TOWARDS A NEW HITTING MODEL IN TENNIS

Damien Lafont

International Journal of Performance Analysis in Sport, 7(3), 106-116.

Towards a new hitting model in tennis

Damien Lafont
A.S. Montferrand Tennis, Ligue d'Auvergne de Tennis, France

Abstract
This study highlights recent observations in tennis which have revealed that the head position and gaze direction during the hitting process distinguished significantly elite players (with significant results in Grand Slam tournaments) from other top players: Elite players spent more time tracking the ball and fix the contact zone (or hitting zone) throughout the hitting action. These characteristics of elite players provide the basis for a simplified hitting model which emphasizes the fixation on the contact zone until the end of the follow-through.

Keywords: Tennis; Head; Control; Gaze; Contact

1. Introduction

In tennis, top players are expected to always maintain fixation on the ball as they completed the hitting action. However, what showed us observations is very different. Indeed, from the analysis of hitting sequences taken in high speed video (Yandell, 2005; Murphy, 2007) and photos (Lafont, 2007) highlighted that elite players (who had performed particularly well in Grand Slam tournaments) like Roger Federer and Rafael Nadal maintain their head still and in the direction of the contact zone, even after contact (Fig. 1-5).

To date, the modelling of top player's hitting process was often questionable due to the specificity of each player, but thanks to the technical quality of Roger Federer and the demonstration of his efficiency, we can have a good idea of what are the requirements for efficient stroke execution. In particular, Federer is held out as the ideal model for body posture, head position and gaze direction during the stroke execution. Thus, merging scientific research and on-court knowledge of tennis specialists, this study will provide a background as to how head and gaze control can help players for a better contact point, a trademark of elite players. These considerations on the hitting phase in tennis will lead to a simplified hitting model for the basic strokes – forehand and backhand.

Figure 1. Federer's backhand at impact. Federer practices holding his head down while completing the stroke. He has a perfect hitting position, which is chin up, eyes focused on hitting zone, and head still on contact (with permission of Advantage-Tennis.com).

Figure 2. Backhand after impact. Federer keeps his head and gaze still in the direction of the hitting zone. His gaze remains absolutely still on the ball just as the stroke is performed. He is not attempting a visual hold on the ball (with permission of Advantage-Tennis.com).

Figure 3. Federer's forehand at impact. He hits well in front of the body (with permission of Advantage-Tennis.com).

Figure 4. Federer's post-impact forehand. After contact, his head remains still in the direction of the contact zone (with permission of Advantage-Tennis.com).

Figure 5. Lifting motion and head control. After impact, Rafael Nadal does not attempt to follow the ball. Notice how the head and eyes have tremendous focus on the hitting zone – the key characteristic of elite players (with permission of Advantage-Tennis.com).

2. A new hitting model

If we consider the basics of stroke production in the perspective of gaze control, two fundamentals have to be addressed. The first one concerns the visual component. In particular, Stein and Slatt (1981) pointed the main limitation of vision in tennis is that the eye cannot follow a ball at high speeds. They reported that during the last part of the ball's flight onto the racket, it is travelling too fast for the eye, and vision gets blurred. The eyes can follow a ball in focus until about 150 milliseconds before impact (Flotat, 2003), i.e. five to seven feet before racket impact, and then they lose track, because of physiological visual limitation and also often because of a sudden head shift (Braden and Bruns, 1977). Moreover, as the tennis player constantly moves on the court, his visual acuity decreases (Stein & Slatt, 1981) and his vision goes to a level of legal blindness. Thus, it is not feasible to accurately seeing contact between the tennis ball and the racquet. These considerations concerning the visual limitation of stroke production lead Brabanec and Stojan (2006) to introduce the term 'invisible technique' to describe this contact point which gives the real efficiency of a stroke.
Second, in the context of power- and speed-based game (Pearson, 2006), balance is perhaps the most important factor to hit a successful shot and achieve gaze control in the hitting phase. In tennis, the concept of keeping the body and the racquet under control while moving is referred to as dynamic balance (Hassan, 2006a). For example, watching Federer, one can observe how quiet his head remains, especially when running. Federer clearly keeps his head still, displays great stability as he stays "down" after contact (Saviano, 2001) and is tremendously balanced in each of the shots (Roetert & Riewald, 2004). This ability to maintain dynamic balance is one of the signs of elite players (Saviano, 1999; Riewald & Lubbers, 2004). They keep their head still and their shoulders are on a straight line, aligned with their hips (Perlstein, 1999; Saviano, 2003), especially at crucial points in a match (Elliot, 1989; Groppel, 1986). Hence, controlling the upper body balance will lead to minimized head movement prior to the contact point, and therefore, enhanced visualization of the ball can be achieved (Perlstein, 1999; Williams, 2000; Yacub, 2003). Stillness in the head during contact also generates more racket head acceleration by creating a stop action for the shoulders and torso (Saviano, 1999). More specifically, balance influences the contact point, i.e. the distance away from the body that the ball is contacted, which at high level takes place in front of the body as illustrated on figures 3 (Ford et al. 2002). Hence, contrary to the hypothesis of Gillet et al. (2003) on specific balancing strategies in tennis, observations of Roger Federer tend to demonstrate that consistent head control and then balance reflect the expertise of the players.
To develop a consistent gaze control during the hitting phase, the players should try to exert control on three stages: before, during and after impact.

