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MOVEMENT PATTERN RECOGNITION ABILITY OF MALAYSIAN RHYTHMIC GYMNASTICS JUDGES

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Abstract

This study examined the significance of movement pattern recognition ability in the judging performance of 30 rhythmic gymnastics judges who were classified correspondingly as expert, non-expert and novice. Results indicated that the expert and non-expert participants were superior to the novice participants in their movement pattern recognition ability and their judging performance but there were no differences between the expert and non-expert participants. When the participants were regrouped according to their movement pattern recognition ability; low, average and high, the results showed that there were very significant differences in the judging performances of the three groups classified according to their movement pattern recognition ability. This suggests that movement pattern recognition ability influences the judging performance of a rhythmic gymnastics judge.

Keywords: judging performance, expertise, rhythmic gymnastics, movement pattern recognition

Introduction

The determination of a winner in rhythmic gymnastics is very much dependent on the judges' evaluation of the performances of the gymnasts. This evaluation is quantified according to the judges' perceptual analysis with reference to the Code of Points. While the expert judges' superiority in the knowledge of the Code of Points is acknowledged by the International Gymnastics Federation and documented in sports research pertaining to this (Ste Marie, 1999), little is done to identify the perceptual and cognitive attributes which assist the expert judge's evaluation. An understanding on the perceptual and cognitive processes may mediate a higher mastery in the judges' performance and produce more correct judgements during competitions. The research goal here was to examine the differences between the expert and non-expert judges and the extent of movement pattern recognition ability's role in the rhythmic gymnastics evaluation process on the part of the judges.

The evaluation of performances in any domain can be a demanding and complex task. An array of incoming perceptual information must be deliberated on and this information must be incorporated with previous knowledge as well as with specific evaluation criteria before churning out a numerical value. In sports such as rhythmic gymnastics, the judges not only observe the skills but also have to integrate their knowledge of errors and deductions associated with errors committed. Additionally, the task must be completed instantaneously while the performance is ongoing. This process is replicated each time with every gymnast by the rhythmic gymnastics judges who also have to cope with 'temporal pressure' on top of their immensely demanding task. Despite all these, expert judges are proven to be able to maintain consistency in their judgment (Ste-Marie, 1999). The seminal work of Chase and Simon (1973) and de Groot (1965) explained the development of this expertise in an information-processing perspective by linking performance to cognitive functioning (Ste-Marie, 1999). The input of information to be entered during judging is compounded by the endless possibilities in the way a gymnast could perform her task. A gymnast could perform the skills in a variety of foot or body positions, different number of repetitions or rotations and different presentation styles. In addition, gymnastics judging entails the retrieval of stored memory concerning the symbol codes, levels of difficulties and the representation of the required execution for all gymnastic elements. Furthermore, the judge would have to make a minimum of 16-18 decisions in 90 seconds which works out to be one in every five seconds. These demands challenge the limited capacities of attention, memory and speed of processing that are characteristic of humans. Thus, the judging of a rhythmic gymnastics performance is a challenging cognitive task. Given the speed, individuality and precise nature of the skills performed, judges may have to use cognitive strategies to reduce the cognitive load and hence facilitate the process of judging (Alcock, Carmen and Sadava, 1994).

Expert judges are typically very accurate in their evaluations as compared to novices (MacMahon and Ste-Marie, 2002; Ste-Marie, 1999). Their superiority has been attributed to numerous factors ranging from innate qualities to systematic training. It is contended that the primary factor distinguishing expertise was the number of hours spent in deliberate practice which was attributed a causal role in the attainment of expertise (Ericsson, Krampe and Tesch-Römer, 1993). There is also a growing body of evidence to support this contention from chess (Charness, Tuffiash, Krampe, Reingold and Vasyukova; 2005) and sports (Law, Côte and Ericsson, 2007; Deakin and Cobley, 2003; Helsen, Starkes and Hodges, 1998; Hodges and Starkes, 1996). On the other hand, experts' superior performance is defined by the fact that they appear unconstrained by many of the limitations that confine others attempting to do the same task (Salthouse, 1991). In adopting this view for the explanation of the rhythmic gymnastics evaluation performed by judges, it becomes pertinent to establish how the constraints on human information processing are circumvented by the expert judges.

It has been reported that experienced rugby referees used more episodic and semantic information to make their calls when compared to less experienced referees (MacMahon & Ste-Marie, 2002). The results from Ste-Marie's (1999) study suggested that expert gymnastics judges knew the symbol codes and the level of difficulties associated with gymnastic elements significantly better than the novice judges did. Thus, when evaluating an event, expert judges have more information at their disposal to make a more accurate decision. However, an expert system requires more than knowledge before it can display expertise in a given domain. Based on the International Gymnastics Federation's judges' examination results, it was found that excellent knowledge of the Code of Points (rule book) does not necessary indicate superiority in judging skills. The International Gymnastics Federation (FIG) Rhythmic Gymnastics Technical Committee has been directed to address the inadequacy of the examination to establish the judging expertise (FIG Bulletin No. 202 August 2006). The same study also established that knowledge of the Code of Points did not correlate with the experts' better perceptual anticipatory skills. Based on these studies which employed an expert-non-expert paradigm, it was concluded that the superiority of the experts were of a qualitative nature rather than based on quantifiable measures (Starkes, 1987; Starkes, Deakin, Lindley and Crisp, 1987; Huber, 1997).

