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Generality and Specificity of Attention Dimensions in Elite Table Tennis Players

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Abstract

Good attentional focus is recognized as one of the key assets of an athlete. It becomes even more crucial in table tennis, a fast-paced sport requiring quick reactions and constant attention. To understand attentional patterns in table tennis, this study utilized the four subscales of the Multidimensional Inventory of Sport Excellence (MUSI) questionnaire: Extensive Internal Attention (EIA), Extensive External Attention (EEA), Narrow Internal Attention (NIA), and Narrow External Attention (NEA). The questionnaires were administered to general university students (Control, n=143) and skilled table tennis players (TTP, n=137) which included national-level table tennis players of Taiwan (NTTP, n=20). Taking gender as a covariate, a mixed model ANCOVA was used to compare the scores on attention dimensions between the control group and TTP (experiment 1) and the control group and NTTP (experiment 2). The weekly practice hours of TTPs and NTTPs were higher than the control group in both experiments. In both experiments, participants scored significantly higher on the narrow aspects of attention dimensions (NIA and NEA). In experiment 2, NTTPs scored higher on all dimensions than the control group, showing a group effect, particularly a significant difference in NIA. Our study indicates that attention generality occurs in all groups, i.e. the narrow dimensions of attention are significantly higher than the broad/extensive dimensions. Specifically, professional table tennis players have significantly higher NIA than the control group. Our results suggest that NIA could be used to differentiate elite table tennis players. Therefore, developing NIA is an important factor for athletic success.

Keywords: *attention dimensions, table tennis, attention styles, narrow focus of attention, NIA*

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Introduction

The ability to be attentive has been widely regarded as a major prerequisite in motor learning, whether in sports or education while abnormalities in attention could potentially signify the presence of mental disorders (Li et al., 2024). In athletic competitions, attention and technique can sometimes be used to compensate for the lack of physical strength, but when attention is compromised, it cannot be compensated for by skill or physical strength. Therefore, it is essential for athletes to understand the dynamics of attention.

Nideffer (1976) divides attention styles based on direction (internal and external) and breadth (broad and narrow), re-

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sulting in four dimensions of attention: Broad/Extensive Internal Attention (EIA), Broad/Extensive External Attention (EEA), Narrow Internal Attention (NIA) and Narrow External Attention (NEA). EEA is used to assess the environment quickly then EIA is used for problem-solving, strategic thinking and planning. NIA is used to rehearse, systematize, and organize the information from the previous step and once a performance-relevant objective has been selected, NEA is employed for execution. Recent studies also show that attention is dynamic and complex (Hutchinson & Tenenbaum, 2007) that changes during various performance stages (from the planning stage to the execution stage) and has varying effects on motor performance (Becker et al., 2020).

In sports psychology, attention dimensions are a promising measure to identify high-performance athletes. For example, using attention styles, scholars were able to identify Olympic medallists and world champions (Nideffer et al., 2000). In another study comparing elite-level performers at the Australian Institute for Sport (AIS) in Australia with a group of athletes from around the world who had either won an Olympic medal or a world championship, researchers found a direct relationship between the level of performance of elite-level athletes and the scores on attention dimensions (Nideffer et al., 2001).

The aforementioned attention dimensions were first systematically included in the Test of Attentional and Interpersonal Style (TAIS) (Nideffer, 1976). However, (Nideffer, 2007), mentions, "It is important to point out that TAIS was not developed as a sport psychology measure, but rather as a more general measure of performance relevant characteristics". Additionally, TAIS received some criticism from different researchers, pointing out that TAIS was neither situation nor sport-specific (Vallerand, 1983; Van Schoyck & Grasha, 1981). Recently, researchers have designed a sports-specific scale: The Multidimensional Inventory of Sport Excellence (MUSI) Questionnaire (Sindik, Botica, et al., 2015; Sindik, Schuster, et al., 2015). MUSI has been validated separately in a sample of 248 Croatian male and female athletes (participating in sixteen different sports), showing adequate construct validity and reliability (Cronbach's alpha) ranging from 0.72 to 0.90 for all questionnaires (Sindik, Botica, et al., 2015; Sindik, Horvat, et al., 2015; Sindik, Schuster, et al., 2015). MUSI extensively covers a total of nine different psychological characteristics grouped into two major components: 1) MUSI: attention scales and mental energy (six scales) (Sindik, Botica, et al., 2015) and 2) MUSI: Anxiety and Hardiness Scales (three scales) (Sindik, Schuster, et al., 2015). The attention scales of MUSI are based on the TAIS but significantly modified to compensate for the criticisms in TAIS (Sindik, Botica, et al., 2015). Therefore, MUSI is an ideal tool for studying attention dimensions in sports. However, MUSI has not been investigated in table tennis yet.

