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A Video-Based Analysis of Rhythmic Accuracy and Maintenance in Junior Tennis Players

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Abstract

This study mainly focused on the video-based analysis of two parameters of rhythmic ability: rhythmic accuracy (RA) and rhythmic maintenance (RM). The effects of tempo on these parameters were also investigated. The participants were junior competitive tennis players (n= 41, age= 13.46 ± 1.64 years). The video-based analysis system that relies entirely on the features extracted automatically from the audiovisual data was used to determine the RA and RM performances of the participants for the tempos of 44 and 50 bpm. The results revealed that participants significantly performed better RA and RM scores in fast tempo test. In addition, results also indicated that participants had significantly higher scores on accuracy task in both tempos. In conclusion, the study attempted to determine the rhythmic ability via a video based system. Using the proposed system, rhythmic ability analysis can be applied to a wide range of participants in a very short time and further analysis on the collected data can easily be conducted.

Keywords: Rhythmic ability analysis, rhythmic competence, tempo differences, tennis

INTRODUCTION

The nature of tennis requires adaptation to the external stimuli (trajectory, speed, height, and spin of the ball) and thus, participation in tennis training enables children to experience various rhythmic motives with different tempos (Zachopoulou et al. 2000). Depending on the age of the players, opponent, and the court surface, the points in tennis might either end with a single stroke or after a long rally. Therefore, players need to maintain their rhythmic movement patterns not only for a short time but also for a long duration of time.

Rhythmic ability was generally analyzed through its two components, namely, rhythmic accuracy (RA) and rhythmic maintenance (RM). Zachopoulou et al. (2000) defined these components respectively as the synchronization of body movements in a rhythmic stimulus and as the continuous reproduction of a rhythmic motive without the presence of a rhythmic stimulus. The main difference between the tests of RA and RM is the presence and absence of the external rhythmic stimulus. In the literature, there exist two different approaches to carry out the tests for rhythmic ability analysis: observer-based and tool-based. Among these, the Rhythmic Competence Analysis Test (RCAT) is an example for the observer-based method. Weikart (1989) designed RCAT, which includes nonweight-bearing movement, seated, and weight-bearing movement, standing and walking, in order to evaluate an individual's beat competency by testing his/her ability to perform a movement task to the underlying steady beat. The performance of each individual was videotaped and evaluated by examiners.

On the other hand, as an example for the tool-based method, Kioumourtzoglou et al. (1998), Derri et al. (1998), Zachopoulou et al. (2000), and Zachopoulou and Mantis (2001) used a system composed of a metronome for auditory stimulus and a computer with an integrated electronic time switch and three ground-tables with interior mechanical sensors to automatically record the time difference between two continuous steps. Even though the tool-based methods do not depend on the judgement of examiners, they necessitate special equipment for recording the data.

As an alternative to the tool-based methods, in this paper, a novel rhythmic ability analysis system that relies entirely on the features extracted automatically from the audiovisual data was used. The main advantage of the system is that it requires neither special equipment nor expert judgement. Using the video based system analysis, the effects of tempo on the parameters of rhythmic ability were investigated. Additionally, the influences of presence and absence of the external rhythmic stimulus were also compared in two tempos.

METHODS

Subjects

Subjects were male (n= 21, age=13.38 ± 1.75 years) and female (n=20, age=13.55 ± 1.57 years) junior competitive tennis players ($Total_N$= 41, $Total_{Age}$= 13.46 ± 1.64 years). They were informed on the purpose of the study and the testing procedures. Informed consent was signed by the parents of the participants. Ethical approval was obtained from the Human Subjects Ethics Committee of Middle East Technical University.

Data Collection Instruments

The block diagram of the video based analysis system is given in Figure 1.