A number of studies have demonstrated superior detection of pertinent information on the part of expert judges, referees and umpires. It has been demonstrated that experts attend more to relevant information and are able to screen away irrelevant information (Abernethy and Russel, 1987; Abernethy, 1991). Expert officials were significantly more accurate at identifying the type of foul or infraction in a basketball sequence (Deakin and Allard, 1991). In gymnastics, expert judges were found to be better at detecting errors in a gymnastic performance than novice judges (Ste-Marie and Lee, 1991). Ste-Marie (2000) surmised that experts through their knowledge and selectivity can better detect critical performance aspects that novices may miss. In sport expertise research with athletes, it has been shown that highly skilled athletes are able to use advance information better than novices in order to predict the outcome of visually presented information (Abernethy and Zawi, 2007; Abernethy, Zawi and Jackson, 2008). There was also evidence that this predictive advantage benefitted the gymnastics judges, with expert judges better at extracting kinematic cues from the gymnastic performance (Ste-Marie, 1999). The study also revealed that the novices looked down towards the judging forms significantly more than the experts while the performance was ongoing. It was suggested that the novice judges were perhaps coping with the information overload by taking down notes. In view of the nature of the judging task under time pressured situations and continuous incoming information, it is most likely that the expert rhythmic gymnastics judges have learned to circumvent processing limitations encountered by novice judges by acquiring certain cognitive structures. One possible acquisition from the repeated judging tasks could be an improvement in the pattern recognition skills.

The importance of pattern recognition skills was first seen in de Groot's (1965) research on expert and novice chess players. He found that experts were able to recognize more rapidly meaningful patterns on the chessboard and that this skill aided the recall of strategy-relevant information. Additionally, this characterized much of human learning as pattern learning (Charness, 1991). The activation of knowledge in memory requires the ability to recognize and classify patterns in a set of stimuli (Gagne, 1985). Pattern recognition requires that one organizes existing knowledge around meaningful patterns and develops procedures for relating new information to the patterns. In professional practice, recognition of a particular pattern of information becomes the stimulus for carrying out a series of subsequent actions. It was suggested that repeated representations of examples with varying degrees of similarity will develop the pattern recognition skill (Anderson, 1983). Deliberate practice of this nature strengthens one's ability to recognize and discriminate meaningful patterns and enhances the generalization of pattern recognition skills to new situations. Similarly, in the gymnastics judging process, the evaluation of numerous routines would leave indelible mark on the pattern recognition ability of the judges.

So far, little has been done to identify the perceptual and cognitive attributes which assist the expert judge's evaluation. An understanding on the perceptual and cognitive processes may mediate a higher mastery in the judges' performance and produce more correct judgements during competitions. Therefore, it will be helpful to examine the differences between the expert and non-expert judges and the extent of pattern recognition ability's role in the rhythmic gymnastics evaluation process. Our primary purpose of this study was to examine the link between the pattern recognition ability of the rhythmic gymnastics judges with their judging performance.

Method

This study compared the judging performance and the movement pattern recognition ability of the three groups of expert, non-expert and novice rhythmic gymnastics judges. The judges performed a series of movement pattern recognition tasks (Movement Pattern Recognition Test) and a set of routine judging exercises (Judging Exercises). Tests were conducted to verify the reliability of the MPRT test. Based on test and retest, the reliability was found to be 0.85. The content validity was confirmed by the top ranking rhythmic gymnastics judge in Malaysia who was nominated by the Malaysian Gymnastics Federation. The scores were processed to investigate for differences in movement pattern recognition ability and judging performance among the three groups of judges.

Participants

Thirty female rhythmic gymnastics judges (mean ± SD: age 45.20 ± 7.89 yr) were identified by the Malaysian Gymnastics Federation as been actively involved in judging. Twenty of them have participated in an international rhythmic gymnastics judging course for the 11th cycle, organized under the auspices of the International Gymnastics Federation (FIG) and were subsequently ranked as FIG and non-FIG judges after the judges' examination. For this study, these judges were correspondingly classified as expert and non-expert judges. Ten other national judges who did not attend this course formed the novice group in this study. Consent was obtained from all the participants. It should be noted that none of the judges were present at the Universiade Games in Bangkok and were thus not familiar with the rankings or the difficulty scores that had been awarded to the senior gymnasts featured in the experimental instrument (Judging Exercises).

