Original Article

Exploring cognitive processing speed, emotional intelligence, and topspin shot accuracy in table tennis

JEKI HARYANTO[1], IVAN MALAGOLI LANZONI[2], ANDREAS NIKOLAKAKIS[3], CLEMENS DRENOWATZ[4], EVAL EDMIZAL[1], BERTO APRIYANO[5], PADLI[1], MIODRAG MILOVANOVIĆ[6], TAMARA LUKÁČOVÁ[7], BORYI BECERRA-PATIÑO[8]
[1] Coaching Department, Faculty of Sport Science, Universitas Negeri Padang, INDONESIA
[2] Department for Life Quality Studies, University of Bologna, ITALY
[3] Department of Physical Education and Sports Science. Democritus University of Thrace, GREECE
[4] Division of Sport, Physical Activity and Health, University of Education Upper Austria, AUSTRIA
[5] Department of Physical Education, Faculty of Sport Science, Universitas Negeri Padang, INDONESIA
[6] Faculty of Physical Education and Management of Sports, Singidunum University, SERBIA
[7] Department of Music, Art and Physical Education, Faculty of Education, University of Presov, SLOVAKIA
[8] Group Management and Pedagogy of Physical Activity and Sports (GPAFD), Faculty of Physical Education, National Pedagogical University, COLOMBIA

Abstract
Problem: Achieving accuracy in topspin shots is crucial for table tennis players to secure victories. Understanding the psychological factors influencing this skill is imperative for achieving success. **Objective:** This study aims to investigate the correlation between cognitive processing speed (CPS) and emotional intelligence (EI) with topspin accuracy (TPA) in table tennis. Recognizing the significance of these psychological factors, the research seeks to shed light on their impact on topspin performance. **Method:** Employing a quantitative approach, this study uses a correlation method to examine the relationships between CPS, EI, and TPA. A total of 89 participants, with an average age of 19.10±0.30 years engaged in this study. Data on topspin accuracy was collected by administering a topspin accuracy test, followed by administering a cognitive processing speed test and completing an emotional intelligence questionnaire. Spearman-Rho tests were used to determine the association between the variables. **Result:** The study reveals noteworthy findings: (1) a positive relationship between cognitive processing speed and topspin accuracy (r = 0.372, *p* < 0.05). (2) there is a positive relationship between emotional intelligence and topspin accuracy (r = 0.380, *p* < 0.05). These results underscore the significance of both cognitive processing speed and emotional intelligence in influencing topspin accuracy. **Conclusion:** Cognitive processing speed and emotional intelligence affect topspin accuracy. Coaches and practitioners are urged to take cognizance of these psychological components when designing training programs, emphasizing the need to enhance both cognitive processing speed and emotional intelligence for optimizing topspin performance in the sport. This research contributes valuable insights for coaches, athletes, and sports psychologists, facilitating a comprehensive understanding of the psychological dynamics involved in achieving precision in topspin shots.
Keywords: intelligence capability, emotion state, cognitive response, stroke precision, accuracy in racket sport.

Introduction

Table tennis is a high-speed sport (Z. Zhang, 2022) that requires speed and accuracy. As the ball travels quickly between the areas of the two opponents, players only have a short time to process information that will determine their return (e.g., ball placement, speed) (Takami et al., 2022). Accordingly, table tennis players must practice their ability to anticipate the arrival of a fastball (Ren et al., 2022). In today's sports, where speed is increasingly valued, proper ball placement is critical for victory. In today's sports, where speed is increasingly valued, proper ball placement is critical to victory (Signorile et al., 2005; Firdaus & Mario, 2022). Accuracy in performing specific hitting techniques will help athletes score points by putting the ball in difficult-to-reach positions for the opponent. In sports, precision is essential, (Amaro et al., 2022; Özdalyan et al., 2022), and coaches should pay attention to these training programs. Improving accuracy should be developed by coaches in table tennis so that athletes can carry out sport-specific skills and techniques accurately (Panero et al., 2022). Players who have high accuracy are more likely to win compared to players with low accuracy. In addition, players with well-developed skills have a higher efficiency that reduces effort and energy demands of their during the match (Kwon et al., 2017).