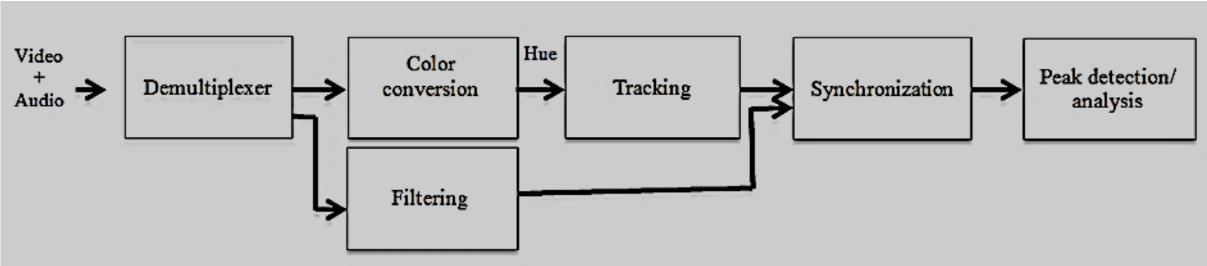

Figure 1. Video based analysis system

In the video based system, the input data was prerecorded video and associated audio. As a first step, the audio and video were de-multiplexed to be processed independently. The audio data was pre-filtered (band-pass filter) to eliminate the surrounding noise so that the metronome beats could be clearly identified. In the meantime, to process the video data, first, each frame of the video is converted from RGB (Red-Green-Blue) color space to HSV (Hue-Saturation-Value) color space since RGB color space is sensitive to illumination and its components are correlated. For further analysis, only the H component of the frames is used. The participants were expected to start from a predetermined location to initialize the algorithm (Figure 2).

Figure 2. Initial shoe locations marked on H component of a video frame

Once the initial boxes shown in Figure 2 were localized, the color content (H) of the boxes was tracked using mean-shift tracking (Ido et al., 2010). Mean-shift tracking algorithm is an iterative scheme based on comparing the color distribution of the interest region in the current frame and color distribution of candidate regions in the next frame. The aim in this approach was to maximize the correlation between two color distributions. The tracked boxes (left and right shoes) used in this method are shown in Figure 3.

Figure 3. The tracked left and right shoes

The tracking was done for the overall duration of the video sequence and the center of mass for each tracked box was plotted. In this plot, the minimum points of the curves give us the tapping instants of the individuals. Since the sampling rate of the audio and the frame rate of the video were known, the time instants of tapping and the metronome beats were synchronized and overlaid.

Data Collection

The participants were firstly asked to perform 15 steps synchronized with the metronome beats and secondly 35 steps in the absence of the beats. The video and metronome beats were synchronously recorded. For all recorded videos and audios, using video based tool, the time instants of tapping and the metronome beats were determined as described above. Since the period of the metronome beats were known, it was extrapolated for the time duration without any beats. Recorded data were analyzed based on the timing error (in msec) for tapping with and without metronome beats measured as shown in Figure 5 using Equation 1.

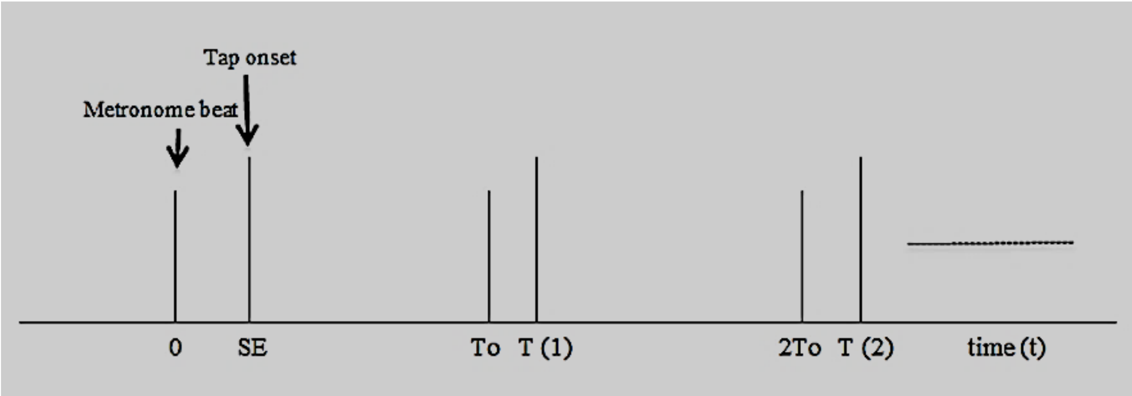

Figure 5. Timing errors

$$\text{T\_Error}(t) = T(t+1) - T(t) - To \text{ where } To = \begin{cases} 1.363s \ \ for\ 44bpm \\ 1.2s\ for\ 50\ bpm \end{cases} \quad (1)$$

SE is the initial synchronization error which is not used in the analysis. Metronome beats are the actual beats for the case of RA and extrapolated beats for the case of RM. In the study of Söğüt et al. (2015), it has been shown that timing errors obtained using the visual analysis tool coincides with the ground truth data obtained using RCAT.