Testing Procedures

All participants were informed that the purpose of the research was to study cognitive processing in sport evaluation. The judges were ensured of their anonymity and that the results would not be communicated to anyone. Upon giving informed consent, participants were asked to sit at an appropriate distance in order to adequately view the screen. The video footage was projected onto the screen to almost life size specification. Once seated, the research procedure is outlined and the participant was given a practice trial to familiarize with the testing procedures. After that, the movement pattern recognition ability test was administered. The participant provided the necessary responses on the Movement Pattern Recognition Ability Test (MPRAT) recording booklet.

The judging exercises (JE) commenced fifteen minutes after the movement pattern recognition ability test (MPRAT). Each participant was reminded to judge as a difficulty judge in the judging exercises. Following the instructions, the participant viewed the video footage with two sets of the technical value forms arranged in the order of the viewing programme. She need not provide the scores for the first set which consists of five bench-mark exercises but was asked to familiarize with the judging procedure. The bench-mark score was displayed 40 seconds after the end of each routine. The bench-mark set was shown so as to have the participants start from a common context, as well as to familiarize them with the experimental procedure. After that, the participant was provided with the second set of official difficulty forms arranged in the order of appearance. She was given three minutes to go through the set of forms. Ten routines followed and the participant wrote down the score on the form after having evaluated each routine. As in actual competitions, the participants noted their evaluations on the official forms within a period of 40 seconds after the end of each routine. The participant was also not permitted to rewind or review the video footage. The official difficulty forms were collected after this judging exercise.

Instruments

Movement Pattern Recognition Test

The movement pattern recognition ability test (MPRAT) consists of 12 movement series depicting three different elements from each of the four groups of body movement; leaps and jumps, balances, flexibility and waves, and pivots. For each movement series which comprises of eight frames, there is a pause of six seconds between frames for the participants to write down the name or judging symbol of the anticipated body movement as specific as possible at the space allocated on the Movement Pattern Recognition Ability Test Recording Form. If there was no response, the participant was to leave it vacant and move on to the next space. There is a total of 7 pauses for every movement series followed by a 20 seconds break between two movement series. This protocol was observed throughout until the completion of all 12 series. A sample of these series is shown in Figure 1. The scoring system for this test is given in Table 1. The consultant for this study who was nominated by the Malaysian Gymnastics Federation confirmed the content validity of this test.

