they process incoming information, which leads to decision bias during performance. This study aims to examine how working memory capacity affects the decision process of tennis players when they are in high-pressure situations. Through experimental design, different levels of tennis players completed working memory tests together with decision-making tasks, and their performance was analyzed under both high-pressure and regular conditions. Results from statistical analysis showed that athletes with larger working memory capacity could integrate information more effectively under stressful settings, and they tended to produce better decisions. Athletes with smaller working memory capacity showed more frequent decision bias, such as wrong selections and missed timing. The study indicates that improving working memory capacity can enhance decision performance under high pressure, and this offers a new view for research within sport psychology while also providing direction for training and psychological skill development among tennis players.

1. Introduction

1.1. Research Background

High-pressure situations are common in competitive sports, and tennis, as a sport requiring fast responses and strategy execution, often exposes athletes to pressure from match outcomes, opponent performance, and audience expectations. Under such conditions, athletes need to integrate multiple sources of information quickly and then make the most suitable choice, which reflects the core function of working memory. The limits of working memory capacity become especially clear in high-pressure situations and turn into a key factor influencing the quality of decisions. When athletes face heavy mental and physical stress, the effectiveness of working memory becomes weak, their processing of information slows down, and judgment errors begin to appear, which lead to decision bias. When working memory capacity is insufficient, accuracy and timing in decision performance decline under heavy task load, and this often causes athletes to perform below their normal level at important match moments. Many elite athletes maintain stable performance in major matches, and this is closely connected with strong working memory function. Studying how working memory capacity influences decision bias under high-pressure settings helps explain psychological and behavioral patterns under extreme competition, and it provides valuable theoretical support. This study is useful for designing training strategies that strengthen sport performance, increase decision quality during matches, and improve overall competitive outcomes.

1.2. Research Significance

Studying the relationship between working memory capacity and decision bias in tennis players under high-pressure conditions holds important theoretical and practical meaning. At the theoretical level, the study deepens understanding in both sport psychology and cognitive science and clarifies the key role of working memory in decision making during sports. Examining how working memory

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capacity influences information processing and decision accuracy under high-pressure situations offers a new view on how athletes make decisions when they face tense competition. It also provides real evidence for expanding and refining related theoretical models. At the practical level, findings from this research guide athlete training as well as psychological support. By identifying the relation between working memory capacity and decision bias, coaches and sport psychology specialists can design targeted training methods to help athletes enhance working memory ability and improve decision quality under stress. These results also provide evidence for psychological preparation and emotional control before competition, allowing athletes to adapt better to competitive pressure and improve their performance. Overall, this study brings new ideas for theory building and offers practical suggestions with clear applied value.

2. Related Concepts and Theoretical Basis

2.1. Related Concepts

2.1.1. Working Memory Capacity

Working memory capacity refers to an individual's ability to store, process, and retrieve information within a limited period of time, and it is a major concept in cognitive psychology [1]. Working memory is treated as a core part of the cognitive system that handles information receiving, encoding, and output. According to the model proposed by Baddeley and Hitch, working memory is made up of the central executive system, the phonological loop, and the visuospatial sketchpad [2]. The central executor coordinates incoming information, while the phonological loop processes sound-based input, and the visuospatial sketchpad processes visual and spatial information. Working memory capacity is often measured through short-term tasks such as digit span tests, which indicate how much information an individual can process effectively within a short time window. Under high-pressure situations, the limits of working memory become more obvious, and the ability to process information declines, leading to lower decision efficiency. When athletes face complicated match settings, limited working memory capacity prevents them from integrating different types of information, which affects judgment of technical and tactical actions. Lack of capacity increases cognitive load, and decision bias appears in forms such as wrong selections and slow reactions. These outcomes influence match performance directly. Therefore, improving working memory capacity becomes an important part of training, and this offers practical meaning for sport psychology.