2.1. Before impact

Before impact, all the relevant cues are collected during the anticipation phase which allows to partially compensate the above-described visual limitation (Rowe and McKenna, 2001). As the body of the player moves into the ball, he should keep his head fixed and eyes down. With the head still and in front and the shoulders level, then it is easier to anticipate the opponents shot and judge the ball's flight path (Reynolds, 1996).

When the opponent strikes the ball, four variables of that hit are irrevocably determined: direction, depth, speed, and spin (Perlstein, 1999). With experience, as soon as the opponent hits the ball, the player automatically evaluates all these variables related to the flight path of the ball and determines the contact point well before the actual contact occurs (Brabanec and Stojan, 2006). Thus, the ball should be tracked closely as it comes off the opponent's racquet

and during the critical first part of its flight, so the hitting action can be set up and organized correctly. Then, as the ball approaches, the player must develop a fluid footwork preparing the shot and should stop before he hits the ball, thus he can easier maintain a balanced body on the hit and position himself to hit the best shot possible (Williams, 2000; Brabenec and Stojan, 2006).

Soloway (2003) stressed that the focus must be always on the trajectory. However, as the eyes are drawn naturally to moving objects and will track the ball automatically, mental effort should not be wasted tracking the ball throughout the trajectory and the player should make no effort to follow it to the point of impact (USTA, 2002). In fact, under highly constrained conditions, tracking the ball with the eyes is not necessarily the most efficient strategy (Montagne et al., 1993; Flotat and Keller, 2004). Instead, prior to impact his gaze should shift directly on the impact point and fix about the hitting zone. Yandell (2007) showed that Federer gets to that sideways position only about 2/100s or 3/100s of a second before the hit.

2.2. Impact

As afore-indicated, the key to all tennis strokes is when and where the racket makes contact with the ball. The previous section has underlined that proper contact depends on balance. Players should prepare the swing early enough so that they are able to make the racket contact the ball while it's still in front of them (Van Raalte and Silver-Berstein, 1999; Ford et al. 2002; USTA, 2002). Hitting the ball in front of the body, i.e. as forward as possible is about hitting early (see Fig. 3 where Federer hits very far forward). This means players should generally avoid taking an excessive backswing, which often results in the racket contacting the ball late, making it difficult to achieve control and pace. Despite the impact is non-visual event (Stein and Slatt, 1981), i.e. the player can't see the ball at impact as it bends the strings and leaves the racquet, for each stroke, he should try to identify the ideal contact point (USTA, 2002). To this end, he should point in the direction of the hitting zone during the hitting phase (Ford et al. 2002; Saviano, 2003; Hagelauer, 2006). This stage could be eventually combined with a visualisation of the hitting zone.

At this point of the hitting process, the player should avoid a common error. Indeed, as seen previously, most often, the gaze moves when the racquet contacts the ball though impact point doesn't necessitate head movements. The cessation of motion of body, especially the head stabilizes the vision (Stein and Slatt, 1981). It is by focusing the eyes at the striking area that insures a precise contact consistently (Ford et al., 2002). Here, the "object of contact" is not the ball, but rather the contact zone itself. When the racket contacts the ball, the player should stay with his stroke and not suddenly pull off the ball or jerk his head up to see where the ball is going (Braden and Bruns, 1977). The fundamental benefit of adopting this strategy is that it greatly increases the chances of a better centering, i.e. an optimum contact point, the trademark of the best players (Saviano, 2001; Brabanec and Stojan, 2006), well illustrated on Fig. 3. Additionally, it helps a player stay focused on the shot as opposed to rushing and looking down the court (Saviano, 1999).