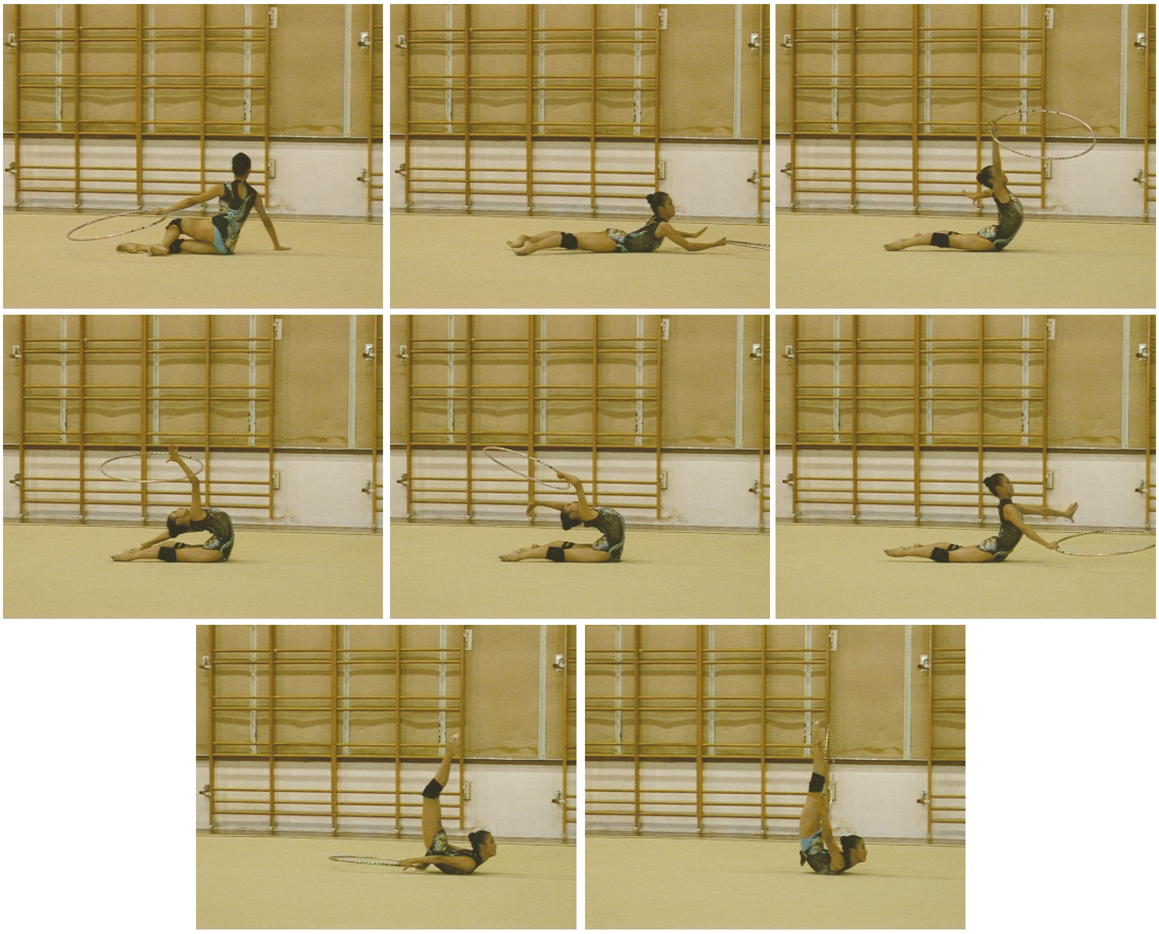

Figure 1: A Section of Movement Pattern Recognition Ability Test Using the Flexibility Body Movement.

Table 1: Scoring system for Movement Pattern Recognition Ability Test (MPART)

Task Achievement	Scoring Based on Response Temporal Positioning						
	Frame A	Frame B	Frame C	Frame D	Frame E	Frame F	Frame G
Body Movement Group only	**60**	**50**	**40**	**30**	**20**	**10**	**0**
Body Movement (but not accurately defined)	**80**	**70**	**60**	**50**	**40**	**30**	**20**
Specific Body Movement	**100**	**90**	**80**	**70**	**60**	**50**	**40**

Judging Exercises

The set of judging exercises used in this study is composed of five bench-mark routines and ten routines for evaluation. The bench-mark routines comprised of one of each competition apparatus; rope, hoop, ball, clubs and ribbon whereas the judging routines consisted of two of each competition apparatus. All the routines were according to senior competition programmes except for the ball routines. This was because the competition programme for senior gymnasts in the current Olympic cycle comprised of only rope, hoop, clubs and ribbon. The ball routines were performed by the top Malaysian junior gymnasts.

The judging set for rope, hoop, clubs and ribbon was selected from the video footage recorded during the Apparatus Finals of the Universiade Games. The ball routines were performed by the top junior Malaysian gymnasts and recorded at the National Sports Council Gymnasium in Kuala Lumpur. The final set which was accompanied by valid difficulty forms, were checked and evaluated by a judge appointed through the Malaysian Gymnastics Federation. These forms were pre-submitted by the coaches on the projected value of routine's difficulties. The length of each routine ranged from 82 seconds to a maximum of 90 seconds; averaging about 87 seconds. There was a 40 seconds intermission between two routines which is the standard time allowed during which the judge has to write down her score for the difficulty value on the form before the next routine comes on. The scoring system for the participants is based on the difference of the participant's score from the expert judge's score; similar to the system used by the FIG Technical Committee. This system is shown in Table 2.

Table 2: Scoring system for Judging Exercises

Difference in value with reference score	0	±0.1	±0.2	±0.3	±0.4	±0.5	±0.6	±0.7	±0.8	±0.9
Score awarded	10	9	8	7	6	5	4	3	2	1

Example: Participant's Score = 4.4
Reference Score = 4.3
Difference between scores = 0.1
Score awarded = 9

Statistical Analysis
The main dependent measure was the movement pattern recognition ability score. The scores were checked on the violation of equal-variance assumption and to protect the normality of the distribution of scores. Min and standard deviation were employed to describe overall data. For main group comparison, a 3 x 4 two-way ANOVA mixed design with the Bonferroni procedure was used for hypotheses testing. As sphericity is assumed violated in all repeated measures behavioural studies, this violation will be checked through the Bonferroni adjustment of the transformed data (Keppel, 1991). The Bonferroni procedure is a conservative procedure to control the experimentwise error rate or to protect from making the error of rejecting the null hypothesis when it is true. The Scheffe procedure with Bonferroni-adjusted values was used to obtain post-hoc comparison of significant main effects. Analysis of the characteristics of the participants from the three groups with their judging performance was also conducted using the Pearson correlation coefficient, r. The correlation coefficient is also a measure of the size of the effect to the judging performance (Field, 2005; Thomas, Nelson and Silverman, 2005). All statistical analyses were performed through the use of a statistical software package (SPSS version 16.0, SPSS Inc., Chicago, IL). The level of significance was set at $P \leq 0.05$.

Effect sizes were indicated by omega squared ($\omega 2$). Omega squared is a less biased measure of effect size associated with ANOVA and provides a more accurate measure of the variance attributed to the independent variables (Field, 2005; Thomas, Nelson and Silverman, 2005). This effect size measure provides indices of effect that are consistent with Cohen's (1988) guidelines for defining the magnitude of the effect. Effect sizes of 0.2, 0.5 and 0.8 represented small, moderate and large differences (Cohen, 1988). The power of the study was also calculated at the predetermined level of $\alpha = 0.05$.

