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Exploring Technical and Tactical Differences between a Top Table Tennis Player with an Intellectual Disability and an Able-Bodied Player: Application of the 3S Theory

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Abstract

Purpose: This study applied the 3S theory (Speed, Spin, Spot) as an analytical framework to compare the technical and tactical characteristics of a top able-bodied (AB) table tennis (TT) player with an intellectual disability (ID).

Methods: A case study focused on five international matches played during high school periods by two elite players: Player H (AB) and Player C (ID). "The Intellectual System in Competitive TT" was employed to gather data, with descriptive statistics and Chi-square tests used for analysis.

Results: Serving & Receiving: The player with ID excelled in serving over receiving ($\chi 2$ =12.40, p <.001), whereas the AB player showed no significant difference, highlighting the ID player's weaker receiving skills. 3S Serving Strategies: The ID player used 38 serving strategies (28.15%), with the top five making up 53%, indicating less diversity. By contrast, the AB player applied 53 strategies (39.26%), with the top five accounting for 35.4%, showing greater tactical variability.

Receiving Techniques: The ID player relied on 26 strategies (41.27%), with 56.6% focused on "control" techniques. Meanwhile, the AB player used 39 strategies (61.90%), evenly dividing between "offensive" and "control" techniques, displaying more balance.

Error Types: While shot error types did not significantly difference, However, the higher frequency of "Offensive Receiving Errors" and "Control Receiving Errors" in the ID player further confirmed his notable weaknesses in receiving performance.

Conclusions: This study effectively applied the 3S theory to examine the technical and tactical characteristics of the ID player in real matches, addressing past restrictions of static testing. It confirmed that ID players usually play simplified serving and receiving strategies, offering valuable guidance for TT coaches and players in refining training and match tactics.

Keywords: Table Tennis; 3S Theory; Intellectual Disability; Technical and Tactical Strategies; Intelligence Analysis

Introduction

Since the 1960s, the scientific analysis of competitive table tennis (TT) has steadily gained attention. Researchers have incorporated multidisciplinary approaches to enhance athletes' training effectiveness and competitive performance [1]. With TT officially becoming the Olympic event in 1988, international competition intensified, prompting nations worldwide to actively promote scientific training systems. Through technical analysis, tactical simulations, and data monitoring, they strengthened athletes' core abilities in speed, spin, and spot control [2,3]. This development trend not only transformed traditional training models but also ushered TT into a new era of technical refinement and tactical stratifications. In the field of disability sports, TT players with an intellectual disability (ID) have gradually become a focus of sports science research since they were officially included in the 2012 London Paralympic Games [4]. However, compared to able-bodied (AB) athletes, the ID group shows significant differences in cognitive processing, motor

coordination, and tactical execution [5], which means that their technical and tactical analysis must integrate special education and adaptive training strategies. Early studies mainly focused on the basic technical assessments of ID players, such as service success rates and receiving reaction times [6], stroke accuracy and serving precision [7], or examining the effects of training interventions through standardized tests [4]. Although these results help to establish a basic training framework, there has been little exploration of the tactical selection patterns and technical application effectiveness of ID players in real combat situations, leading to a gap between training arrangements and competition demands. To break through this limitation, we adopted Dr. Wu's "3S Theory" (Speed, Spin, Spot) proposed in 2011 as a key turning point. This theory deconstructs the core of TT skills into three dimensions: 3 speeds, 5 spins, and 9 landing spots, creating a total of 135 complex variations, and has developed a systematic functional assessment tool, which has been successfully applied to the technical diagnosis of athletes with physical and intellectual disabilities [8,9]. Subsequent research further verifies that the 3S framework can effectively analyze the tactical decision-making logic of top players in high-speed confrontations. For example, creating offensive opportunities through spin variations or utilizing landing spots to disrupt the opponent's pace [3,10,11]. It is worth noting that existing research related to 3S mostly targets AB players, and the analysis of the ID players remains at the basic technical level, without extending to dynamic tactical interactions in practical setting, and this knowledge gap may limit the depth of the scientific training development for ID table tennis.