Data Analysis

Descriptive statistics (mean ±SD) were calculated for the RA and RM scores in each tempo and for both genders. The Independent-Samples T Test was initially conducted to determine the gender differences. Since no significant differences were found on both tasks in both tempos data were analyzed regardless of gender. The Paired-Samples T Test was utilized to determine the effects of tempo (44 and 50 bpm) on RA and RM, and to compare the two different components of rhythmic ability for both slow and fast tempos. Statistical significance level was set at $p < 0.05$.

RESULTS

Rhythmic accuracy and maintenance scores of participants at both tempos are presented in Table 1. Results revealed that participants performed better rhythmic ability scores on RA ($t_{(40)} = 3.561$, p =

0.001), and RM ($t_{(40)}$ = 2.979, p = 0.005) in the fast tempo test. In addition, results also indicated significant differences between rhythmic ability parameters. Accuracy scores of the participants were better at both slow ($t_{(40)}$ = - 4.027, p = 0.000) and fast tempo tests ($t_{(40)}$ = -3.954, p = 0.000) than the maintenance scores.

Table 1. Descriptive statistics (mean ± standard deviation) for RA and RM scores (sec) in both tempos

Variables	**RA**		**RM**	
Tempo (bpm)	44	50	44	50
Male	0.078 ± 0.026	0.067 ± 0.023	0.116 ± 0.060	0.087 ± 0.033
Female	0.075 ± 0.032	0.057 ± 0.018	0.100 ± 0.039	0.078 ± 0.029
Overall	0.077 ± 0.029	0.062 ± 0.021	0.108 ± 0.051	0.082 ± 0.031

DISCUSSION

The preliminary objective of this study was to determine the rhythmic accuracy and rhythmic maintenance through using a video-based analysis system. The role of tempo on these parameters was also examined. The results revealed that participants performed better scores on fast tempo test in both tasks. In other words, synchronization of the participants with the external stimuli was more precise when the time interval was shorter.

This result contrasts with the findings of Agdiniotis et al. (2009). In their study 180 pre-school children were tested with RCAT at the tempos of 120 and 130 bpm and significantly better performances were reported in the slower testing tempo. On the other hand, the result is in line with the studies of Kumai and Sugai (1997), Zachopoulou et al. (2000), and Mastrokalou and Hatziharitos (2007). Zachopoulou et al. (2000) studied the rhythmic accuracy and maintenance of children participating regularly swimming, tennis and basketball training, and controls. A laboratory instrument, involving a metronome and auditory stimulus, was used to measure rhythmic ability of the participants at two different tempos (44 and 50 bpm). As a consequence, performance of the overall children on both tasks was stated to be superior in the fast tempo test. According to Fraisse (1982), the possibility of rhythmic perception depends on tempo. Involvement of cognitive mechanism in the longer time intervals might cause deficiency in rhythmic ability performance (Mastrokalou and Hatziharitos, 2007).

The results of this study also indicated differences between two parameters of rhythmic ability. Participants significantly performed better scores on rhythmic accuracy than rhythmic maintenance at both slow and fast tempos. Namely, rhythmic ability of the participants was more precise when they stepped synchronized with the metronome beats than stepped in the absence of the beats. Zachopoulou et al. (2000) reported contrasting results. They found no differences between RA and RM scores of tennis and basketball players within the same tempo. Besides, the maintenance performance of the swimming group was found better than the accuracy performance. However, supportive findings were observed from the study of Mastrokalou and Hatziharitos (2007). They found higher scores on rhythmic accuracy. Although rhythmic ability was studied vastly in sport sciences literature there has been limited evidence so far regarding the discrepancy between these parameters.

In conclusion, the study attempted to determine the rhythmic accuracy and maintenance by means of a video base system. Using the tool, the influences of tempo on rhythmic accuracy and maintenance were investigated at two different tempos. The tempo was found to be an effective factor on rhythmic ability. Since the evaluation was automatic, using the proposed system, rhythmic ability analysis can be applied to a wide range of participants in a very short time and further analysis on the collected data can easily be conducted.

Authors Note

This study was partly presented at the 1. International Symposium on Sport Sciences, Engineering and Technology in İstanbul, Turkey.

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