Decoding (un)known opponent's game play, a real-life badminton eye tracking study

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Abstract

Is the underlying cognitive processes different when playing with an opponent whose game play is familiar to that of an unknown? This study filtered the advance cues extracted by expert and amateur players when paired with an opponent whose game play is familiar to that of an unknown opponent. Our data collected in a real-life naturalistic game play conditions suggests that at the beginning of the game and for the first serve only the opponent's torso is crucial for cues and as the game progresses the information from the feet seems to be sufficient for the expert players in contrast to the data from the amateur player. Subsequently the preparatory or quiet-eye period for the serves at the beginning of the game play was higher than for later serves for all player sets. The preparation time for known opponents by expert players was higher for the first serve than for the unknown opponents but by the fifth serve the duration was negligible. Analysis of complete rallies show that post-serve attention allocation to opponent's racket and shuttle-in-flight is paramount in the play for both sets of opponents. Taken together the results of this investigation suggests that expert player's visual attention was distinguishable to that of an amateur player and expert players quickly decode unknown opponent's competence fairly early in the game play and follow consistent pattern of visual search. The results from the preliminary experimental data suggest the possibility of understanding how humans employ dynamic pattern recognition models in visual-search.

Introduction

Data collected from real-life naturalistic conditions provides insight into anticipation, prediction and rapid re-adjustments processes applied by players in a sport like badminton. Analysis of data like eye gaze collected from players engaged in real-time naturalistic game play can provide an accurate reflection of player behavior. Inferences on the underlying cognitive and motor skills can be derived to a certain extent from two main indices, visual search patterns and fixation duration in the preparatory, anticipatory and execution phases of the game play. In this study we report scanpath analysis reflecting the visual search in later two phases with emphasis on the quiet eye period in the preparatory phase. We do this by comparing data from three players paired against opponents with whom they have played before and others whose game play was unknown. A wearable eye tracker (Tobii Glasses I) was used to collect saccadic eye movement and the fixation duration, which is an estimate of attention allocation at particular regions of interest important for game strategy, though it was shown that other factors like stress can also influence fixations (Abernethy, 1988, 1990). The quiet-eye period in our case is the preparatory phase of the player just before executing the serve. This period is defined as the time taken to access task relevant cues and strategize appropriate motor actions (Vickers, 1996).

Previous studies on badminton which looked at differences in experts versus novice game play using spatial occlusion concept (Abernethy & Russel, 1987a,b) show the former exhibited better anticipatory behavior while the later needed more information for decision making. In the same study a video recording of game play was shown to novice and expert players who wore a mobile eye tracker and the fixation duration at five distinct regions – shuttle-in-flight, opponent's arm,racket,head,face,legs – revealed that both groups have similar early fixations regions though time on the racket and arm was more for the expert while it was the head area for the novice. Secondly they report that the order of the fixation on the cues was not dissimilar. A similar study on tennis (Goulet et al., 1989) aimed to understand visual search pattern reported that focus was on shoulder/trunk of the opponent in the preparation stage and then shifts to the racket during the execution phase while novices depend on more cues by using pre-recorded game play as stimulus. Singer et al., (1996) also used simulated tennis play and found differences between skilled and non-skilled player in visual-search , reaction time and decision accuracy with non-skilled players fixating longer on the opponent's head and less systematic in the tracking of the in-flight ball. It was also shown that player's ability to anticipate opponent's intentions from postural cues is an advantage (Rowe & McKenna, 2001) and a skill that is acquired over time by players.

Using a more sensitive eye tracker, Abernethy (1990) conducted experiment with video recorded squash game play projected on a huge screen on the wall of the squash court. The players were positioned in the court and the data showed that experts fixate on head/arm more than on the racket as compared to novice players, from which they inferred that experts are capable of eliciting advance cues just from posture. The fixation times were not different for the two groups and visual search pattern variation was not evident. A meta-analysis of three decades of work (Mann et al. 2007) which compared the attentional allocation of experts and novices report that the former have fewer long duration fixations translating to possible higher information extraction (Williams et al., 1999) quicker. The quiet-eye time , as another gaze behavior index, of experts was found to be higher when compared to less-skilled players across studies on a wide range of domains including in sports (Mann et al 2007). Other studies on badminton looked at the dynamic patterns from the players mutual spatial displacement within the court as an important variable for speed scalar product estimates which showed increased stroke variability to disrupt stable patterns (Chow et al., 2014).