An overview of the current literature shows that the academic community generally believes that AB players and ID players may differ in their athletic characteristics [12,13]. Due to cognitive limitations, ID players tend to adopt simplified tactical strategies [5,14], however, this inference largely originates from static tests in laboratory settings and lacks of support from real competition data. In reality, as the competitive level of para-TT improves, top ID players may not develop complex patterns of tactic execution that adapt to their traits, such as compensating for reaction speed with anticipatory ability or replacing high-risk attacks with high stability [9]. Therefore, clarifying the differences in 3S tactical dimensions between ID and AB players can not only re-examine existing theoretical assumptions but also provide empirical evidence for specialized sports training. The purpose of this study is to use the 3S theory as an analytical framework to analyze and compare the tactical and technical execution characteristics of two top international TT players (one from the AB category and the other an ID player) in actual competition through case studies. It aims to systematically analyze the similarities and differences in the speed control, spin application, and landing point distribution of the AB and ID players during the serving and receiving processes by analyzing competition videos, and further explore the differences in the types of errors made by the two players, ultimately verifying the argument that "ID players' tactics tend to be simplified." The results are expected to expand the application scope of the 3S theory while providing a theoretical basis and practical guidance for the scientific training and competition strategy formulation of ID players in TT.

Methods

Subjects

This study examined serving and receiving tactic differences between elite AB and ID male players. To ensure consistency, we selected Player H (an AB player from Japan) and Player C (an ID player from Taiwan), who both reached world-class levels in high school and ranked as high as world No. 2. To ensure reliability, the analysis focused on five key international matches (all wins) from their high school periods against the top 10 world ranking players, factoring in physical age for representativeness.

Research Tools

The Intellectual System in Competitive TT (ISCTT) developed by a Taiwanese research group, was used as the data collection tool [3, 15]. This system specialized in gathering five critical types of intelligence for each shot made by both players during a match. These included hitting mode (2 categories), technique (12 categories), speed (3 levels), spin (5 varieties), and spot (9 positions).

Data Collection

Data Sources

The source of data collection is the publicly available competition videos shared through the YouTube channel.

Recording

After importing the match video into ISCTT, each ball hit was analyzed by pausing the video and assessing five key elements: hitting mode, technique, speed, spin, and spot. Two nationally qualified coaches with over 10 years of TT analysis experience jointly determined these attributes. This process continued for each point until the match was fully recorded.

Data Analysis

Descriptive statistics were used to calculate the frequency distribution and percentage of serving and receiving in the execution of the 3S strategy. In addition, the Chi-Square test was used to examine the differences in serve winning percentages, receive winning percentages, and error type performances between the two players. The significance level for the statistical tests in this study was set at α=.05.

Results and Discussion

Overall performance of ID and AB players in serving and receiving

The ID and AB players showed performances in serving and receiving in terms of overall points scored and points lost (Table 1). In terms of ID player's performance, he served a total of 183 balls in 5 matches, winning 118 points and losing 65 points, with a serving success rate of 64.48%. Additionally, in 5 matches he

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received 182 balls, winning 84 points and losing 98 points, with a receiving success rate of 46.15%. Based on analysis of the chi-square test (χ^2=12.40, p<.001), we found that ID player's scoring rate in serving was significantly better than his scoring rate in receiving. In terms of the performance of the AB player, he made a total of 257 serving in 5 matches, scoring 118 points and losing 65 points, with a serving scoring rate of 51.36%. In addition, he received a total of 260 balls, winning 137 points and losing 123 points, with a receiving scoring rate of 52.69% in the 5 matches. Although the AB player's receiving scoring rate was slightly higher than the serving, there was no significant difference (χ^2=0.09, p=.762) (Table 1). Moreover, the reason for the discrepancy in total serving and receiving between the two players was the ID player's matches being a best of 5 sets format, while the AB player's matches were mostly a best of 7 sets format.

Table 1: Chi-square test on the scoring performance of two players in serving and receiving.

Players	Serving & Reserving	Score	Loss	Total	x^2	P
ID Player	Serving	118 (64.48%)	65(35.52%)	183(100%)	12.4	0.000***
	Receiving	84(46.15%)	98(53.85%)	182(100%)		
AB Player	Serving	132(51.36%)	125(48.64%)	257(100%)	0.09	0.762
	Receiving	137(52.69%)	123(47.31%)	260(100%)		

Note: ***p<.001, df = 1.