Results

Movement Pattern Recognition Ability Comparisons
Assumptions of normality, homogeneity of variance and sphericity were met. The results revealed that there were significant differences between the movement pattern recognition ability of the three groups of expert, non-expert and novice participants, $F(2, 28) = 5.441$, $p = 0.010$. The Scheffe post-hoc test confirmed that the differences between the expert group and the novice group ($p = 0.035$), and the non-expert group with the novice group ($p = 0.023$) were unlikely to have arisen from sampling error. The respective effect sizes of 0.596 and 0.558 indicate that these effects are large and accounts for more than 25% of the variance (Cohen, 1992, 1988). However, there was no significant difference between the expert and the non-expert participants. The overall omega squared value represented an effect size of 0.308, showing that nearly 31% of the variation in the movement pattern recognition ability for the all movement series can be accounted for by differing levels of expertise whereas the omega value of 0.555 represents a large effect size (Field, 2005; Thomas, Nelson and Silverman, 2005). In addition, the power of the test is high with a value of 0.804. Means ± SD for each of the parameters mentioned are shown in Table 3.

Table 3: Means and standard deviation values for the movement series scores in the Movement Pattern Recognition Ability Test (MPRAT)

Scores	Mean	Standard deviation
Jump movement series		
Expert	741 00	255.45
Non-expert	768.00	293.364
Novice	340.00	154.416
Balance movement series		
Expert	493.00	291.85
Non-expert	490.00	353.40
Novice	317.00	171.60
Pivot movement series		
Expert	619.00	240.25
Non-expert	653.00	267.04
Novice	384.00	166.21
Flexibility movement series		
Expert	362.00	125.68
Non-expert	364.00	186.62
Novice	259.00	77.95
Total MPRAT		
Expert	2215.00	770.18
Non-expert	2275.00	940.91
Novice	1300.00	409.44

Judging Performance Comparisons

In terms of judging performance, there were also no differences between the expert and non-expert participants but both groups of participants were significantly superior to the novice participants. The results did not show any pertinent or conclusive differences between the expert and the non-expert groups. Means ± SD for each of the parameters mentioned are shown in Table 4. However, correlation analysis revealed a strong relationship between the movement pattern recognition ability and the judging performance of the participants which is shown in Table 5.

Table 4: Means and standard deviation values for the judging performance scores in the Judging Exercises (JE)

Scores	Mean	Standard deviation
Rope routines		
Expert	9.40	4.60
Non-expert	9.80	5.22
Novice	1.00	1.16
Hoop routines		
Expert	7.10	4.77
Non-expert	8.70	5.66
Novice	0.70	1.34
Ball routines		
Expert	8.90	6.15
Non-expert	9.10	7.22
Novice	1.10	1.29
Club routines		
Expert	8.40	3.95
Non-expert	9.30	6.45
Novice	0.80	1.14
Ribbon routines		
Expert	4.90	4.20
Non-expert	6.20	4.24
Novice	0.00	0.00
Total JE		
Expert	38.70	14.11
Non-expert	43.10	15.82
Novice	3.60	4.60

Table 5: The correlation between the characteristics of the research participants with their judging performance using Pearson correlation coefficient, r

Characteristics of Participants	Judging Performance	Significance Level (One-tailed)
Judging qualification		
Overall	0.723**	0.000
Expert	0.026	0.471
Non-expert	a	a
Novice	0.794**	0.003
Judging experience		
Overall	0.379*	0.019
Expert	0.185	0.304
Non-expert	0.158	0.332
Novice	0.061	0.434
Judging frequency		
Overall	0.371*	0.022
Expert	0.416	0.116
Non-expert	0.131	0.359
Novice	0.119	0.372
Coaching experience		
Overall	0.409*	0.012
Expert	0.045	0.451
Non-expert	0.293	0.206
Novice	0.683*	0.015
Pattern recognition ability		
Overall	0.828**	0.000
Expert	0.797**	0.003
Non-expert	0.828**	0.002
Novice	0.899**	0.000

a Judging qualification is a constant
* Correlation is significant at the level 0.05
** Correlation is significant at the level 0.01

Subsequently, when the participants were regrouped statistically according to their pattern recognition ability; low, average and high, the results showed that there were very significant differences between the judging performances of the three groups classified according to their pattern recognition ability. Descriptive statistics (Table 6) showed that the participants of the high pattern recognition ability group performed better than the participants of the medium and low pattern recognition ability groups.

