Falling for a fake: The role of kinematic and non-kinematic information in deception detection

So Hyun Park[a], Donghyun Ryu[b], Liis Uiga[a], Rich Masters[a], Bruce Abernethy[c] and David L. Mann[d]

[a] Te Huataki Waiora Faculty of Health, Sport and Human Performance, The University of Waikato, New Zealand

[b] Institute for the Psychology of Elite Performance, School of Sport, Health and Exercise Sciences, Bangor University, Bangor, UK

[c] School of Human Movement and Nutrition Sciences, University of Queensland, Brisbane, Australia

[d] Department of Human Movement Sciences, Amsterdam Movement Sciences and Institute of Brain and Behavior Amsterdam, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

Corresponding author

So Hyun Park,

Te Huataki Waiora Faculty of Sport, Health and Human Performance

The University of Waikato

Private Bag 3105

Hamilton 3240, New Zealand.

Email: shp24@students.waikato.ac.nz

Abstract

Kinematic and non-kinematic visual information has been examined in the context of movement anticipation by athletes, although less so in deception detection. This study examined the role of kinematic and non-kinematic visual information in the anticipation of deceptive and non-deceptive badminton shots. Skilled (*n*=12) and less skilled (*n*=12) badminton players anticipated the direction of deceptive and non-deceptive shots presented via video footage displayed in normal (kinematic and non-kinematic information), low (kinematic information emphasized), and high (non-kinematic information emphasized) spatial frequency conditions. Each shot was occluded one frame before shuttle-racquet contact or at contact. In deceptive trials, skilled players showed decreased anticipation accuracy in the high spatial frequency condition (*p*=0.050) compared to normal and low spatial frequency conditions, which did not differ. The study suggests that an emphasis on kinematic information results in accurate anticipation in response to deceptive movements and that an emphasis on non-kinematic information results in less accurate anticipation by experts.

Short title

Deception detection in badminton

Keywords

Deception, Anticipation, Spatial frequency, Expertise

Introduction

Deception in sport is an acquired skill that often fools opponents and produces gasps of admiration from knowledgeable spectators. Consequently, deception *detection* is a crucial ability that performers require to protect themselves from incorrect judgments when anticipating the subsequent movement of an opponent (Cañal-Bruland & Schmidt, 2009).

Runeson and Frykholm (1983) first examined deceptive movements when they asked participants to discern whether actors were lifting a heavy box or faking the act of lifting a heavy box (i.e., the box was empty). Participants were able to discern deception and correctly estimate the weight of the box, even when the lifting movements were represented by point-light displays only.[1] Runeson and Frykholm (1981, 1983) argued that participants were able to estimate the weight of the box because specific kinematic cues were associated with the genuine lifting movements (e.g., the pelvis tilted forward to compensate for the heavy weight of the box). They proposed that rather than execute a deceptive *action,* a person can only move with *intent* to deceive*,* as veridical kinematics of the movement will always be present (Kinematic Specification of Dynamics, KSD, Runeson & Frykholm, 1983).

Research examining deception in sport, on the other hand, has shown that while movement detection is primarily a function of essential kinematic cues (see Abernethy & Zawi, 2007 for badminton; Ward, Williams, & Bennett, 2002 for tennis; Abernethy, Gill, Parks, & Packer, 2001 for squash, cf. Shim, Carlton, Chow, & Chae, 2005), non-kinematic information can overshadow essential kinematic information. For example, Abernethy, Jackson, and Wang (2010a, 2010b) examined the ability of skilled and less skilled badminton players to anticipate

[1] Point-light displays portray the joints and limbs of the body, reminiscent of a stick-figure man, thus presenting essential kinematic information, such as the direction and velocity of the arms and legs.

the direction of badminton shots executed with and without deceptive intent in normal displays and point-light displays. While deceptive shots resulted in inferior anticipation accuracy in normal displays for both skilled and less skilled players, skilled players were unaffected by deceptive intent in point-light displays. Abernethy et al. (2010a, 2010b) concluded that non-kinematic superficial visual information (e.g., facial expression, gaze direction, contour, texture) *may be* responsible for deceiving an opponent since anticipation accuracy differences between deceptive and non-deceptive strokes were eliminated when non-kinematic information was unavailable in the point-light displays.