Researchers have used MUSI: Attention Scales and Mental Energy in a sample of 91 above-average athletes (35 handball and 56 volleyball players), revealing no statistically significant difference in attention dimensions (EIA, EEA, NIA, and NEA) between the two groups (Sindik, Horvat, et al., 2015), which may be due to the lack of an appropriate control group (low-skilled group). In this study, we focus on table tennis, a fast-paced sport requiring rapid reactions and continual attention. Table tennis has benefits in improving cognition (Yamasaki, 2022) and attention (Wang et al., 2016) but is not precisely evaluated in different dimensions of attention. Therefore, we designed this study to investigate the attention dimensions in skilled table tennis players in a complete experimental design, including a control group. We hypothesize that there will be difference in the pattern of attention between the study groups.

Material and Methods

Participants

The current study included 282 participants, divided into two categories based on their table tennis skill level. Category 1 (the control group, n = 143, male/female = 72/71, age = 23±7 years) consisted of general university students having low or no skill in table tennis (weekly practice hours ≤ 5) from various colleges of National Cheng Kung University (NCKU). The participants in the control group occasionally participated in other sports or physical activities including basketball, table tennis, walking, aerobic exercises, physical fitness, baseball, swimming, tennis, etc. in their leisure time. In contrast, participants in category 2, the skilled table tennis players (TTP, n = 139, male/female = 71/68, age = 21±2 years, weekly practice hours ≥ 12), were selected from the finalist teams of 16 different universities who gradually won university-level competitions across Taiwan and finally made it to the Nationwide Annual Inter-University Table Tennis Competition. In the TTP group, there were national-level table tennis players (NTTP, n = 20, male/female=16/4, age = 22 ± 2 years, weekly practice hours ≥ 20). The NTTP group were award-winning players who had fulfilled the criteria to represent Taiwan, Republic of China (ROC) in international table tennis contests. Only 13.99 percent (20 players) of the TTPs were from the top 10 universities with no NTTP. The stated weekly practice hours for NTTP and TTP were the table tennis practice hours while the duration of accumulative sports/physical activity were reported for the control group. The experiments were conducted following the declaration of Helsinki (1975), with the experimental protocol approved by the Ethical Committee of NCKU.

Questionnaire

In this study, we used the four subscales from the Attention Scales and Mental Energy scale of MUSI: EIA (number of items=8), EEA (number of items=6), NIA (number of items=7), and NEA (number of items=7). Previously, MUSI has been validated separately in a sample of 248 Croatian male and female athletes (participating in sixteen different sports), showing adequate construct validity and reliability (Cronbach's alpha) ranging from 0.72 to 0.90 for all questionnaires (Sindik, Botica, et al., 2015; Sindik, Horvat, et al., 2015; Sindik, Schuster, et al., 2015). In the current research, we aimed to analyze different attentional dimensions and used the following four subscales: EEA (e.g. scanning external environment), EIA (e.g. considering possible moves), NIA (e.g. mental rehearsal), and NEA (e.g. execution) (Nideffer, 1976; Ziegler, 1994). In the MUSI, all the questionnaires utilize a 5-point Likert scale, from strongly disagree (1) to strongly agree (5). However, the literature recommends using a Likert scale of 6 points for response recording as it permits better precision of the measuring instrument (Chomeya, 2010; Gries et al., 2018; Nemoto & Beglar, 2014). Consequently, we adopted a 6-point Likert scale and carefully translated the questionnaires into Chinese for the participants' better understanding, comprehension, and