2.1.2. Decision Bias in Sports

Decision bias in sports refers to wrong judgments or choices when athletes make decisions, and these appear when cognitive processing or mental state is disturbed [3]. In competitive settings, decision bias often shows in technical errors, poor tactical selections, or slower responses. The bias forms when cognitive load rises under pressure and when athletes fail to manage information accurately. Decision bias is affected by mental conditions, attention distribution, and working memory capacity. Under high pressure, athletes face more sources of distraction such as opponent performance, audience expectations, and time limitation, and these stress factors increase anxiety and affect decision making. When working memory capacity is low, athletes are easily influenced by emotional reactions and cannot maintain rational thinking in fast-changing match conditions, causing decision quality to fall. The consequences of decision bias often influence match outcomes, damage athlete confidence, and create negative mental reactions.

2.2. Theoretical Basis

2.2.1. Working Memory Theory

Working memory theory, proposed by Baddeley and Hitch, forms the basic framework for understanding how information is processed [4]. It includes the central executive system, which manages and controls information, the phonological loop, which handles sound-based input, and the visuospatial sketchpad, which processes visual and spatial information. In intense match environments, athletes must store and process information rapidly, and when working memory

capacity is limited, processing efficiency declines and decision errors appear. Athletes with larger capacity integrate information better and tend to perform at a higher level. Time pressure, opponent strength, and situational demands influence how cognitive resources are allocated, which affects decision outcomes.

2.2.2. Decision-Making Theory

Decision-making theory studies how individuals make choices in uncertainty and complexity. In the field of sports, it explains how athletes can quickly evaluate the situation, opponents and their own state under high pressure to make the best response. The decision-making process includes information collection, program selection and other steps. High pressure will increase the cognitive load, resulting in slow information processing or misjudgment, decision-making deviation, anxiety and other emotions will inhibit decision-making ability. Decision-making theory is applied to training. By simulating high-pressure situations, it can help athletes improve their decision-making ability and adaptability in a stressful environment and optimize competitive performance.

3. Mechanisms of the Influence of High-Pressure Situations on Working Memory Capacity

3.1. Influence of Physiological Stress Response

High-pressure situations will activate athletes' physiological stress, such as accelerated heart rate and increased secretion of adrenaline and cortisol. Although this can improve the body's alertness, excessive stress hormones will inhibit the function of the prefrontal lobe, and the prefrontal lobe is the key brain area responsible for working memory and complex decision-making. Damage to the function will directly limit the working memory capacity and reduce the flexibility of information processing, resulting in athletes making mistakes in judgment and decision-making deviations in the competition.

3.2. Changes in Attention Resource Allocation

High-pressure situations will increase the cognitive load and make the distribution of limited attention resources tense. Athletes have a "tunnel vision", that is, excessive attention to a certain information (such as opponent's movements) and ignore his key factors (such as their own position), resulting in one-sided decision-making and mistakes. Negative emotions such as anxiety will aggravate attention imbalance and reduce flexibility. Optimizing attention distribution is the key to maintaining working memory capacity under high pressure.

3.3. Interference from Emotional States

Negative emotions such as anxiety and tension under high pressure will occupy a large amount of cognitive resources and directly limit the working memory capacity, resulting in rigid thinking and difficulty in adjusting strategies flexibly. Emotional fluctuations will cause physiological anti-interference with attention distribution and information integration such as accelerated heart rate. When athletes pay excessive attention to the results of the game or their own performance, it is easy to ignore key information and produce decision-making deviations. Improving emotional regulation ability is very important to improve decision-making under high pressure.

4. Analysis of the Association between Working Memory Capacity and Decision Bias in Sports

4.1. Influence of Working Memory Capacity on Information Processing

In high-pressure tennis, the working memory capacity directly affects the information processing and decision-making quality of athletes. Large-capacity athletes can quickly integrate multi-source information such as opponent dynamics, their own technology and the situation on the field, form a comprehensive cognition, and quickly and accurately reduce the risk of decision-making mistakes [5]. When serving, they can weigh the opponent's position, standing wind speed and other factors at the

same time. Insufficient capacity, it is easy to lead to narrow attention, ignoring key information and judging mistakes. Improving working memory capacity through cognitive training is the key to improving the information processing ability of athletes under high pressure and improving competitive performance.