JEKI HARYANTO, IVAN MALAGOLI LANZONI, ANDREAS NIKOLAKAKIS, CLEMENS DRENOWATZ, EVAL EDMIZAL, BERTO APRIYANO, PADLI, MIODRAG MILOVANOVIĆ, TAMARA LUKÁČOVÁ, BORYI BECERRA-PATIÑO

Accuracy plays an essential role in various types of sports. A study by (Kuswahyudi et al., 2021) reported that accuracy in aiming at targets in archery is influenced by arm muscle endurance and arm muscle length. An experimental study claimed that players who were given special jump shot training in the treatment group had a better level of accuracy compared to the shot accuracy of basketball athletes in the control group (Cieślicka et al., 2019). Throwing accuracy in handball was also found to be correlated with the maturity of the player. However, the anthropometric characteristics and self-efficacy of the players do not correlate with accuracy in throwing the ball (Fragoula et al., 2021). In tennis players, stroke accuracy is influenced by the angel face of the racket and ball height impact factors (S. Zhang et al., nd). In addition, Williams et al. (2021) revealed that during actual playing conditions, the height of the ball will vary, therefore players who can consistently adjust the angle of the racket to the right height of the ball will be able to produce accurate and consistent returns. Furthermore, skills in performing certain techniques like topspin will be influenced by physical abilities such as power and flexibility (Edmizal et al., 2023). The capacity of an athlete to sustain muscle function and cognitive focus throughout a match is pivotal. A rapidly fatiguing brain, leading to diminished performance during exertion, correlates with decreased accuracy. Continuous monitoring of athletes' movements during competition is imperative for timely identification of performance decline, facilitating proper evaluation and analysis of their on-field actions (Host & Ivašić-Kos, 2022). The accuracy of a shot is significantly influenced by muscle strength. Strong muscles facilitate the propulsion of the shot over greater distances and toward desired targets. Conversely, inadequate muscle strength compromises accuracy, impeding the shot's trajectory due to the muscles' limited ability to generate force (Canossa et al., 2016). Muscles experiencing fatigue lead to diminished work accuracy. This phenomenon arises from the muscles' compromised capacity to function optimally, thereby hindering the attainment of optimal shot accuracy (Rashid et al., 2020).

The low accuracy of topspin possessed by players makes it difficult to get points from opponents. Previous studies that have been carried out related to hitting accuracy in table tennis, such as improving forehand hitting accuracy using specific tools during the training process (Shukur et al., 2022). In addition, a study used a tool that was able to recognize four types of hitting techniques (Yen et al., 2023). Another study used a shot-type assessment tool that assessed *spatiotemporal features* (Aktas et al., 2021) and Cao et al. (2020) used ball training while eyes were closed. A study from (Niźnikowski et al., 2022) revealed that the players who concentrated on hitting the ball within the target area demonstrated significantly improved accuracy compared to the group instructed to pay attention to their grip. Furthermore, an experimental study aimed at increasing the accuracy of topspin shots was carried out by giving elastic bands as a treatment to 12 table tennis players. The results of this study showed that there was a significant increase in topspin accuracy compared to players who were not trained with elastic bands, which was attributed to the presence of increasing muscle coordination and physical control abilities (Nikolakakis et al., 2020). North et. al (2019) emphasize the consistency of follow-through movements to improve hitting accuracy in table tennis. Inconsistent follow-through movements and lack of correction, therefore, will result in slower player development. The phases of the ball-hitting movement by professional athletes are also faster compared to players with lower skill levels and the bat position is relatively higher in professional players (Z. Zhang et al., 2016). In line with the previous statement, the speed of the wrist joint when hitting the ball will affect the ball's speed and ball rotation (Zheng et al., 2021). An athlete's ability to direct the ball precisely to the target area is influenced by the skill level of the player and the opponent (Le Mansec et al., 2016). Moreover, speed and accuracy are influenced by a person's mental activity, which is affected by muscular and mental fatigue (Mikicin, 2022; Le Mansec et al., 2018). Both, mental and muscular fatigue, therefore, lead to a decrease in the quality of the players' strokes in a competition (Le Mansec et al., 2017). However, there's not a lot of research on how thinking skills and emotional intelligence are linked to accurately hitting the ball in table tennis. So, our study looked into how these factors are associated with achieving topspin accuracy. The goal is to help coaches and players better understand the elements influencing performance.

The study aims to determine the relationship between cognitive processing speed as well as emotional intelligence with topspin accuracy in table tennis. The findings of this study will be very useful for coaches, athletes, teachers, and lecturers as additional new information about the sport of table tennis.