This study differed from previous studies that mostly evaluated in laboratory settings. We further analyzed and verified the differences in tactical execution between top ID and AB players based on the real competitive performance. From the above results, we identified that the ID player had a significantly better scoring performance on serving compared to receiving in this case study. The result aligned with the findings of Sheu et al. [16], which noted consistency with the concept that TT players with ID exhibited advantages or disadvantages in their playing styles, indicating that the player had clear strengths and weaknesses. In contrast, the AB player showed balanced scoring performances in both serving and receiving without significant differences. His winning rates exceeded 50%, indicating that the AB player performed well in both serving and receiving, without showing obvious weaknesses for opponents to exploit them. It is worth noting that the receiving performance of the ID player was evidently at a disadvantage in these five matches won, further reinforcing our understanding that the ID player may have much clearer strengths and weaknesses in playing TT.

The 3S characteristics of the server for ID and AB players

Table 2 presents the findings of the top five serving usage rates for the ID player on 3S. He served a total of 183 balls across five matches, employing 38 different serving strategies, which accounted for 28.15% of 135 variations; the top five usage rates accounted for 53% (ranging between 4.9% to 19.7%), with an average win rate of 55.4%. Table 3 presents the analysis results for the top five highest usage rates of 3S serving by the AB player. He executed a total of 257 serves across five matches, employing 53 serving strategies, which accounted for 39.26% of the 135 variations. The top five usage rates only accounted for 35.4% (ranging between 7.0% to 7.4%), with an average winning rate of 52.7%. From the characteristics of the 3S serving of the two players (ID vs AB), it can be observed that the ID player's 3S variations have a significant gap. The ID player tended to rely on the same pattern to execute his serving tactics, and his serving strategy was notably concentrated and singular (Table 2). For example, his best scoring serving pattern performed by the ID player was "medium-speed /no spin / middle-short," with a usage rate as high as 19.7% and a winning percentage of 75%. Evaluating from the winning percentage, his performance indeed achieved great effectiveness, but the use of the same strategy inevitably showed a high degree of predictability, which may lead to adaptation by opponents and potential countermeasures in higher-level matches due to a lack of much variability.

Table 2: Top five serving usage rate of 3S in the ID player (n=183).

Speed	Spin	Spot	Frequency	Usage ratio	Winning ratio
Medium speed	No spin	M-S	36	19.70%	75.00%
Medium speed	Side back spin	M-S	23	12.60%	39.10%
Medium speed	Back spin	M-S	16	8.70%	68.80%
Medium speed	Side back spin	BH-L	13	7.10%	38.50%
Medium speed	Side back spin	M-I/O	9	4.90%	55.60%
Total (Average)			97	53.00%	-55.40%

Note1: M-S: Middle Short□BH-L: Backhand Long□M-I/O: Middle Inside/Out.

Note2: ID Player used 38 strategies (28.15%) among 135 variations of the 3S serving.

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Table 3: Top five serving usage rate of 3S in the AB player (n=257).

Speed	Spin	Spot	Frequency	Usage ratio	Winning ratio
Low speed	Side back spin	FH-S	19	7.40%	52.60%
Medium speed	Side back spin	M-I/O	18	7.00%	72.20%
Medium speed	Side top spin	M-S	18	7.00%	55.60%
Medium speed	Side back spin	M-S	18	7.00%	44.40%
Low speed	Back spin	FH-S	18	7.00%	38.90%
Total (Average)			91	35.40%	-52.70%

Note1: FH-S: Forehand Short; M-I/O: Middle Inside/Out; M-S: Middle Short

Note2: AB Player used 53 strategies (39.26%) among 135 variations of the 3S serving.

In contrast, the AB player's serving strategy of 3S was more diverse, with the top five usage rates evenly distributed at 7% (Table 3), indicating that their serving variations were more diverse, which increased the difficulty for opponents when returning reduced the consistency of their serving, making it harder for opponents to adapt during the return. This enabled players to more effectively execute their own tactical styles. In high-level competitive arenas, serving is the key to generating offensive advantages. If the tactics are overly simplistic and lack variation, they are easily predictable by opponents, preventing the maximization of one's serving advantage. This argument aligns with past research on the serving strategy of Olympic men's singles bronze medalist Ovtcharov. He consistently gained an advantage by varying his serving position and method, while controlling the spin and length variations of the ball [17]. Additionally, The ID player utilized 38 of 135 serving variations (28.15%), whereas the AB player employed 53 strategies (39.26%), demonstrating significantly higher diversity in 3S serving patterns within the AB group.