4.2. Working Memory Capacity and the Selection of Decision Strategies

Athletes with working memory capacity can formulate and adjust the efficiency of decision-making strategies. Athletes with large capacity can comprehensively evaluate the opponent's style, their own situation and competition situation, formulate targeted tactics, and adjust flexibly under high pressure. In the face of strong enemies, they can optimize the batting strategy and position in real time, while athletes with insufficient capacity are prone to rigid strategies, over-reliance on intuition, and ignore changes in the field. High anxiety will interfere with working memory and affect decision-making. Scientific training can enhance working memory capacity, which can help athletes formulate more flexible and effective strategies under high pressure and improve overall competitiveness.

4.3. Dynamic Relationship between Working Memory Capacity Changes and Decision Bias

There is a dynamic relationship between changes in working memory capacity and decision-making bias. In high-pressure situations, the relationship is obvious. When athletes' working memory capacity is at a high level, they process and integrate a large amount of information more effectively and make reasonable decisions in complex competition environments [6]. In this situation, athletes pay attention to multiple important factors at the same time, such as the opponent's tactics, the progress of the game and their own technical state, which helps to improve the accuracy and timeliness of decision-making. When the working memory capacity decreases or is affected by external pressure, athletes will encounter the problem of excessive cognitive load, resulting in an increase in decision-making deviation. In high-pressure situations, athletes are easily distracted and emotional fluctuations intensify, resulting in their inability to effectively process information at critical moments. They will ignore important local information or inappropriate reactions. Athletes are nervous in the game and unable to accurately evaluate the opponent's actions and make wrong tactical decisions.

5. Strategies for Reducing Decision Bias in Tennis Players under High-Pressure Conditions

5.1. Psychological Training Strategies

5.1.1. Pressure Coping Training

Pressure coping training improves athlete performance under high-pressure conditions. Through training in effective skills and mental strategies, athletes manage stress responses. They should learn to understand their stress sources and identify situations that cause anxiety and nervousness during matches. This can be done by recording match experiences and emotional reactions. Understanding personal coping patterns helps athletes form more targeted response strategies. Pressure management skills such as deep breathing, muscle relaxation, and mindfulness meditation help reduce tension before and during matches [7]. Deep breathing lowers heart rate and helps athletes remain calm. It improves concentration and reaction speed. Muscle relaxation helps reduce physical tension and supports flexible movement. Simulating match settings is also important. By setting pressure conditions similar to real matches, athletes gradually adapt to pressure and develop mental resilience. Coaches can add time limits or score pressure during training, so athletes learn how to remain calm and make suitable decisions.

5.1.2. Attention Training

Attention training is an important strategy to improve the performance of tennis players in high-pressure situations. Through systematic training methods, athletes can improve their concentration and adjustment ability to meet the needs of complex competitions. Athletes need to train to improve

concentration. They can exercise their attention by focusing on specific goals or tasks. Using visual tracking exercises, athletes can focus on changes in ball trajectory in training, improve sensitivity to fast-moving objects, and enhance information processing ability. Distributed attention training can help athletes learn to weigh multiple information in complex competition environments. In training, coaches can design multiple task exercises at the same time, so that athletes can receive instructions from their teammates while hitting the ball, and improve their attention distribution ability and multitasking ability. Training helps athletes better cope with the opponent's dynamic changes and complex situations on the field in the game. Psychological training plays an important role in attention training. Athletes can enhance their resistance to internal and external interference through meditation and mindfulness exercises. Mindfulness training helps athletes learn to pay attention to the present, reduce sensitivity to external noise, maintain inner calm, and improve concentration in the game [8].

5.2. Cognitive Training Strategies

5.2.1. Working Memory Training

The core of training is to improve the working memory capacity of athletes through systematic exercises, and integrate and utilize information more effectively in a stressful environment. The use of memory load tasks can effectively stimulate the working memory of athletes. The use of digital span tasks or alphabetic sequence recall to allow athletes to remember and reproduce a series of information in a specific time, exercise memory ability and concentration skills. Combined with functional training strategies is an effective means to improve the working memory capacity. By designing multi-tasking line processing training, specific language instructions or tactical choices at the same time, it can directly improve the ability of athletes to integrate information in complex situations. This kind of training helps athletes quickly analyze the technical state of their own movements in the game and make accurate decisions. In the training process, situational simulation is very important. By simulating the high-pressure situation in the real game, athletes carry out working memory training under pressure to help them gradually adapt to the complex competition environment. Teamwork and interactive training increase confrontation and challenge, and promote athletes to improve their cognitive ability in social interaction. Combined with the feedback mechanism, working memory training effectively consolidates the training effect. Coaches give feedback to athletes from time to help identify strengths and weaknesses, and improve the training effect in a targeted manner. Through the comprehensive application of the above methods, working memory training significantly improves the performance of athletes in high-pressure situations, reduces decision-making deviation, and enhances competitive ability.