The ability to gauge the expertise levels of the opponent and play optimally is a strategy applied by even reasonably good players in elite sports like badminton. As in any competitive setting the player needs to quickly gauge and decipher the opponent tactics from overt visual cues like facial expressions, body posture and spatial position on the court and also covert memory models formed from previous encounters with the opponent. In the absence of prior information, the player needs to quickly build the same early on in the game to win. An expert player's skill is based on the ability to analyze opponent's strength and weakness and evolve response strategy accordingly. Of interest to cognitive research and to sports personnel is the dynamic process applied by expert players who are able to quickly decode an unknown opponents game play, which is the focus of the present study. Towards this we collected data in a open-to- sky mud badminton court in near natural game play conditions from 3 highly rated badminton players pitched against six known and unknown opponents.

Methods

Participants

Two players (P1, P2) rated 9/10 with at least 6-7 years of experience and having participated in inter-college tournaments and a third player (P3) who was rated 7/10 but has not taken part in any serious competitive matches were paired with 6 opponents (O1,O2,O3,O4,O5,O6) each. Of the 6 opponents, O1,O2,O3 were comparable in expertise to P1 and P2, while the rest of the opponents were fairly good players. O1 and O2 had played in practice sessions with P1 and P2 while the other opponents game play was unknown. P3 had played with O1 and O3 before. The participants were all in the age group of 18-23 years and right-handed. The known and unknown opponents were mixed to take care of any habituation that might occur in the players. All players had given their consent before taking part in the experiment.

Procedure

The eye movements were recorded from head-mounted tracking device from Tobii (Glasses 1, http://www.tobii.com/), the recording unit connected to the glasses is the size of a smart-phone and hooked onto the participants track-pants and hence allows for natural play. All the experiments were carried out in the same familiar open-air court in naturalistic conditions and the frame-grab in Figure 1 shows the court with heatmap overlaid from a recording. For each pair of participants 10 random serves from the three players were collected, as the data was collected from naturalistic real-time game play, utmost effort was made to ensure that opponent and player's spatial position in the court was constant through out the forehand-serves with minimal variation in the velocity of release of the shuttle. The participants were allowed to continue the rally till one of them dropped a shot. After all the sets were completed the player was asked to rate the opponent's play. on a scale of 1-10. The rating was taken purely on the basis of their game play on that particular day. The fixation duration above a threshold of 70ms and the scanpath was analyzed at three phases: a) the preparatory b) actual execution of the serve by the player and c) the complete rally.

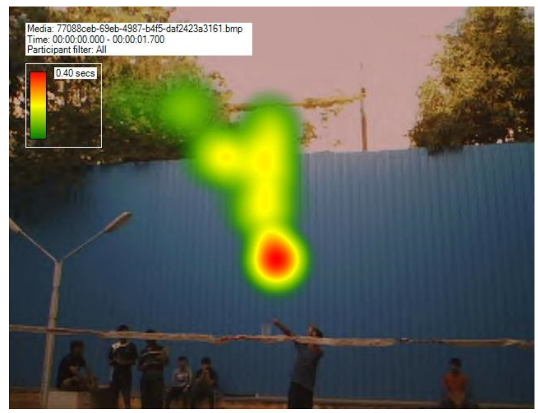

Figure 1: The badminton court where the data was collected and the heatmap sample from one of the recordings.

Data analysis

Eye movement data was recorded at 30 frames per second. The video recording from the eye tracker was analyzed frame by frame using the Tobii's studio. Heat maps were generated for each serve from preparation time of a serve to when the rally is dropped by either one of the players. These heat maps provide a relative measure of the duration of gaze of the player in the different areas of interest in the scene. From the coordinates the fixation duration at each gaze position in the scan path was estimated with main regions of interest being the opponent's – torso, feet and racket and the shuttle for 4 serves out of the 10. The selected serves were the first, second, fifth and the eighth for all the sets. The scanpath of the player is represented in the form of state diagrams, wherein each fixation duration at a position of interest is a state and change in eye movements is the transition between the states.