Table 6: Mean and standard deviation scores of the regrouped participants' judging performance in the judging exercises

Category (Pattern Recognition Ability)	No. of participants (N=30)	Minimum score	Maximum score	Mean	Standard Deviation
High	10	43	61	53.00	5.793
Medium	10	8	36	29.00	9.707
Low	10	0	12	3.40	4.115

An one-way analysis of variance showed that there were significant differences between the judging performance of the three groups of differing levels of pattern recognition ability, $F (2, 28)= 127.548$, $p = 0.000$. The omega squared value represented an effect size of 0.927, showing that about 93% of the variation in the overall judging performance for the evaluation exercise can be accounted for by differing levels of pattern recognition ability whereas the omega value of 0.963 represents a very large effect size (Field, 2005; Thomas, Nelson and Silverman, 2005). In addition, a follow-up Scheffe test indicates that the participants from the three groups of pattern recognition ability were significantly different from each other ($p < 0.05$). The power of the test is very high with a value of 1.000. This finding aligns to the views of Ericsson, Krampe and Tesch-Römer (1993) and Feltovich, Prietula, and Ericsson (2006) that expertise involves an adaptation of the cognitive system to circumvent the great demands posed by the complex cognitive task. The adaptation here is the engagement of the pattern recognition ability in the judging evaluation task.

Discussion

This study is the first, to our knowledge, to examine differences in the judging performance and movement pattern recognition ability among rhythmic gymnastics judges. An important feature of the present study is that the pattern recognition ability of the participants was matched to their judging performance and their classification of judging expertise. The main finding was that the participants' judging expertise was better predicted by their movement pattern recognition ability. These results suggest that the movement pattern recognition ability is a cognitive strategy engaged by the expert rhythmic gymnastics judges to circumvent the limited human cognitive resources during the judging process.

The categorization of the expertise of the participants in this study was based on the results of the International Rhythmic Gymnastics Judges' Course held in 2005. At the point of recruitment of the judges as participants in this study in 2008, the expert and non-expert judges have more than three years of judging involvement since that significant classification. The initial results showed that there were no differences between the performances of the expert and non-expert judges in the evaluation exercises. The expertise of the judges, particularly the non-expert judges obviously has evolved since that classification. While the characteristic of international judging qualification (or rather the lack of it) had a direct impact on the judging performance of the novice participants, it bore no significance on the judging performance of the expert and non-expert participants. The possession of coaching experience among the novice participants also demonstrated a significant link with their judging performance [$r = 0.41$, p (one-tailed) < 0.05]. Other than that, judging experience [$r = 0.38$, p (one-tailed) < 0.05] and judging frequency [$r = 0.37$, p (one-tailed) < 0.05] were the other significant characteristics linked to the judging performance. In the case of the novice participants, their lack of knowledge about judging according to international requirements by virtue that they did not attend the international judging course, explains their inadequacy in the evaluation exercise. This is in line with previous studies (Feltovich, Prietula, and Ericsson, 2006; French, Nevett, Spurgeon, Graham, Rink and McPherson, 1996; Huber, 1997; Boyd and Yin, 1999; French and McPherson, 1999) that knowledge and content matter are important to expertise. However, the knowledge paradigm which was used to determine the status of expertise was found to be inadequate for the divide between the expert and non-expert participants. As forwarded by Ericsson, Krampe and Tesch-Römer (1993), "…eminent performance goes beyond expert mastery of available knowledge and skills…" (p. 370). Obviously, another cognitive strategy is required to bring about the leap in the level of expertise and not merely maintaining the same level as suggested by Thomas, French and Humphries (1987). Indication from the correlation analysis results suggested a stronger affiliation between the movement pattern recognition ability and the judging performance of the participants. This was proven when the participants were regrouped based on their movement pattern recognition ability. There was clear evidence that the high movement pattern recognition ability group out-performed the participants from the medium and low movement pattern recognition groups in the judging performance. The high movement pattern recognition ability group produced significantly more accurate scores in their judging performance of the routines in the evaluation exercise. Movement pattern recognition ability is shown here to be able to differentiate the judging performance of the participants. This suggests that the ability which is a perceptual-based mechanism is used to assist them in correctly identifying upcoming elements and thus free their limited resources to attend to the analysis and judgmental components of their task. This is parallel to findings by Feltovich, Prietula, and Ericsson (2006) and Ste-Marie (2003) that cognitive strategies allow the efficient use of information and knowledge to circumvent the limitations of human cognitive system and innovative efforts were found to bring substantial gains in improvement of performance.

Although the non-expert and expert participants did not record partaking in any activities designed specifically to increase their performance in judging which will qualify as deliberate practice (Ericsson, Krampe and Tesch-Römer, 1993), they regularly judged in the major national rhythmic gymnastics competitions. The frequency of their judging involvement and judging experience were significantly linked to their judging performance. Ericsson, Prietula and Cokely (2007), Malhotra, Lee and Khurana (2005) as well as Ericsson and Lehmann (1996) dismissed the direct role of experience with regards to expertise, but it appears in line here that experience did assist in the formation of "swift pattern recognition based on experience" (Leonard and Swap, 2005; p. 13). This is reflected in the strong link between the pattern recognition ability and the judging performance. However, the associations between the two characteristics of experience and pattern recognition ability as well as how pattern recognition ability evolved, were not examined further in this research.