Similar to point-light displays, a visually blurred display minimizes non-kinematic information but not kinematic information.[2] Jackson, Abernethy, and Wernhart (2009) found that experienced tennis players displayed improved anticipation accuracy (i.e., judging the direction of a tennis serve) when stimuli were presented with a high level of visual blur. Consistent with point-light display evidence, this finding suggests that kinematic information is necessary for successful anticipation of movements and that minimizing non-kinematic information potentially enhances the pick-up of that kinematic information. Similar findings have been reported by other researchers (e.g., Mann, Abernethy, & Farrow, 2010; Ryu, Abernethy, Mann, & Poolton, 2015; Ryu, Mann, Abernethy, & Poolton, 2016); however, little research has examined the role of visual blur in deception (c.f., Ryu, Abernethy, Park, & Mann, 2018; van Biemen, Koedijker, Renden, & Mann, 2018). If experts are less affected by deception when non-kinematic information is absent (during point-light displays) (Abernethy et al, 2010a, 2010b), then the same should be true when visual blur is used to remove non-kinematic information. Thus, the current

[2] *Spatial frequencies*, like audio frequencies, are components of an image, which determine the level of detail available. An image with small details and sharp lines contains high-SF (non-kinematic) information, such as facial expression, gaze direction, contour, and texture. An image that is blurred on the other hand contains low-SF (kinematic) information.

study aimed to explicitly examine the roles of kinematic and non-kinematic information on anticipation accuracy of skilled and less skilled badminton players when responding to deceptive and non-deceptive badminton shots. We specifically manipulated visual information available to participants, by presenting images with only low spatial frequency components (removal of superficial information in order to emphasize kinematic information) or only high spatial frequency components (emphasizing non-kinematic superficial information). This allowed us to compare information pick-up when images were blurred, and thus only kinematic information was available (low spatial frequency) or when images were detailed, and non-kinematic information was emphasized (high spatial frequency). Consistent with previous research, we hypothesized that: if non-kinematic information is responsible for deceiving an opponent then accuracy at anticipating badminton shot direction should be worse in high spatial frequency conditions.

Method

Participants

Twelve skilled (*M* experience = 13.8 ± 0.8 years; *M* age = 21.4 ± 0.7 years old) and 12 less skilled (*M* experience = 0.9 ± 0.2 years; *M* age = 22.6 ± 0.3 years old) badminton players participated in this experiment. All procedures were reviewed and approved by a local ethics committee and written informed consent was collected from each participant.

Testing Stimuli

Participants watched a series of occluded video clips showing badminton strokes. They were asked to anticipate where the shuttle would land as quickly and as accurately as possible. Five highly skilled badminton players were recruited to be actors for the purposes of generating recorded video footage. For non-deceptive trials, the players were asked to return a serve with an overhead stroke to one of four areas of the court (front-left, back-left, front-right, and back-right) without deceptive intent. However, for deceptive trials, the players had to return the serve towards the instructed area using any form of deception that would be used in regular competitions (e.g., misleading gaze or head direction). For each area of the court, different shots were filmed so that deceptive intent was represented by depth or direction. For example, for the front-left area, the shot was faked either towards the back-left or the front-right area of the court. Only successful shots were included. The video clips were recorded in high definition footage (1920 x 1080 pixel resolution) at 30 Hz with a digital camera (Sony HDR-FX 1 handicam). Thirty-two video clips (16 deceptive, 16 non-deceptive) were selected for use in the study. Each was occluded one frame before shuttle-racquet contact and at contact. A Gaussian filter (Matlab version R2014b; Mathworks, Massachusetts, USA) was then used to create three spatial frequency settings: normal-SF (the original video), low-SF (0-4 cycles per degree) and high-SF (4-22.7 cycles per degree). Brightness was adjusted to match the original video (see Figure 1).

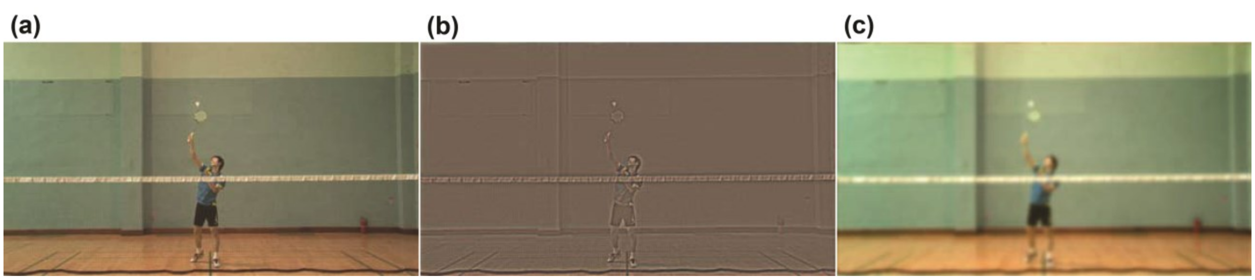

Figure 1. Screenshot of each spatial frequency video clip (a) normal-SF information, (b) high-SF information only, and (c) low-SF information only.