Results

The scan path before and just after the serve is analyzed from two views a) quiet eye during the preparatory phase, and b) the visual search pattern as the game progresses. Four serves (s1,s2,s5,s8) for each pair of players was analyzed to look at differences in salient cues a player gathers in order to strategize an optimal serve and the variation across the serves. Table 1 lists the average fixation period of the first and last two serves in the preparatory phase period grouped for known and unknown opponents. The preparatory period is the time just before the serve is executed by the player. For the known opponents the average preparatory time was higher (824ms) than for the unknown (670ms) for the first serves while the time for second set of serves was slightly higher for the unknown(435ms) than the knows (332ms). The preparatory time for the first serves were higher than for the later serves for both set of opponents.

Table 1: The average fixation duration in milliseconds for preparatory or quiet-time period for known and unknown players.

	serve: s1,s2 time (ms)	**Serve: s5,s8 time(ms)**
Known		
P1	940	515
P2	755	297
P3	779	185
Average	**824**	**332**
Unknown		
P1	721	494
P2	464	387
P3	827	426
Average	**670**	**435**

The scan path data from the preparation to execution of the serve gives insights to the visual cues gathered by the player to plan the serve, predict the return and anticipate the response. Figure 2 is the state diagram representation for the 4 serves, for one known (O1) and an unknown (O5) opponent for each of the players. The scanpaths of all opponents were analyzed but not included in the figure due to size issues. The higher rated player, P1's first landing fixation is the opponent upper body for all the unknowns and for 1 known player of the 6 opponents for the first serve (red, Figure 2a), from second serve on the first fixation was the opponent's feet consistent across all opponents. Attention was also allocated to the opponent's upper body after executing the serve and tracking the shuttle in-flight for 4 out of the 6 opponents. The first fixation position for P2 (figure 2b) was the opponent's upper body for 3 opponents – 2 unknown- in the first serve while for 2 others (both unknown) it was the opponent's feet and for one it was below the 70ms threshold, so not considered. As was the case with P1, from the 2^{nd} serve the first fixation point was the opponent's feet. In the case of the amateur player, P3, the first landing position was also the opponent's upper body in 4 (one known and rest unknown) but gets random from the second serve switching between feet, upper body and shuttle. Interestingly P3 did not shift attention to the opponent's body after executing the serves whereas P1 and P2 fixate on the opponent for 4 opponents after executing the serve.