2.3. After impact

During the last phase of the hitting action – the follow through - a fixation of long duration is needed on the hitting zone, even after the ball is hit. This is the key point of the hitting model. Such fixation should start when the player strikes the ball and continues until he finishes his follow-through (Fig.4). However, not follow the ball after it has left the racquet is difficult because eyes are captured by fast object in motion. Nevertheless, the player should 'hang on' to the shot for the duration of the follow-through, even though the ball is here and gone in an

instant. As consistently achieving such control is difficult, Yacub (2003) suggested a golfer's technique. A golfer would look at the ball, putt, and hold the head steady for a split second (eyes are kept at the contact point) before looking at the target. Advanced players actually get there, and hold the eyes steady for a split second afterward (Vickers, 2002; Vickers, 2007). The main point is that maintaining focus on the ball as they hit is not needed. Instead, the concentration must be on the contact zone, not on the target. Ford et al. (2002) have well understood the benefits of adopting such focus on the contact zone. Moreover, it is the only study which suggested that focus on the contact zone should be prolonged even after contact.

If a player fails to realize how important it is to maintain the head still on the follow-through, he has a tendency to pull off the ball at or before impact. It can be a critic of the lifting motion when players tend to throw their head up and back when they lift. When the head is moved excessively, the player risks throwing the whole body out of balance (Hassan, 2006b). Then, if the racket is about to strike the ball, and the player suddenly lift his chin, this is going to lift his racket and cause him to hit off-centre. Nevertheless, as showed in Fig. 5, even while lifting, the player can keep his head still and in the direction of the contact zone.

Therefore, after the impact, the player should not worry about hitting the ball to specific places and should continue to fix where the ball and the strings have been contacted, it will allow his eyes to leave it before the impact, i.e. too soon (Braden and Bruns, 1977; Trabert et al., 1979; Perlstein, 1999). Only when he feels the shot has completely left his racquet should he peacefully turn his head toward the flight of the ball (Perlstein, 1999). When hitting in this manner, player have plenty of time to stay over the ball, then 're-track' the ball before it reaches the net and will have enough time to prepare for his next shot (Braden and Bruns, 1977). It is confirmed by consistent gaze control of Roger Federer even on the fastest surfaces of play.

2.4. Trajectory

The fact that Federer seems to have slightly less control with high top-spin balls (on clay court) than flat ball reveals that gaze control is also a matter of trajectory. Control of the gaze in interceptive timing tasks is dependent on how predictable or unpredictable the flight of the object is. When the flight of the ball is relatively constant, early tracking is sufficient, and the athlete has no need to see the ball when it nears. In this case, it is not very useful to watch it all the way through its entire flight. However, when the ball spins or jumps in an unpredictable way, as it does on many strokes, then the type of gaze control will involve both early and late tracking (Land and McLeod, 2000). Moreover, the difficulty in controlling heavy top spin lies in the depth of the shot (Fox, 1993). Eye estimates better right-left trajectories than forward-backward (Letort, 2003). As the configuration of the court put in priority the player in the later situation, read top spin trajectories is more difficult (Kreuzer et al., 2003). Thus, as suggested by Williams (2000) and Soloway (2003), the adage 'keep your eye on the ball' can be extended from where it is to what it's doing, i.e. the trajectory. In this context, Federer demonstrates that the strategy which consists of focusing on the contact zone is an efficient way to use the eyes in a fast-moving ball sport such as tennis. In particular, as suggested by Ford et al. (2002), it eliminates the source of input errors present in the classical visual pattern, i.e. focusing on the ball, and generated by the numerous fixations as the ball traverses along its flight path (continuous refocusing).

2.5. The 3F routine

The three stages of the hitting process can be grouped into a routine - 3F, i.e. Flight, Focus and Fixation. First, the player picks up the relevant information relatively to the trajectory, i.e.

the flight of the ball. Then, the player‘s focus shifts from the ball to the contact zone. The second stage is essentially an intense visual focus on the contact zone. Finally, the third stage of the routine aims to bring the player to an optimum level of balance and focus on present after impact with a fixation on the contact zone which must be maintain until the end of follow-through. As this routine is executed only by the truly great players, the 3F process and more largely head and gaze fixation on the contact zone may be viewed as one of the common denominators introduced by Saviano (2003) that transcend all styles of play and lead to better game, what he called the key fundamentals of the game.