It appears that the non-experts, rather than the experts, appeared to progress more in terms of judging expertise in the period of three years after that significant judging course. It is noted that after that classification, the expert participants assumed decisive roles during any judging assignments in Malaysia. On the other hand, the non-expert participants constantly received feedback and instructions to change their scores in the event of any scores out of range where the expert's score were used as a point of reference. We would like to suggest that the non-expert participants had made deliberate efforts to improve either consciously or unconsciously. Under such circumstances, the non-expert participants were motivated (imposed or internalized) to reduce the range in the scores meted out during competitions.

Judging and coaching experience were revealed as contributory to the expertise of the rhythmic gymnastics judges. A potential direction for research on the influence of these two aspects is to identify the relevant activities and the amount of time and frequency the judges allocate to these activities. A detailed diary or historical record of these will disclose environmental conditions and individual differences which predispose certain individuals towards higher judging expertise. While there was no mention of activities which possess any resemblance of deliberate practice in this study, a careful analysis will tell us how the judges progress and develop their judging skills.

Conclusion

It is evident that the possession of knowledge and content matter is the primary prerequisite to the attainment of expertise. However, this proves to be the one of the many prerequisites to the attainment of high level expertise. The comparisons between experts, non-experts and novices in this study unravelled that while the knowledge level discriminates the novices from the others, there is more than knowledge to achieve higher level expertise in rhythmic gymnastics judging. The knowledge paradigm was mostly used to determine the status of expertise of the rhythmic judges but exposure to the judging process (of more than three years) in the current Olympic cycle increases the performance of the non-expert judges in order to close up the gap with the expert group of judges. The findings of this study align with the opinion of the Rhythmic Gymnastics Technical Committee (RG-TC) of the International Gymnastics Federation that mere knowledge about the Code of Points is insufficient to meet the criteria of being a good judge (FIG, 2006). The judges still require other skills or strategies to cope with the evaluation task. Although the rhythmic gymnastics judges are provided in advance with the technical forms which indicate the difficulties to be performed, the remaining information processing demands are still very challenging to the cognitive resources. The practical implication of this study provides a new dimension in the training of expert rhythmic gymnastics judges which is traditionally based on knowledge.

The important challenge to researchers currently relates to ascertaining how pattern recognition ability can contribute further to the advancement of the expertise of rhythmic gymnastics judges in their judging performance. One proposition is that with increased exposure, the imprinting process (Williams, Ward and Smeeton, 2004) of the pattern recognition ability allows the processing of stimuli to be conducted with increased speed, accuracy and general fluency. Therefore, further research is required on the influence of pattern recognition ability towards the advancement of judges' expertise in their evaluation roles as it has vast implications on the training of judges and a paradigm shift in the training of judges. This will only facilitate the quest of producing more expert judges which certainly provides an impetus in the correct direction to the development of the sport.

References

Abernethy, B. (1991). Visual search strategies and decision-making in sport. International Journal of Sports Psychology, 22: 189-210.

Abernethy, B. & Russell, D.G. (1987). Expert-novice differences in an applied selective attention task. Journal of Sports Psychology, 9 (4): 326-345.

Abernethy, B. & Zawi, K. (2007). Pick-up of essential kinematics underpins expert perception of movement patterns. Journal of Motor Behavior. 39(5): 353-367.

Abernethy, B., Zawi, K. & Jackson, R.C. (2008). Expertise and attunement to kinematic constraints. Journal of Perception. 37: 931-948.

Alcock, J.E., Carment, D.W. & Sadava, S.W. (1994). A textbook of social psychology (3rd ed.). Scarborough, ON: Prentice-Hall Canada.

Anderson, J.R. (1983). The architecture of cognition. Cambridge, MA: Harvard University Press.

Boyd, M. & Yin, Z. (1999). Cognitive-Affective and behavioral correlates of self-schemata in sport. Journal of Sport Behavior, 22 (2): 288-302.

Charness, N. (1991). Expertise in chess: The balance between knowledge and search. In, K.A. Ericsson & J. Smith (Eds.), Toward a general theory of expertise, (pp. 39-63). New York: Cambridge University Press.

Charness, N., Tuffiash, M., Krampe, R., Reingold, E. M., & Vasyukova, E. (2005). The role of deliberate practice in chess expertise. Applied Cognitive Psychology. 19: 151-165.

Chase, W.G. & Simon, H.A. (1973). Perception in chess. Cognitive Psychology. 4: 55–81.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). New Jersey: Lawrence Erlbaum Associates, Publishers.

de Groot, A.D. (1965). Thought and choice in chess. Paris: Mouton & Company.

Deakin, J. M., & Allard, F. (1991). Skilled memory in expert figure skaters. Memory & Cognition. 19, 79-86.

Deakin, J.M. & Cobley, S. (2003). An examination of the practice environments in figure skating and volleyball: A search for deliberate practice. In J.L. Starkes and K.A. Ericsson. (Eds.), Recent advances in the study of sport expertise (pp. 90-113). Champaign, IL.: Human Kinetics.

Ericsson, K.A., Krampe, T. & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. Psychological Review. 100(3): 363-406.