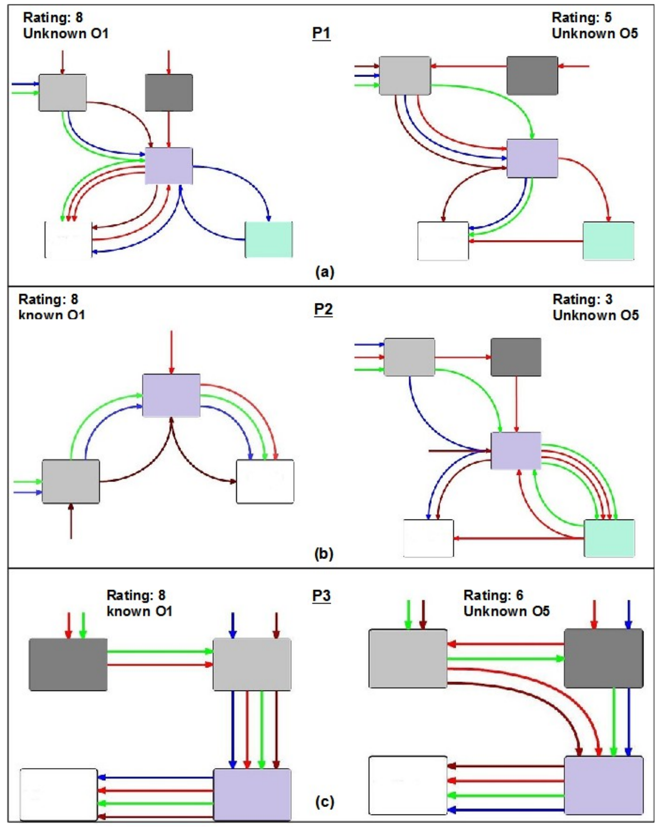

Figure 2: state diagram representing the scan path from preparation to execute a serve and just after. Red: s1 (serve 1), Blue: s2, Green: s5 and Brown: s8. a) P1 with an known opponent -O1 and an unknown -O5. b) P2's serve with known -O1 and unknown -O5 and c) P3's with known O1 and unknown -O5. The nodes/states color code: opponent (before serve) – dark grey. Opponent's feet (before feet) – light grey. Opponent's racket – blank/white. Shuttle – lavender. Opponent (after serve) – green.

The detailed scan-path diagrams of two competitive rallies of the eighth serve of players P1 and P2 is shown in Figure 3, with opponents O1 and O5. As can be inferred from the sample set of data, at the beginning the players attention is on opponent or opponent's feet but shifts to opponent's racket and shuttle during the actual rally especially when paired with a known and higher rated opponent (O1) a trend that was noticed from the analysis of other rallies with known players. For unknown opponents the attention away from shuttle or racket was dependent on the rally duration and the type of shot hence, no consistent pattern was discernible. For the amateur player (P3) the fixations were random shifting to opponent and feet during the rally frequently.