Testing Procedure

The experiment consisted of one practice block (12 trials for familiarization) and two test blocks (96 trials each), which were programmed using Experiment Builder software (SR Research Ltd., Mississauga, ON). The order of the test blocks (Block 1 and Block 2) was counterbalanced between participants, and a mandatory 10-minute break between test blocks was employed. For each of the trials, participants were required to watch the video clip (viewing distance 60 cm from the display monitor, subtending a visual angle of 28.5° × 21.6°; screen size: 304.8 x 228.6 mm) and anticipate the landing position of the shuttle by pressing a button on a keyboard corresponding to one of the four landing positions.

Dependent Variables and Statistical Analysis

Response accuracy and response time were calculated to evaluate performance on deceptive and non-deceptive trials. Response accuracy was determined as the percentage of trials in which participants responded correctly. Response time (in ms) was determined as the mean time that elapsed between occlusion of the clip and the button-press response. Separate 2 (Group: skilled, less skilled) x 2 (Occlusion time: one frame before contact, contact) x 3 (SF: normal-SF, high-SF, low-SF) repeated measures ANOVAs were conducted for deceptive and non-deceptive trials. Planned *t*-tests were used to establish whether response accuracy was significantly different from the 25% level that would be achievable by chance. Greenhouse-Geisser corrections were applied to the degrees of freedom when the assumption of sphericity was violated, and effect sizes were reported as partial eta-squared (η_p^2) values. The level of significance was set at $p = 0.05$.

Results

Deceptive trials

A main effect was evident for Group, F (1, 22) = 56.16, p < .001, η_p^2 = .719, but not for Occlusion time, F (1, 22) = 3.93, p = .060, η_p^2 = .151, or SF, F (2, 44) = .721, p = .492, η_p^2 = .032. There was no two-way interaction; however, a significant three-way interaction between Group, Occlusion time, and SF was evident for response accuracy, F (2, 44) = 4.09, p = .023, η_p^2 = .157 (see Figure 2). Two-way ANOVAs were, therefore, conducted to deconstruct the interaction by examining each occlusion time separately (i.e., one frame before shuttle-racquet contact versus contact). At one frame before contact, SF played a role in the anticipation of landing position for deceptive movements, F (2, 44) = 3.29, p = .047, η_p^2 = .130. Specifically, skilled players were less accurate when anticipating landing position in high-SF compared to normal-SF (p = .053) and low-SF (p = .054) conditions with no difference between low-SF and normal-SF (p = .660), whereas, less skilled players displayed no differences in anticipation accuracy across the SF conditions (all p values > .157). When clips were occluded at contact, SF played no role in anticipation of landing position for deceptive movements in either skilled or less skilled players, F (2, 44) = 0.85, p = .437, η_p^2 = .037. Skilled players performed above chance level in all conditions (all p values < .002), with the exception of the high-SF condition one frame before contact (p = .180), whereas less skilled players performed at chance level in all conditions (all p's > .056). Analysis of the response times revealed a significant main effect for Occlusion time (F (1, 22) = 4.29, p = .050, η_p^2 = .163), with response time at contact faster than response time one frame before contact. However, there were no significant main effects of Group or SF condition, Group, F (1, 22) = .008, p = .931, η_p^2 < .001; SF, F (2, 44) = 2.18, p = .125, η_p^2 = .090, or interactions (all p values > .496).