Materials & methods
Study design and Participants
This research takes a quantitative approach to analyze the relationship between the variables of cognitive processing speed, emotional intelligence, and topspin accuracy. A total of 89 students (age: 20.3 ± 1.0; 18% female) volunteered to participate in this research. The study was carried out in September 2023 in the Faculty of Sport Science, Universitas Negeri Padang table tennis lecture room, Indonesia. The participants in this study were beginner players who were taking a table tennis course, with an average playing experience of 2 years.
Procedure
The study protocol was approved by Universitas Negeri Padang, the Faculty of Sports Sciences, and the lecturer who taught the table tennis course provided access to the participants. Participants provided written informed consent before data collection. Tests were administered by trained technicians and the test procedure

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was explained to the participants in detail in addition to a test simulation. Before the recording to determine stroke performance participants completed an emotional intelligence questionnaire. Upon completion of the questionnaire, participants completed a warm-up and performed the cognitive processing speed test and the topspin accuracy test.

Instruments

Cognitive Processing Speed (CPS)

This test aims to measure the cognitive processing speed of table tennis players (Mohsen & Maleh, 2020) by dividing a table tennis table into 5 equal parts. A ball-throwing machine (Huipang HP07) with a speed of 25 balls thrown in 25 seconds randomly plays balls of five different colors in different areas of the participants' table. Based on the color of the ball the participants have to return the ball to an area with the same color on the opposite side of the table. As shown in Figure 1 there were five colored areas and 5 balls from each color resulting in a total of 25 3-Star donic balls. Balls that did not match the target color were given a score of 1 and balls that hit the correct area were given a score of 2. Balls that missed the table entirely were given a score of 0. The participants in this study used their bats due to familiarity with the characteristics of their bats.
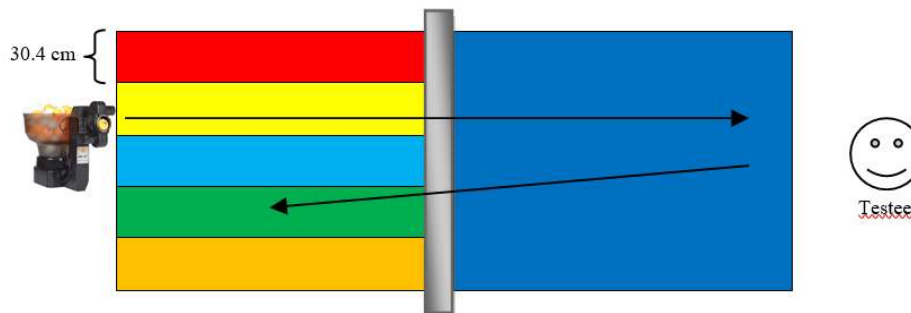

Figure 1. The target area of cognitive processing speed

Trait Emotional Intelligence Questionnaire Short Form (TEIQue-SF)

The TEIQue-SF (Petrides, 2009) was utilized in this study, to evaluate Emotional Intelligence, whose factor structure has been verified for sports (Laborde et al., 2016). The TEIQue-SF aims to assess the individual's self-perceived abilities and behavioral dispositions using a 4-point Likert scale format ranging from 1 (completely disagree) to 4 (completely agree). This inventory contains 30 items and four factors: well-being, self-control, emotionality, and sociability.

Topspin precision

This topspin accuracy test was carried out by playing 10 strokes toward a predetermined area that would result in the highest possible score (Figure 2). Balls that did not hit the table also received a score of 0. As has been shown for the cognitive processing speed test balls were played to the participants by a throwing robot (Huipang HP07) with consistent speed and height (Haryanto et al., 2023). In addition, to a score for ball placement, stroke technique was judged and participants received a score of 0 if they did not perform a topspin stroke.
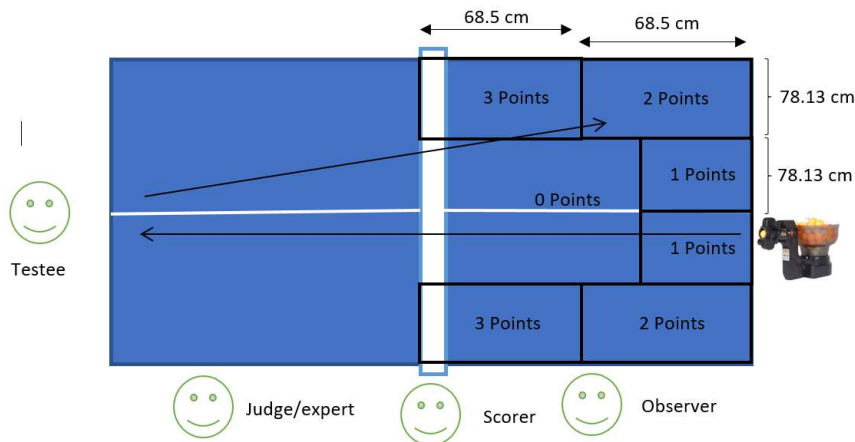