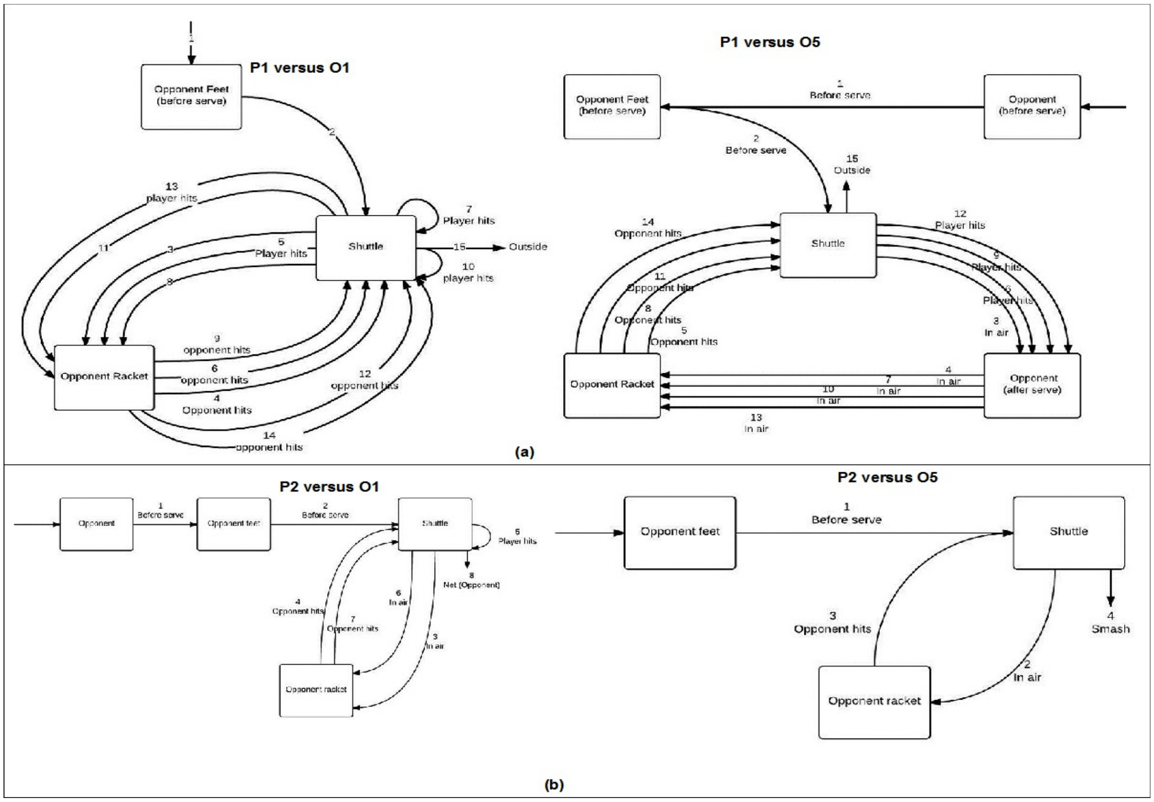

Figure 3: State diagram representation of the scanpath data for 2 rallies each of a) P1 and b) P2 players with O1 and O5. The action or response that triggers the state change (gaze change) is indicated by the lines connecting the states.

Discussion and Conclusions

The aim of the study was to investigate cognitive and motor skill differences when a badminton player is paired against known and unknown players. The visual search patterns suggest a deviation in the first relevant visual cue gathered by the player in the first serve as against subsequent serves, a trend that is noticed when playing with either known or unknown opponents. The explanation could be the need for player to 'seize' the facial expressions for cues on anxiety, nervousness or casualness to make an estimate or guess the expertise levels (unknown opponent) or intensity for the current game play (known). For example an easy casual countenance might be perceived to indicate a fairly good player and cues. And the posture of the torso can possibly give clues about the planned response especially for unknown players in the beginning of the game play. After the first serve and the subsequent rally from the second serve on, the first landing gaze is the opponent's feet for nearly all pairs which could be due to either the player ability to retain a memory of the opponent's facial expressions or from the position of the feet the player could deduce the upper body stance or a combination of both.

Additionally, the better players (P1 & P2) tend to look at the opponent after the serve for some the serves, which could be either a function of the type of serve which requires the player to reconfirm the opponents body cues to gauge motion pattern or the time for response was longer due to in-air flight time of the shuttle and attention shifts to the opponent. The second gaze to the opponent could also be to fine-tune the game play by recording the current spatial location and plan to position the return at a location further away. For the amateur player (P3), after the serve the opponent upper body was not tracked for any opponent which means the player is missing important overt and covert cues. The landing fixation for ensuing serves was either the feet or upper body, and hence no pattern is followed in contrast to higher rated players P1 and P2. This could mean that amateurs have not evolved an optimal scanpath or the ability to elicit visual cues. In studies comparing expert versus novice (Mann et al., 2007; Abernethy & Russell, 1987b) no difference was found in visual search, but the paradigm applied was to analyze players response to a serve whereas in our study the interest was visual cognition applied by player to predict opponent's response to a serve. Further experiments with amateurs need to be conducted to validate our preliminary finding.

Though the scanpath pattern from known and unknown opponents was almost similar the preparatory duration or quiet eye period shows that for known and unknown opponents the first two serves were higher across all the three players and by the fifth serve the quiet time was significantly lower. This could be because post the first serve the opponent's upper body is not allocated attention. Additionally the time period for the first serves for known opponent was higher than for unknown and the difference is lower as the game progresses that is, by the fifth serve. The longer eye time for higher rated known players when playing with equally skilled opponents could possibly mean a structured planning processes applied by these players or even anxiety at the beginning of the play (Williams & Elliott, 1999). The differences in information processing from visual cues of the expert players (P1 & P2) and the amateur (P3) player is similar to the findings reported in novice versus expert comparison studies ((Abernethy & Russell, 1987b).

In conclusion, the experiment conducted in real-life settings and with very few motor control instructions means we acquired natural actions but it also threw up data analysis challenges and confident assertions were not exactly possible. Nevertheless from the current set of data, we can infer that players decode unknown opponents game play fairly early in the game formulate patterns from visual cues efficiently. An observation we noted was the immersive play by the participants due to fewer restrictions in motor actions or game play mechanisms. Future work could consider more participants of national or international standards to set the baseline for preparatory visual search pattern and fixation times. Models from the coaches or professional players can be used by players to optimize acquisition of covert and overt information.

Acknowledgments

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