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convenience. In our pilot study (n = 22), the Cronbach's alpha values (EIA = .96, EEA = .92, NIA = .87, NEA = .72) between 6 Likert scale and 5 Likert scale of the Chinese MUSI were validated (Tavakol & Dennick, 2011). For the current study, Cronbach's alpha of the Chinese MUSI with 6 Likert scale were calculated to confirm its reliability. In MUSI, a higher score indicates more developed attention skills on all the scales except for EIA, which is reverse coded, meaning the lower the score, the more developed the attention dimension (Sindik, Botica, et al., 2015). During the analysis, we accounted for EIA by subtracting the achieved score on this dimension from the accumulative score of EIA questions.

Study Design

The current research was executed in a non-laboratory setting, and all the responses were recorded using "Google Forms." Individual responses were carefully recorded in person for all participants to ensure the integrity of the data. The control group participated in this study between 2020-2021, while the NTTPs were recruited at the Nationwide Annual Inter-University Table Tennis Competition in the year 2021.

Statistical Analysis

The questionnaire responses were examined, and only valid responses were considered for further analysis. This study used independent t-tests and Chi-squared statistics to evaluate participant's attributes (age, gender, and weekly practice hours). A mixed design analysis of variance (ANOVA) was used to assess attention dimensions between the TTPs and the control group in experiment 1 and between the NTTPs and the control group in experiment 2. In case of statistical differences between the factors of age and gender, this study included them as covariates and proceeded to an analysis of covariance (ANCOVA) to account for any effects resulting from the covariates. Furthermore, Greenhouse Geisser's correction was used to meet the sphericity assumption (if violated), and significant effects were followed up on with multiple comparisons with Bonferroni post hoc correction. This study used a probability value (p-value of $< .05$) to infer statistical significance and report the effect size as the partial $\eta 2$ value. All statistical analyses were performed using the statistical analysis software SPSS 25.0.

Results

Questionnaire Analysis

In the present study, a total of 282 questionnaires were received. After analysing the questionnaires, two responses were excluded from the study as the subjects provided the same answer to each question and upon confirmation the subjects admitted that they didn't pay attention to the survey questions and selected the same option for each question. The remaining questionnaires (n=280) were included in the current analysis. Figure 1 provides a detailed overview of the questionnaire distribution and the participants grouping criteria. The Cronbach's alpha values (EIA = 0.83, EEA = 0.82, NIA = 0.70 and NEA = 0.75) for the current study showed an acceptable reliability.

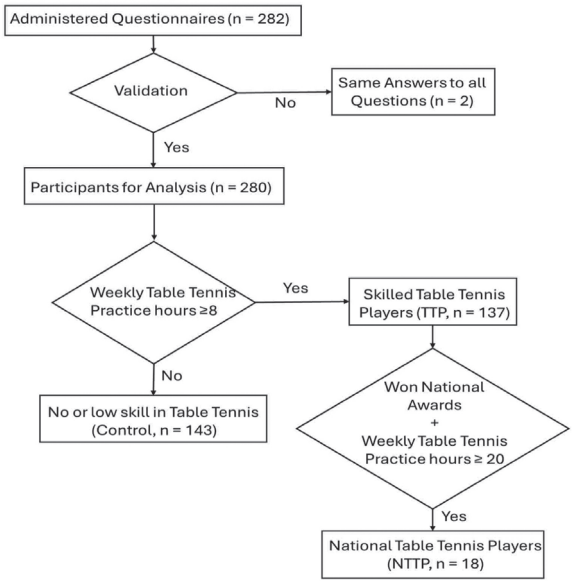

Figure 1. An overview of the analysis of the questionnaire and the participants groups involved in this study.