Figure 2. Topspin accuracy target area

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Statistical Analysis

Due to the lack of normal distribution of the data non-parametric correlation tests *(Spearman-Rho)* were carried out to determine the association between the variables of interest. Data descriptions are displayed by carrying out descriptive statistical analyses such as mean and standard deviation. Data analysis in this research was carried out with the help of Microsoft Excel and IBM SPSS version 26.

Results

A total of 89 students (20.3 ± 1.0) (73 male, 16 female) participated in the study. Descriptive characteristics can be seen in Table 1.

Table 1. Characteristics of participants in the study

Variables	Mean		Standard deviation	
	Male (n=73)	Female (n=16)	Male (n=73)	Female (n=16)
Age	20.4	19.8	1.0	0.7
Height	168.4	154.8	6.2	5.8
Weight	60.3	51.4	9.3	7.0

Cognitive processing speed was 29.8 ± 6.5 for male and 29.3 ± 5.3 for female participants respectively. Emotional intelligence was 86.1 ± 9.6 for males and 82.4 ± 6.8 for female participants, and topspin accuracy was 19.6 ± 4.7 for males and 18.6 ± 4.8 for female participants. Detailed descriptive statistics from this research will be shown in Table 2.

Table 2. Descriptive statistics of the variables in the study

Variables	Speed of cognitive processing	Emotional intelligence	Topspin accuracy
Mean	29.67	85.46	19.45
Standard deviation	6.38	6.38	4.72
Variance	40.75	86.77	22.30
Maximum	43	113	30
Minimum	13	63	11
Range	19	50	19

Both, cognitive processing speed and emotional intelligence were positively correlated with topspin accuracy (Table 3)

Table 3. Spearman's Rho test results between variables

Variables	N	Coefficient Correlation	p
Cognitive processing speed and topspin accuracy	89	0.372	0.000
Emotional intelligence and topspin accuracy	89	0.380	0.000

Discussion

Our research results show a significant positive correlation between cognitive processing speed as well as emotional intelligence and topspin shot accuracy in table tennis. These findings support previous research suggesting that athletes' cognitive abilities play a role in sports performance. Professional athletes have better cognitive function compared to non-professional athletes (HE Scharfen & Memmert, 2019). Speed in processing information is not only needed in academics but also during sports. Decisions must be made quickly and precisely by athletes (Lovett et al., 2022). In a correlational study with 15 youth soccer players, it was shown that the players' cognitive intelligence was directly associated with playing skills such as dribbling, juggling, and ball control (HE Scharfen & Memmert, 2019). Faster cognitive processing may allow players to better anticipate an opponent's movements, leading to increased accuracy in executing topspin shots. The ability to maintain cognitive performance over a longer time will increase the accuracy and speed of a player's performance throughout a match (Díaz-García et al., 2023). Accordingly, a study reported that the cognitive reaction time of children who have high cognitive processing speed and good muscular fitness will be much shorter than children with slow cognitive processing speed (Tsai et al., 2020). As the speed of cognitive processing can be increased

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with training, such as vision training, regular exercise can improve a person's cognitive abilities and this type of training is highly recommended for improving the abilities of athletes (Fortes et al., 2023).