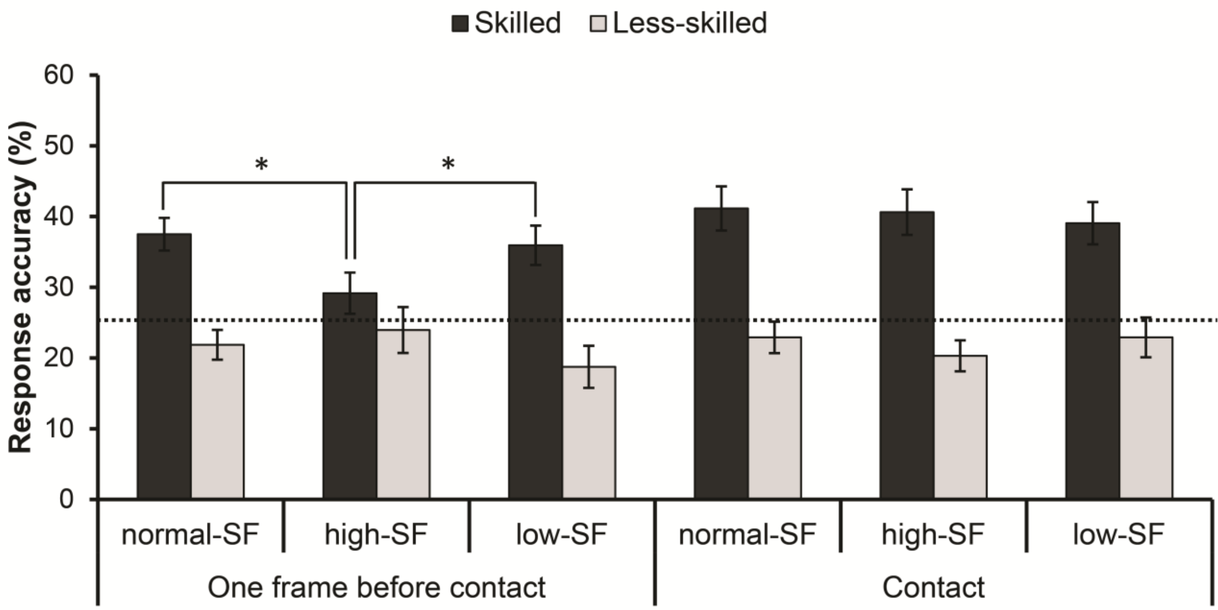

Figure 2. Mean response accuracy (%) one frame before shuttle-racquet contact and at contact in deceptive trials. Error bars represent the standard error of the mean. Dotted line represents chance level response accuracy. SF = spatial frequency.

Non-deceptive trials

For non-deceptive trials, the results revealed a significant main effect of Group, F (1, 22) = 94.21, $p < .001$, $\eta_p^2 = .811$, Occlusion time, F (1, 22) = 4.46, $p = .046$, $\eta_p^2 = .169$, and SF, F (1, 22) = 5.12, $p = .010$, $\eta_p^2 = .189$. There was a two-way interaction between Occlusion time and SF, F (2, 44) = 3.46, $p = .040$, $\eta_p^2 = .136$ (see Figure 3). One frame before contact, response accuracy in the low-SF condition was lower than in the normal-SF condition ($p = .045$). At contact, response accuracy in the low-SF condition was lower than in the normal-SF ($p = .015$) and high-SF ($p = .009$) conditions. Skilled players performed above chance for all trials (all p values < .001), whereas less skilled players performed at chance level one frame before contact but above chance at contact during the normal-SF ($p = .011$) and high-SF ($p = .007$) conditions, but not during the low-SF condition ($p = .874$). The analysis of response time revealed a significant interaction between Occlusion time and SF, F (2, 44) = 3.22, p < .050, η_p^2 = .128, but all other main effects and interaction effects were non-significant (all p values > .070). At contact, response time was faster in the low-SF (p = .027) and high-SF (p = .026) conditions compared to normal SF condition, but there was no difference one frame before contact (p values > .703).