Experiment 1

In the first part, there was a significant difference in weekly practice hours between the control and the TTP ($t = 16.07$, $p < .05$). We found no statistically significant difference in the factor of age between the Control group and the TTP ($t = -1.83$, $p = .07$), but the gender factor significantly differed ($\chi 2 = 334.01$, $p < .05$). Consequently, we included gender as a covariate and conducted a mixed model ANCOVA to compare the scores of attentional dimensions obtained via the four scales of MUSI (EIA, EEA, NIA, and NEA) between TTPs and the Control group. Overall, both the control and the TTP groups showed similar patterns, scoring higher on the narrow aspects of attentional dimensions (NIA and NEA). Figure 2 provides a visual depiction of the results. The ANCOVA results showed a significant main effect in the attention dimensions ($F(1.69, 468.63) = 95.30$, $p < .05$, $\eta 2 = .26$) and no group interactions were observed. Pairwise comparisons with Bonferroni's post hoc correction revealed that NIA was significantly higher than EIA and EEA, and similarly, NEA was significantly higher than EIA and EEA.

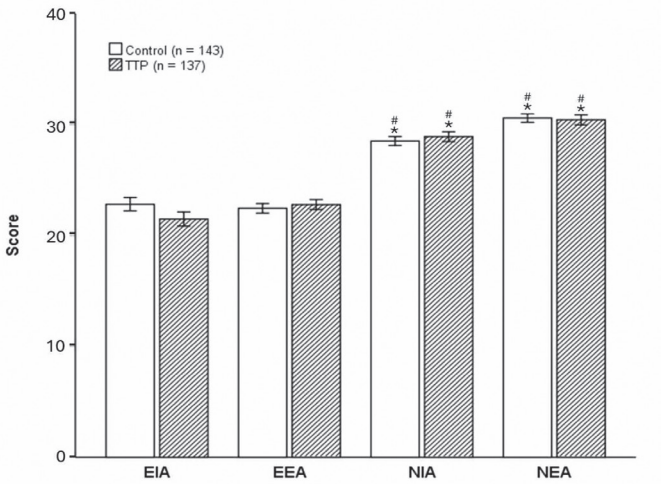

Figure 2. Scores of the control group and the Table tennis Players (TTP) on four attention dimensions: Extensive Internal Attention (EIA), Extensive External Attention (EEA), Narrow Internal Attention (NIA), and Narrow External Attention (NEA) based on the Multi-Dimensional Excellence Movement (MUSI) scale. Data is presented as mean ± standard error. "#" compares with EIA, and "*" compares with EEA.

Experiment 2

In experiment 1, we observed a similar pattern between the control group and TTP; therefore, we selected the NTTPs from the TTPs and compared them with the control group in experiment 2 to investigate further. Similar to the findings from experiment 1, there was a significant difference in weekly practice hours between the control and NTTP ($t = 45.52$, $p < .05$). We observed no significant difference in the factor of age between the Control and NTTP ($t = 1.33$, $p = .18$), but there was a significant difference in the gender factor ($\chi 2 = 221.45$, $p < .05$). Therefore, we incorporated gender as a covariate and performed a mixed model ANCOVA to compare the scores of attentional dimensions obtained via the four scales of MUSI (EIA, EEA, NIA, and NEA) between the NTTP and Control group. Like in experiment 1, the control and NTTP showed similar patterns, i.e. scoring higher on the narrow aspects of attentional dimensions (NIA and NEA). Figure 3 provides a visual representation of the results. The results of ANCOVA revealed a significant main effect in the attention dimensions ($F(1.62, 256.85) = 22.44$, $p < .05$, $\eta 2 = .12$) and no significant difference in group Interactions. However, the group factor differed significantly ($F(1,158) = 5.94$, $p < .05$, $\eta 2 = .036$). Pairwise comparisons with Bonferroni's post hoc correction showed that NIA and NEA were significantly higher than EIA and EEA. In particular, the NTTPs scored significantly higher on NIA than the control group.