The results of the research that has been carried out also show that there is a positive significant relationship between emotional intelligence and topspin accuracy. This result is in line with a study that reports that the performance of athletes who have high emotional intelligence is better when compared to the performance of athletes who have low levels of emotional intelligence. Athletes' inability to control their emotions makes them less good at doing various things during a match. The negative thoughts that haunt them while playing are also factors that cause their abilities to decline, apart from goal setting and spontaneous actions without careful consideration also influence their performance (Gatsis et al., 2021; Rasyid et al., 2024; Komaini et al., 2023). A study explains that people who experience mental fatigue will experience a decrease in the speed and accuracy of their work, this mental activity in a person's body will greatly influence what they do (Mikicin, 2022). A similar study explained that mental fatigue experienced by athletes will cause athletes to experience a decrease in accuracy as well as other work performance (Kunrath et al., 2020). Athletes who have good abilities (experts) are also found to have a close correlation with their high level of emotional intelligence. In addition, they also can make quick and good decisions. Athletes who have high emotional intelligence also can anticipate and manage risks carefully (Vaughan et al., 2019). Indeed, a correlational study indicated that the role of emotional intelligence in team sports is very necessary because each individual must be able to feel the feelings of other individuals (Gusril et al., 2022)(Chaeroni et al., 2022), the players in a team must also be able to respect each other and provide motivation so that team cohesion can continue to be maintained. If one player is mentally down then the team's overall performance will also decline, therefore athletes must have good emotional intelligence so that victory can be achieved (Zizzi et al., 2010; Uphill et al., 2012). Emotional intelligence plays a role in overcoming the stress received by athletes during competitions. High levels of stress will be able to be reduced by athletes who have good emotional intelligence, they will be calm in facing critical situations, apart from that, players will also have good leadership attitudes so that the decisions they make tend to be right (Bal et al., 2011). Furthermore, emotional intelligence is related to athletes' analytical sharpness, this is due to the mental calm they feel, so they can think and analyze problems sharply and accurately (Laborde et al., 2016).

Indonesia's achievements in table tennis have not reached the top at the international level. This is due to a variety of factors, one of which is the ability to do a topspin stroke accurately. This stroke is commonly used by professional athletes to put pressure on their opponents. The low level of technical ability and the low accuracy of the players are urgent reasons that must be resolved immediately by table tennis coaches so that their athletes will be able to compete with top international athletes.

The insights gained from this research can be applied to training and coaching in the sport of table tennis. Coaches may consider including exercises that specifically target cognitive processing speed, such as reaction drills and decision-making scenarios. Additionally, a holistic approach to training that integrates cognitive and emotional aspects can improve a player's overall performance. Understanding the complex relationship between psychological factors and technical skills can provide the basis for training programs that suit the individual needs of table tennis players.

It should, however, be considered the present study did not examine professional athletes, and additional research is needed to explore these associations at higher playing levels. In addition, emotional intelligence in this was not assessed in a real match situation. Other instruments, such as direct observation during matches or match simulation during training may be needed to get a better understanding of this concept along with the relationship to playing performance. The small number of participants who were willing to participate in this study along with a lack of difference in playing ability are also weaknesses of this. A difference in rackets used may affect topspin performance as well even though participants claimed that they felt comfortable using their respective rackets.

Conclusion

The topspin shot is a widely used stroke of attack in table tennis. Accuracy in placing topspin shots, therefore, is one of the keys to victory for table tennis athletes. This research examined the association between cognitive processing speed and the accuracy of topspin shots as well as the association between emotional intelligence and the accuracy of their topspin shots. Given the direct association between cognitive abilities and topspin accuracy table tennis coaches should address these components as well when preparing training programs for the short, medium, and long term.

The practical implication of this research is that coaches should start designing drills that stimulate athletes' ability to make quick and precise decisions. Such drills could help athletes to improve their topspin accuracy during real matches. Additionally, coaches must be able to provide advice to athletes to manage stress effectively and enhance their self-awareness. Taken together, coaches should take a holistic training approach as achieving peak performance is not only influenced by physical abilities but also by psychological variables such as emotional intelligence and the speed of cognitive processing. Future research should compare this result with professional table tennis athletes and use a larger sample to enhance the understanding of the relationship

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between cognitive parameters and match performance in table tennis. The relationship with other physical elements also needs to be explored further so that the consistency of hitting accuracy can be understood more comprehensively.

Acknowledgment

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JEKI HARYANTO, IVAN MALAGOLI LANZONI, ANDREAS NIKOLAKAKIS, CLEMENS
DRENOWATZ, EVAL EDMIZAL, BERTO APRIYANO, PADLI, MIODRAG MILOVANOVIĆ, TAMARA
LUKÁČOVÁ, BORYI BECERRA-PATIÑO

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702 --

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