3. Discussion

Attentive observations show that several technical improvements come about simply through controlling the gaze better. Timing improves (Murphy, 2007), hits are better centred, and the head remains down during the shot due to the intense focus on the hitting zone. In brief, strokes could be better executed by most players simply if they know where to fix their gaze efficiently. Hence, it is evident that the importance of the old advice ‘keep your eye on the ball’ still cannot be over-emphasized and can be replaced by the ultimate advices ‘keep your head still,’ ‘keep your eye on the contact zone’ (Ford et al. 2002) or even by “keep your eye off the ball’ (Ford, 1984; Horne, 2000).

In a final analysis, this study shows that what we normally think of as visual problem turns out to be more a question of head control than eye control. So there is some hope to partly compensate the physiological factors, i.e. poor visual acuity. In addition, whereas the stroke signature is individual and specific because every stroke should be a response to a unique set of circumstances and should fit the bio-mechanical specificity of the player (Braden and Wool, 1993; Herbst, 2000; Schönborn, 2006), on the contrary, it seems that the gaze control signature must be consistent independently of the expertise, surface and speed of the ball - a sort of a universal signature.

4. Conclusions

As conclusion, whereas all recent researches show that there is no universal response to the mental problem of the game, on the contrary/opposite, if gaze control will appear applicable no matter what level, surface, or style of play, it could be an amazing tool for player development and better understanding of the game.

At this time, in light of the evidence of Roger Federer’s observation, and in waiting for future experimental studies, players can follow the 3F model: focus on the trajectory, then on the point of impact, and finally on the hitting zone until the end of the follow-through. In the competitive context, every top player has now great mental and physical skill. Thus, the difference in winning and losing will be more and more determined by player’s technical skills. Therefore, this ability to control the gaze throughout the match could be what will make the difference.

4.1. Perspectives

The first perspective that emerges from this study is the need for more interaction between coaches and science. Indeed, on-court methods often have empiric validity but don't always beneficiate of a scientific validation. Having a solid knowledge of strokes, coaches formally involved in tennis can bridge this gap between on-court methods and theoretical research. Thus, close collaboration could provide strong scientific data on the appreciation of gaze control in tennis and may change the current coaching techniques. Therefore, more studies are needed to understand what type of training could be set for head and gaze control. Thus, the observations provided here should also help to develop a well establish method from the 3F model in the perspective of an innovative way of practicing tennis.

Finally, one of the ideas behind the study is that the benefits of gaze control should not be confined to professional players but should be extended to beginner and intermediate players. Indeed, even a weight of evidence is beginning to favour gaze control as all-level requirement for better play, this preliminary study does not yet identify the relative importance of such control according to the level of expertise. Thus, in order to validate the 3F model, further research is needed differentiating age and level of the players, especially in competitive situations.

5. Acknowledgments

The author thanks Professor Edith Filaire for discussions and help, and Mike McCarron for providing high quality photos. Special thanks to Jean Brechbuhl for his specific support, encouragement and, in some cases, critical comment on the material for this study. Finally I would like to thank Scott Ford who saw the importance of this research.

6. References

Brabenec, J., and Stojan, S. (2006). The invisible technique : Two seconds decide the result. **ITF Coaching and Sport Science Review,** 38.

Braden, V., and Bruns, B. (1977). **Vic Braden's Tennis for the Futur**, Little, Brown and Company, Boston, Toronto.

Braden, V., and Wool, R. (1993). **Vic Braden's Mental Tennis. How to psych yourself to a winning game**, Little Brown and Company.

Elliot, B. (1989). **Biomechanics of tennis**, In C. Vaugham (Ed.), in **Biomechanics of Sport,** pp. 264-285, London, CRC Press.

Flotat, J.-C. (2003). **Perception visuelle du mouvement de frappe au tennis : Effet de la pression temporelle, de l'incertitude spatiale et du niveau d'expertise**, Thesis, Université de Strabourg, France.

Flotat, J.-C., and Keller, D. (2004). Precision and moment of hit in expert tennis player. **Science and Sports,** 19, 174-182.

Ford, S. (1984). **Design B, How to play tennis in the zone**, Icarus Press, Indiana

Ford, S. A., Hines, W. L., and Kluka, D. (2002). **A. Parallel processing and peak performance in tennis**, Gambling, La, Gambling State University Press.

Fox, A. (1993). **Think to win, the strategic dimension of tennis**, HarperCollins.