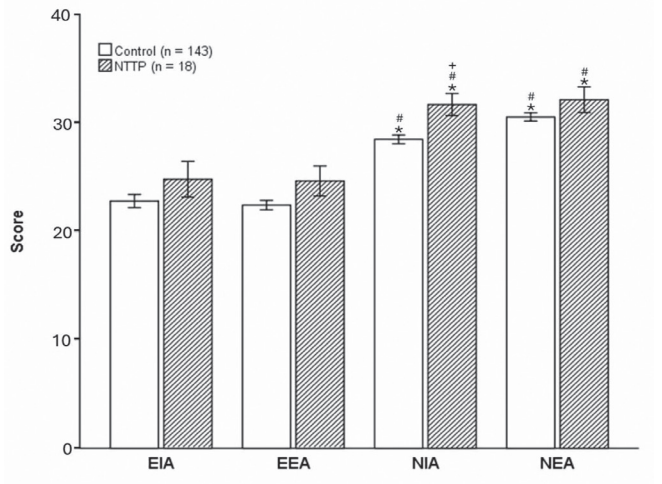

Figure 3. Scores of the control group and the national table tennis players (NTTP) on four attention dimensions: EIA, EEA, NIA, and the NEA based on the MUSI scale. Data is presented as mean ± standard error. "#" compares with EIA, "*" compares with EEA and "+" compares with the control group.

Discussion

In this study, we used four subscales from the MUSI battery of questionnaires to assess attentional dimensions (EIA, EEA, NIA, and NEA) in skilled table tennis players and a control group in two experiments. The weekly practice hours of TTPs were significantly higher than those of the control group (experiment 1), and the weekly practice hours of NTTPs were significantly higher than the control group (experiment 2). In

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both experiments, we used ANCOVA to correct for the gender factor. The results from both experiments revealed that participants scored higher on the narrow dimensions of attention, i.e. NIA was significantly higher than EIA and EEA, and NEA was significantly higher than EIA and EEA. Exclusively, the NTTPs had significantly higher NIA scores than the control group in experiment 2. Our study suggests that in all groups, generality (higher scores on the narrow dimensions) and specificity (higher scores on NIA among NTTPs) exist in attention dimensions.

Previous research utilizing the MUSI: Attention Scales and Mental Energy in a sample of 91 above-average athletes (35 handball and 56 volleyball players) revealed no statistically significant difference in attention dimensions (EIA, EEA, NIA, and NEA) between the two groups (Sindik, Horvat, et al., 2015). However, in the current study, we observed a significant difference between the attention dimensions, particularly prominent in NTTPs, showing a group effect. Intuitively, handball and volleyball share similarities, such as being team sports and predominantly using hands. In their study, both the groups are skilled. Consequently, there is no adequate control group of novices. Additionally, many studies have indicated that professional athletes have better attention performance as compared to novices (Heppe et al., 2016; Jin et al., 2023; Voss et al., 2010; Wechsler et al., 2021). In this study, we also observed a significant difference in attention dimensions because we recruited a control group with no or low skill in table tennis and compared it with skilled table tennis players. Therefore, our findings suggest that the experimental design can include an appropriate control group to highlight the differences in psychological characteristics between athletes of various sports.

In this study, the control group scored higher on the narrow dimensions of attention. The narrow dimensions (focus) correspond to the ability to concentrate on one thing (Nideffer, 2007; Pratt & Whitney, 1991). While comparing 60 white male police applicants in a large metropolitan city with 97 male college students, the research found that police applicants described themselves as having a narrower focus than college students (Nideffer, 1976). In sports, top athletes and Olympic medal and world championship winners were also dominated by a narrow focus on concentration (Nideffer et al., 2001). Additionally, it is well known that academia is attention-demanding and requires focus and concentration (Slattery et al., 2022). Moreover, research indicates that better attention skills can predict academic achievements, highlighting the importance of attention in academics (Gallen et al., 2023). Taken together with the previous studies and the current findings, narrow dimensions of attention are generally more developed.

Furthermore, in experiment 1, the TTP group (from different universities) showed no group difference compared to the control group (from a single university). Using the D2 test of attention (sustained attention), a previous study involving 150 female and 170 male students at a primary school, researchers reported a statistically significant difference in the level of selective attention between the sports group and the non-sport group (Aslan et al., 2020). The present results seem to contradict their findings in attention. However, in their study, the subjects were not involved in a single sport, while in the present study, the subjects only played table tennis. Secondly, age could be a factor as the participants in their study are school students, whereas in this research, the participants are university students. In another study, while comparing students from the same university, table tennis players had significantly better attentional performance (executive network) as compared to non-athletes on the attentional network test (ANT) (Wang et al., 2016). In both these studies, study groups belonged to the same pool of subjects. In contrast to the current study, the TTPs belonged to 16 different universities, and only 20 players were from NCKU. Although homogeneity of the population can be a factor in observing these contrary results, more evidence from different populations is required to clarify these contradictory results. Taken together, the findings of experiment 1 are informative, but the role of sports/table tennis playing on attention enhancement is inconclusive and remains to be determined by further studies.