Tactical characteristics of AB and ID players in receiving

This study aims to gain a deep understanding of players' receiving strategies. For data collection, we matched the 9 potential landing points that the opponent might serve to with the 7 techniques that the AB and ID players might use for returns [10], meaning there could be 63 variations of receiving strategies in this study. Table 4 presents the results of the top five most used receiving strategies by the ID player. Overall, the ID player received a total of 182 balls across five matches, using 26 types (41.27%) of receiving strategies, with the top five strategies achieving a usage rate of 56.6%, ranging from 8.8% to 18.1%. On the opponent's serving positions, it can be observed that there is little variation in the opponent's serving landing points, with "middle short balls" being the most common, followed by "middle inside/out balls". The ID player employed 4 techniques in receiving, namely "drop shot" (19.8%), "long push" (18.1%), "side twist" (9.9%), and "drive loop" (8.8%).

Table 4: Technical characteristics of top 5 receiving usage in the ID player (n= 182).

Opponent's service position	Receiving techniques	Frequency	Usage ratio	Winning ratio
M-S	Long push	33	18.10%	42.40%
M-S	Drop shot	20	11.00%	40.00%
M-I/O	Side twist	18	9.90%	50.00%
BH-L	Drive loop	16	8.80%	43.80%
M-S	Drop shot	16	8.80%	37.50%
Total (Average)		103	56.60%	-42.70%

Note1: M-S: Middle Short; M-I/O: Middle Inside/Out; BH-L: Backhand Long

Note2: ID player used 26 receiving strategies (41.3%) out of 63 variations (9 landing spots* 7 techniques).

Table 5 presents the results of the top five most used receiving strategies by the AB player. Generally, the AB player received a total of 260 balls across five matches, using 39 types (61.9%) of receiving strategies, with the top five strategies achieving a usage rate of 44.2%, ranging from 6.5% to 12.7%. In terms of the opponent's serving placement, there were 4 types of placements variation, namely "forehand short ball" (20.8%), "forehand inside/out ball" (9.6%), "middle inside/out ball" (7.3%) and "backhand long ball" (6.5%). The AB Player's receiving showed 3 types of techniques, namely "side twist" (25%), "drop shot" (12.7%) and "drive loop" (6.5%). With the continuous evolution and changes of the International Table Tennis Federation (ITTF)

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rules, the importance of receiving and serving has become equal [18]. Receiving techniques can generally be divided into two categories [1,19]: one is a proactive attack technique, such as the five techniques collected in this study: "drive loop, smash, fast drive, flip, and side twist"; the other is a passive control technique, such as the two techniques collected in this study: "drop shot and long push". The results of this study highlight the distinct stylistic differences in the receiving techniques of the two players. Firstly, as seen in Table 4, The ID player always employs "controlling techniques" when returning the opponent's short serving, while using "attacking techniques" when responding to the opponent's long serving or inside/outside ball, highlighting that the ID player has a relatively singular receiving strategy, making it easy for the opponent to predict his tactics.

In contrast to the AB player, when he returned short balls from his opponent, he combined "aggressive techniques" (side twist) with "control techniques" (drop shot), sometimes applying pressure and sometimes controlling the landing point to affect the opponent's return. In response to his opponent's different positions with inside/out ball and long ball, he mixed and utilized two active offensive techniques, "side twist" and "drive loop", to suppress the opponent, creating immense pressure on the opponent's serving. Secondly, we found that the usage rate of the ID player (56.6%) was 12.4% higher than that of the AB player (44.2%). The data indicated that the ID player relied more on certain fixed patterns as a return strategy, while the AB player demonstrated a more diverse approach in returns. Additionally, the ID player employed 41.27% receiving strategies, whereas the AB player used 61.90% patterns, further proving that the top AB player had greater diversity in receiving strategies. Finally, the AB player's receiving win rate at 53.3%, which is clearly better than the ID player's 42.7%. The higher receiving win rate of the AB player may be related to his variability and aggressiveness in receiving. According to the past research, the world-top AB male players tended to increase the usage rate of proactive attack returns as the competition level rises, showing a strategic trend from passive to active in receiving [18]. We found that the ID player in the matches leaned towards a stable and conservative approach to returns, while this ensured higher consistency, this playing style did not cause too much pressure and did not make difficult for the server. Conversely, the AB player demonstrated strong active aggression, which consistent with findings from previous studies.