Gillet, E., Leroy, D., and Germaine, N. (2003). Kinematic analysis of balance at tennis players according to the level of expertise, in **Tennis Science and Technology 2** (edited by S. Miller), pp. 217-220, ITF, London.

Groppel, J. L. (1986). Follow the ball for better movement. **Tennis**, 60.

Hagelauer, P. (2006). Point Gagnant. In **Tennis Magazine**.

Hassan, F. (2006a). Acquiring balance skills essential for tennis. **ITF Coaching,** online article, June.

Hassan, F. (2006b). Acquiring vision skills essential for tennis. **ITF Coaching,** online article, June 2006.

Herbst, D. (2000). The signature game. **ITF Coaching and Sport Science Review,** 21.

Horne, J. (2000). Keep your eye off the ball. **Nature Neuroscience,** 3(12), 1236.

Kreuzer, M., Debat, P., Gazelle, F., Vivier, C., Berger, C., Groslambert, A., Mougin-Guillaume, F., Dalmasso, A., Debat, P., Vieille Marchiset, G. (2003). **Le tennis dans toutes ses dimensions, une analyse informationnelle**, Presse Universitaire de Franche Comté.

Lafont, D. (2007). High-speed photo analysis of top players' gaze behaviour. In **Tennis Science and Technology 3** (edited by S. Miller), ITF London, to appear.

Land, M. F. and McLeod, P. (2000). From eye movements to actions: how batsmen hit the ball. **Nature neuroscience,** 3(12), 1340-1345.

Letort, O. (2003). Progressive Tennis – Cool-ourful Tennis. **ITF Coaching and Sport Science Review**, 31.

Montagne, G., Laurent, M., and Ripoll, H. (1993). Visual information pick-up in ball-catching. **Human Movement Science,** 12(3), 273-297.

Murphy, S. (2007). The two secret of timing, Classic lessons, http://www.tennisplayer.net.

Pearson, A. (2006). **SAQ Tennis**, A&C Black, London.

Perlstein, S. (1999). **Winning tennis**, The Lyons Press.

Reynolds, K. (1996). Biomechanics and the five fundamentals. **ITF Coaching and Science Review,** ITF, 10, 3-5.

Riewald, S., and Lubbers, P. (2004). Optimal Technique and the Phases of Stroke. **High Performance Coaching**; USPTA, 6(3).

Roetert, E., and Riewald, S. (2004). The forehand stance. **High Performance Coaching**; USPTA, 6(4).

Rowe, R. M., and McKenna, F. P. (2001). Skilled anticipation in real-world task: measurement of attentional demands in the domain of tennis. Journal **of Experimental Psychology: Applied,** 7 (1), 60-67.

Saviano, N. (1999). The open-stance backhand. **High Performance Coaching,** USPTA, 1(3).

Saviano, N. (2001). One-handed backhand. **High Performance Coaching,** USPTA, 3(4).

Saviano, N. (2003). **Maximum tennis**, Human Kinetics.

Schönborn, R. (2006). Not repeatability of the movement. In **27th European Coaches Symposium**, Tennis Europe.

Soloway, R. (2003). **Tennis in the new age: Ancient knowledge and modern science**, The Quest, Northboro, Massachussetts.

Stein, H., and Slatt, B. (1981). **Hitting blind**, The new visual approach to winning tennis, Beaufort, NY.

Trabert, T., Emerson, R., Seixas, V., Holmberg, R., Lott, G., and Price, B. (1979). **Tennis Feature Inc**., USA.

USTA (2002). **Coaching youth tennis**, third edition, American Sport Education Program, Human Kinetics.

Van Raalte, J. L., and Silver-Bernstein, C. (1999). **Tennis**. Sport Psychology Library, Fitness Information Technilogy, Inc.

Vickers, J. N. (2002). Quiet Eye. **Gazette,** Calgary: University of Calgary, 32(1).

Vickers, J. N. (2007). **Perception, cognition and decision training: the quiet eye in action**, Champain, IL, Human Kinetics Publishers.

Williams, S. (2000). Serious tennis, Human Kinetics.

Yacub, J. (2003). Upper body mechanics in relation to power production and point of contact visualisation, in **Tennis Science and Technoloy** (edited by S. Miller), pp. 205-210, ITF London.

Yandell, J. (2005). Roger Federer and the evolution of the modern forehand, Part 1, p.1, Advanced tennis, http:///www.tennisplayer.net.