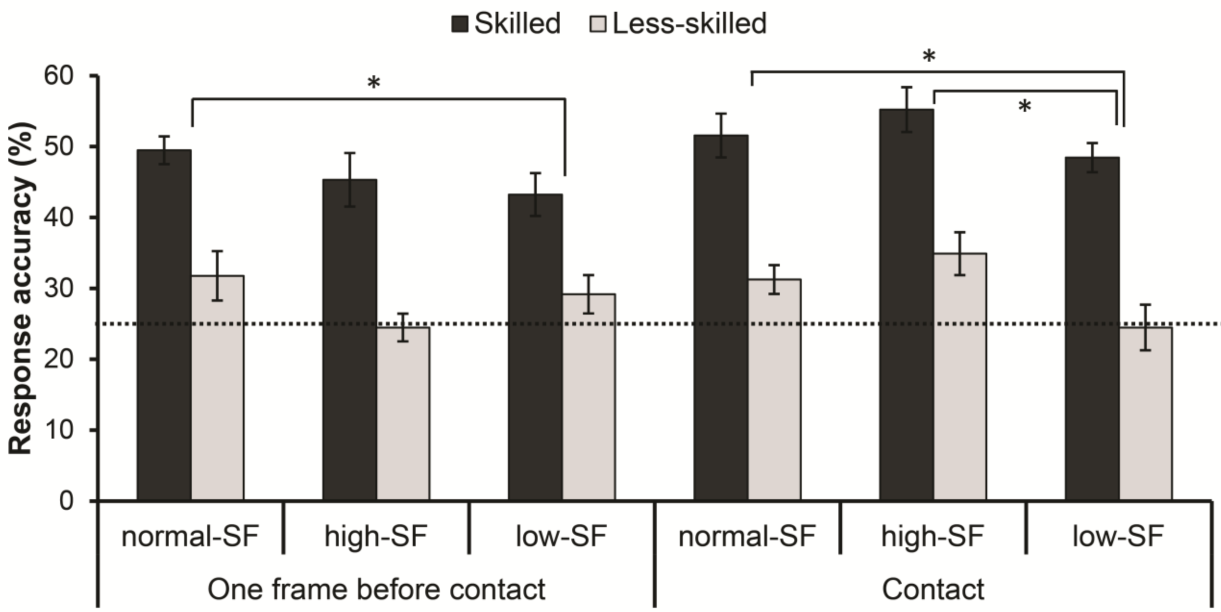

Figure 3. Mean response accuracy (%) one frame before shuttle-racquet contact and at contact in non-deceptive trials. Error bars represent the standard error of the mean. Dotted line represents chance level response accuracy. SF = spatial frequency.

Discussion

Successful movement anticipation relies on the pick-up of essential kinematic information (Abernethy, Jackson, & Wang, 2010a, 2010b; Abernethy & Zawi, 2007; Mann, Abernethy, & Farrow, 2010; Runeson & Frykholm, 1981, 1983), yet, even when performers attempt to deceive an opponent with their movements, they are unable to hide telltale kinematic information (Runeson & Frykholm, 1981, 1983). So why do experts sometimes fall for fakes if the kinematic information is always available? One possibility is that non-kinematic information plays a more significant role in deception than previously thought (Abernethy et al., 2010a, 2010b). We examined the unique effects of kinematic and non-kinematic information on deception by manipulating images so that kinematic information (low-SF) or non-kinematic information (high-SF) or both forms of information (normal-SF) were available during anticipation of the direction of a badminton overhead shot.

The results showed that generally across conditions for both deceptive and non-deceptive trials skilled players were better than lesser skilled players at anticipating shot direction, both one frame before shuttle-racquet contact and at contact. Crucially, the anticipation accuracy of skilled players was significantly lower in high-SF deceptive trials (when non-kinematic information was highlighted) than normal- or low-SF conditions (where kinematic information was present) one frame before shuttle-racquet contact. This difference was not observed at shuttle-racquet contact, where more information was available (approximately 33ms) to unravel the true intent of the player (see also Williams, Ward, Knowles, & Smeeton, 2002).

In the non-deceptive trials, overall anticipation accuracy (skilled/less skilled collapsed) was lower in the low-SF condition compared to the normal-SF condition one frame before shuttle-racquet contact, and compared to the normal-SF and high-SF conditions at contact. This was not expected. Less skilled players performed at chance level in all other conditions, including the low-SF condition at contact, but above chance in the normal-SF and high-SF conditions at contact. It is likely that the performance of less skilled players in the normal-SF and high-SF conditions at contact artificially increased the overall scores relative to the low-SF condition. However, the lack of a skilled/less skilled interaction precludes the opportunity to confirm this explanation statistically.