Table 5: Technical characteristics of top 5 receiving usage in the AB player (n=260).

Opponent's service position	Receiving techniques	Frequency	Usage ratio	Winning ratio
FH-S	Drop shot	33	12.70%	57.60%
FH-I/O	Side twist	25	9.60%	52.00%
FH-S	Side twist	21	8.10%	61.90%
M-I/O	Side twist	19	7.30%	42.10%
BH-L	Drive loop	17	6.50%	52.90%
Total (Average)		115	44.20%	-53.30%

Note1: FH-S: Forehand Short; FH-I/O: Forehand Inside/Out; M-I/O: Middle Inside/Out; BH-L: Backhand Long

Note2: The AB player used 39 receiving strategies (61.9%) out of 63 variations (9 landing spots* 7 techniques).

Analysis of Error Types

Table 6 showed the main differences in the types of hitting errors made by ID and AB players in five matches. Chi-square test revealed that the ID and AB players had no significant differences in the types of hitting errors ($\chi 2 = 4.16$, $p = .384$), indicating that the two top players had identical error patterns. Although there was no difference between the two players, the data revealed that the ID player had a higher error rate in "unforced error", "attack error on receiving", and "control error on receiving" compared to the AB player. Meanwhile, the AB player had a higher error rate in "forced error" and "acceptable error" compared to the ID player. The definition of the five types of errors in this study is based on the classification method proposed by Tsai et al. [15], further defined using the classification attributes of speed (fast, medium, slow) in the 3S theory. From the error patterns of hitting by the two players, there were no significant differences. Two top players from different groups had similar error situations during matches. Most errors were "attack error on receiving", which was largely consistent with previous research [15], indicating that causing errors in top players required high-quality speed. Although the AB and ID players showed the similar error patterns, related data indicated that the ID player may exhibit higher"attack error on receiving" and "control error on receiving" than the AB player. This result once again verifies that the AB player has significant shortcomings in reception. This is likely closely related to the ID player's direct receiving errors or overly simplistic execution of return the ball, which may provide opportunities for the opponent.

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Table 6: Chi-square test of types of error between ID and AB players (n=411).

Type of error	Players				
	ID Player	AB Player	Total	x^2	P
Forced error	55(33.74%)	104(41.94%)	159(38.69%)	4.16	0.384
Acceptable Error	42(25.77%)	66 (26.61%)	108(26.28%)		
Unforced error	35(21.47%	43(17.34%)	78(18.98%)		
Attack error on receiving	24(14.72%)	28(11.29%)	52(12.65%)		
Control error on receiving7(4.29%)		7(2.82%)	14(3.41%)		
Total	163(100%)	248(100%)	411(100%)		

Note: *p<.05, n = 411, df = 4.

Conclusion and Recommendations

This study applied the 3S theory as a framework and employed a case study approach to compare the technical and tactical characteristics of top international AB and ID players in actual TT events. Based on the results and discussion, this study reported two significant contributions. First, by applying the 3S theory in TT, it revealed the differences in technical and tactical execution between elite ID and AB players in actual competition, addressing the limitations of previous research, which primarily relied on laboratory tests. The second contribution was that, by comparing ID and AB players, it preliminarily confirmed that ID players exhibited simpler yet distinctly advantageous and disadvantageous serving and receiving strategies during competitions. This critical finding offered substantial reference value for coaches and players in conducting simulation training or formulating match strategies in the future.

This case study has several limitations. For instance, the research subjects are restricted to two top world-class TT athletes, and the results may not be generalizable to other players. Nevertheless, to ensure the representativeness of the analysis data, five matches that each of these two athletes won during their high school period were selected as the source of data analysis, thereby ensuring data consistency. We recommend increasing the number of research subjects and matches for further analysis. In terms of evaluation metrics, this study currently focuses only on analyzing and comparing the players' serving, receiving, and error types. While some preliminary results have been obtained, there are still many technical and tactical indicators in TT, such as how players apply connection strategies for the first and third shots as well as the second and fourth shots. These areas could be further explored in future research, enabling deeper insights for "effective opponent strategy through mutual understanding."

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