Ericsson, K.A, & Lehmann, A.C. (1996). Expert and exceptional performance: Evidence of maximal adaptations to task contraints. Annual Review of Psychology. 47: 273-305.

Ericsson, K. A., Prietula, M. J., & Cokely, E. T. (2007). The making of an expert. Harvard Business Review. 85: 114-121.

FIG (2006). Bulletin FIG No.202. August 2006. Moutier: International Gymnastics Federation.

FIG (2006). Bulletin FIG No.200. April 2006. Moutier: International Gymnastics Federation.

Feltovich, P. J., Prietula, M. J. & Ericsson, K. A. (2006). Studies of expertise from psychological perspectives. In K.A. Ericsson, N. Charness, P. J. Feltovich & R. R. Hoffman (Eds.), The Cambridge handbook of expertise and expert performance (pp. 41-68). New York: Cambridge University Press.

Field, A. (2005). Discovering statistics using SPSS (2nd ed.). London: SAGE Publications.

French, K.E. & McPherson, S.L. (1999). Adaptations in response selection processes used during sport competition with increasing age and expertise. International Journal of Sport Psychology. 30: 173-193.

French, K. E., Nevett, M. E., Spurgeon, J. H., Graham, K. C., Rink, J. E., & McPherson, S. L. (1996). Knowledge representations and problem solution in expert and novice youth baseball players. Research Quarterly for Exercise and Sport. 67(4): 386-395.

Gagne, E.D. (1985). The cognitive psychology of school learning. Boston, MA: Little, Brown.

Helsen, W.F., Starkes, J.L. & Hodges, N.J. (1998). Team sports and the theory of deliberate practice. Journal of Sport and Exercise Psychology. 20: 12-34.

Hodges, N.J. & Starkes, J.L. (1996). Wrestling with the nature of expertise: A sport-specific test of Ericsson, Krampe, & Tesch-Römer's (1993) theory of deliberate practice. International Journal of Sport Psychology. 27: 400-424.

Huber, J. (1997). Differences in problem representation and procedural knowledge between elite and non-elite springboard divers. The Sport Psychologist. 11: 142-159.

Keppel, G. (1991). Design and analysis: A researcher's handbook (3rd ed.). New Jersey: Prentice Hall.

Law, M.P., Côté, J. & Ericsson, K.A. (2007). Characteristics of Expert Development in Rhythmic Gymnastics: A Retrospective Study. International Journal of Sport & Exercise Psychology. 5: 82-103.

Leonard, D. & Swap, W. (2005). Deep Smarts: How to cultivate and transfer enduring business wisdom. Boston: Harvard Business School Press.

MacMahon, C. & Ste-Marie, D.M. (2002). Decision-making by experienced rugby referees: Use of perceptual information and episodic memory. Perceptual and Motor Skill, 95: 570-572.

Malhotra, V., Lee, M.D. & Khurana, A. (2005). Domain experts influence decision quality: Towards a robust method for their identification. Journal of Petroleum Science and Engineering. 9(7): 1-14.

Salthouse, T.A. (1991). Expertise as the circumvention of human processing limitations. In K.A. Ericsson & J. Smith (Eds.), Toward a general theory of expertise. (pp. 286-300). New York: Cambridge University Press.

Starkes, J. (1987). Skill in field hockey: The nature of the cognitive advantage. Journal of Sport Psychology. 9: 146-160.

Starkes, J.L., Deakin, J.M., Lindley, S. & Crisp, F. (1987). Motor versus verbal recall of ballet sequence by young expert dancers. Journal of Sport Psychology. 9: 222-230.

Ste-Marie, D.M. (2003). Expertise in sport judges and referees: Circumventing information-processing limitations. In J.L. Starkes & K.A. Ericsson (Eds.), Expert performance in sports: Advances in research on sport expertise. (pp 170-189), Champaign, IL: Human Kinetics.

Ste-Marie, D.M. (2000). Expertise in women's gymnastic judging: An observational approach. Perceptual and Motor Skills. 90: 543-546.

Ste-Marie, D.M. (1999). Expert-novice differences in gymnastic judging: An information processing perspective. Applied Cognitive Psychology. 13: 269-281.

Ste-Marie, D.M. & Lee, T.D. (1991). Prior processing effects on gymnastics judging. Journal of Experimental Psychology: Learning, Memory, and Cognition. 17: 126-136.

Thomas, J.R., French, K.E. & Humphries, C.A. (1987). Knowledge development and sport performance: Directions for motor behaviour research. Journal of Sport Psychology. 8: 259-272.

Thomas, J.R., Nelson, J.K. & Silverman, S.J. (2005). Research methods in physical activity (5th ed.). Champaign, IL: Human Kinetics.

Williams, A.M., Ward, P. & Smeeton, N.J. (2004). Perceptual and cognitive expertise in sport: Implications for skill acquisition and performance enhancement. In A.M. Williams & N.J. Hodges (Eds.), Skill acquisition in sport: Research, theory and practice. (pp 328-349), London: Routledge.

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