5.2.2. Decision-Making Thinking Training

Through systematic training, athletes can effectively assess the situation in a rapidly changing competition environment and formulate scientific and reasonable tactical choices. Athletes can use situational case analysis training to solve the best strategies and reasons for mistakes in specific situations by analyzing decision-making examples in previous competitions. Training helps athletes quickly make rational judgments in the face of similar situations. The introduction of tools such as decision trees and tactical simulations can effectively improve the decision-making ability of athletes. In training, the coach can help athletes build a decision tree, analyze the results of different tactical choices, and promote the thinking flexibility and execution ability of athletes in complex situations by repeatedly deducing different tactical paths. Tactical simulation training can allow athletes to practice different tactical choices under pressure, help the combination of physical memory and thinking response, and be effectively applied in the competition. Psychological situational training is equally important [9]. By adding a sense of urgency and external pressure in the simulation environment, athletes practice decision-making thinking under stressful conditions, hone their coping ability, and train them to gradually adapt to high-pressure situations, stay calm, effectively integrate information at critical moments, and make the best decisions.

5.3. Strategy Adjustment during Matches

5.3.1. Pre-Match Preparation

Pre-match preparation is an important link for tennis players to ensure good performance under high-pressure situations. Through effective preparation, athletes can enhance their self-confidence, improve their working memory capacity, and optimize their decision-making ability. Psychological preparation is a key link in pre-match preparation. Athletes should use methods such as mindfulness meditation and self-suggestion to regulate their emotional state. Psychological adjustment skills help athletes reduce anxiety before the game, stay calm, and cope with the pressure brought by the game. Athletes need to make a detailed competition plan and clearly deal with the tactical arrangements of different opponents in the game. By analyzing the video and statistics of the opponent's game, athletes can formulate strategies suitable for themselves and improve their sensitivity to the game situation. Pre-match technical training and tactical drills are very important. Athletes should repeatedly simulate the game situation in training, exercise their technical details and tactical applications, so as to flexibly cope with various situations in the real game. Diet and physical fitness management are aspects that cannot be ignored in pre-game preparation. Athletes should reasonably adjust their diet and hydration according to the time and intensity of the competition, and provide sufficient energy for the body to support various technical movements. Proper rest and recovery training can enable athletes to maintain the best competitive state and avoid fatigue affecting performance.

5.3.2. Adjustment during Matches

Adjustment during matches is essential. It improves working memory and reduces decision errors. Athletes must evaluate situation changes rapidly and respond flexibly. Observing opponent movements, tactical changes, and personal condition is basic. Athletes should track match progress and identify weaknesses [10]. When they detect weaknesses, they increase tactical pressure to gain advantage. Emotional regulation during matches is key. Through deep breathing and positive cues, athletes sustain emotional balance and avoid negative reactions. Proper regulation supports effective working memory use. Communication with coaches is important. Coaches make observations and provide real-time tactical advice. This helps athletes make accurate decisions at critical times.

6. Conclusion

Working memory capacity and decision bias show a close connection under high-pressure conditions. High-pressure conditions increase cognitive load and reduce working memory effectiveness, which raises decision error risk. Improving working memory capacity enhances information processing ability and supports flexible tactical reactions during matches. Practical implementation should focus on psychological training, attention training, and cognitive training. These improve working memory ability and coping ability under pressure. Pre-match preparation reduces decision errors. Athletes form structured plans and conduct scenario simulation, which helps them adapt to stress. Real-time adjustments and emotional regulation during matches support correct decisions at key moments. Future research should examine working memory and decision performance across different sports and consider physiological and psychological factors. This will provide scientific training strategies and support development in sport psychology.

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