In experiment 2, overall, NTTPs had higher scores on all attention dimensions (Figure 3), showing a group effect. Many studies have indicated that professional athletes have better attention performance as compared to novices (Heppe et al., 2016; Jin et al., 2023; Voss et al., 2010; Wang et al., 2016; Wechsler et al., 2021). Moreover, national table tennis players have better attentional performance as compared to non-athletes on the attentional network test (ANT) (Wang et al., 2016). Therefore, the current results provide further evidence that attention plays a crucial role in sports and that better attention skills are a differentiating factor between novices and an elite player.

In this study, in particular, the NIA scores of NTTPs were significantly higher than those of the control group. The questions in this factor focus on following the course of my thoughts during the match, conversing with myself about the possible actions, taking into account the negative thoughts and considering the position of my body during the performance, analysing self-performance, and quickly learning from mistakes during the game (Sindik, Botica, et al., 2015). NEA is employed for execution of the NIA. Because of the high correlation between NIA and NEA, previous studies often combined the two components to measure the focus of concentration (Nideffer, 2007; Pratt & Whitney, 1991). While studying the psychological profiles of Olympic medallists and world champions, researchers found out that a world champion profile has the distinguishing ability to narrow their focus of concentration (Nideffer et al., 2000). The study comparing elite-level performers at the Australian Institute for Sport (AIS) in Australia with a group of athletes from around the world who had either won an Olympic medal or a world championship also found a direct relationship between the level of performance of elite-level athletes and the scores on narrow focus scale (Nideffer et al., 2001). Table tennis is a fast response sport that demands quick and seems to have automatic reactions with low conscious effort, which is described as "flow state" (Csikszentmihalyi, 1990). The flow state is a psychological state used to describe complete immersion in an activity (Biasutti, 2011). In the current study, NTTPs had significantly high scores on NIA reflecting their superior mental ability (flow state), which can contribute to increased productivity and satisfaction especially when the training is tough (Biasutti, 2011). Additionally, this superior mental ability is followed by better execution performance as NTTPs have comparatively higher score on NEA, which agrees with high correlation between NIA and NEA. Taken together with previous studies, the current results provide further evidence that a narrow focus of attention (NIA and NEA) is also a defining characteristic of elite table tennis players that is related to optimal performance.

There are some limitations to this study that need to be acknowledged. Firstly, the Table Tennis Players (TTPs) involved in this study were from 16 different universities, whereas the control group consisted solely of individuals from a single university. The composition of the control group, being from a single university, may have some impact on the results, as it does not encompass the same diversity as the experimental groups. Therefore, for future studies we recommend the inclusion of multi-institutional participants in the two groups that would reduce the risks of institutional/cultural biases. Secondly, the study's participants were exclusively university students. In this study, the number of males (n = 14) and females (n = 4) in the NTTP group are imbalanced, which might cause difficulty in generalization of the current findings. Finally, this study used a cross-sectional experimental design, which is susceptible to biases (such as selection, non-response etc) and poor causal inference.

Conclusion

This study concludes that individuals generally have more developed narrow dimensions of attention which translates to their ability of rehearsing, systematizing, and organizing the information just before execution; specifically, skilled individuals have higher abilities in this regard. The evidence from this study points to the cognitive benefits of sports, particularly highlighting table tennis to improve attentional skills. The findings from this research advocate for promoting table tennis as a tool for cognitive and attentional improvement. Taken together with the current findings and previous studies, expressing high scores on NIA would be an important characteristic for winning medals in athletic competitions. Therefore, we recommend that coaches and table tennis players focus on strategies to develop NIA.

Conflict of Interest

The authors declare no conflict of interest.

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