Our findings suggest that when non-kinematic information (e.g., contour, texture, facial expression, and gaze direction) is predominant, it is more likely that deception will be effective (i.e., anticipation by the opponent will be less accurate). It is unlikely, however, that during deceptive trials non-kinematic information distracts players from picking up or utilizing kinematic information. Otherwise, anticipation accuracy one frame before contact in the deception trials should also have been poor in the normal-SF condition. Indeed, in the normal-SF condition (where both kinematic and non-kinematic information were present) anticipation accuracy was not significantly different from the low-SF condition (where only kinematic information was present). Thus, kinematic information, in our opinion, trumps all other information for experts, at least where deception is concerned.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Abernethy, B., Gill, D., Parks, S. L., & Packer, S. T. (2001). Expertise and the perception of kinematic and situational probability information. *Perception, 30*, 233-252. https://doi.org/10.1068/p2872

Abernethy, B., Jackson, R.C., & Wang, C. (2010a). The perception of deception: The role of kinematic and other information in detecting deceptive intent within movements. *Journal of Sport & Exercise Psychology, 32*, S56-S56.

Abernethy, B., Jackson, R.C., & Wang, C. (2010b). The role of kinematic information in movement prediction and deception. *Journal of Science and Medicine in Sport, 12,* e13. https://doi.org/10.1016/j.jsams.2009.10.028

Abernethy, B., & Zawi, K. (2007). Pickup of essential kinematics underpins expert perception of movement patterns. *Journal of Motor Behavior, 39*(5), 353-367. https://doi.org/10.3200/JMBR.39.5.353-368

Cañal-Bruland, R., & Schmidt, M. (2009). Response bias in judging deceptive movements. *Acta Psychologica, 130*, 235-240. https://doi.org/10.1016/j.actpsy.2008.12.009

Jackson, R.C., Abernethy, B., & Wernhart, S. (2009). Sensitivity to fine-grained and coarse visual information: The effect of blurring on anticipation skill. *International Journal of Sport Psychology, 40*, 461-475. Retrieved from https://dspace.lboro.ac.u./2134/22011

Mann, D.L., Abernethy, B., & Farrow, D. (2010). Visual information underpinning skilled anticipation: The effect of blur on a coupled and uncoupled in situ anticipatory response.

Attention, Perception, & Psychophysics, 72, 1317-1326. https://doi.org/10.3758/APP/72.5.1317

Runeson, S., & Frykholm, G. (1981). Visual perception of lifted weight. Journal *of Experimental Psychology: Human Perception and Performance, 7*, 4, 733-740. https://doi.org/10.1037//0096-1523.7.4.733

Runeson, S., & Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology: General, 112,* 585-615. http://dx.doi.org/10.1037/0096-3445.112.4.585

Ryu, D., Abernethy, B., Mann, D. L., & Poolton, J. M. (2015). The contributions of central and peripheral vision to expertise in basketball: How blur helps to provide a clear picture. *Journal of Experimental Psychology: Human Perception and Performance, 41*(1), 167-185. http://dx.doi.org/10.1037/a0038306

Ryu, D., Abernethy, B., Park, S. H., & Mann, D. L. (2018). The Perception of Deceptive Information Can Be Enhanced by Training That Removes Superficial Visual Information. *Frontiers in Psychology,* 9(1132). doi:10.3389/fpsyg.2018.01132

Ryu, D., Mann, D. L., Abernethy, B., & Poolton, J. M. (2016). Gaze-contingent training enhances perceptual skill acquisition. *Journal of Vision, 16*, 1-21. https://doi.org/10.1167/16.2.2

Shim, J., Carlton, L. G., Chow, J. W., & Chae, W. S. (2005). The use of anticipatory visual cues by highly skilled tennis players. *Journal of Motor Behaviour, 37*, 164-175. https://doi.org/10.3200/JMBR.37.2.164-175 van Biemen, T., Koedijker, J., Renden, P. G., & Mann, D. L. (2018). The Effect of Blurred Perceptual Training on the Decision Making of Skilled Football Referees. *Frontiers in Psychology,* 9(1803). doi:10.3389/fpsyg.2018.01803

Ward, P., Williams, A. M., & Bennett, S. J. (2002) Visual search and biological motion perception in tennis. *Research Quarterly for Exercise and Sport, 73*, 107-112. https://doi.org/10.1080/02701367.2002.10608997

Williams, A.M., Ward, P., Knowles, J.M., & Smeeton, N.J. (2002). Anticipation skill in a real-world task: measurement, training, and transfer in tennis. *Journal of Experimental Psychology: Applied 8*(4), 259-270. http://dx.doi.org/10.1037/1076-898X.8.4.259