Atten Percept Psychophys (2018) 80:166–176
DOI 10.3758/s13414-017-1429-z

Reduced attentional focus and the influence on expert anticipatory perception

Adam D. Gorman[1,2,3] **· Bruce Abernethy**[2] **· Damian Farrow**[1,4]

Published online: 16 October 2017

Abstract The anticipatory memory encodings of expert and novice basketball players were examined under conditions of both full (attended condition) and reduced (unattended condition) attention (see also Gorman, Abernethy, & Farrow in *Attention, Perception, & Psychophysics, 75*, 835–844, 2013a). Participants completed a typical pattern recall task using dynamic playing sequences from basketball, and their responses were compared to both the original target pattern as well as to the series of patterns that occurred immediately after and immediately before the target image. The latter had not previously been employed in a pattern recall task when examining the anticipatory encoding of pattern information. Results revealed that the overall extent of the forward displacement for both the attended and unattended patterns was generally significantly greater for the experts, with the expert advantage tending to be most prominent for the attacking patterns. The novel addition of both forward and backward scenes may provide a more precise measure of the anticipatory effect, suggesting that future research in this domain should use a similar methodological design.

Keywords Attention · Anticipation · Pattern recall · Expertise

The visual world contains an extensive array of dynamic environments in which humans must operate. From avoiding a moving automobile in a busy city street to successfully intercepting a ball in a sporting competition, each situation demands the rapid processing of visual information to execute a suitable, and in some instances, life-saving, response ahead of time (Freyd & Johnson, 1987; Hubbard, 2005, 2006; Kelly & Freyd, 1987). Kelly and Freyd (1987) suggested that the capability to anticipate the subsequent locations of moving stimuli may be an adaptive strategy employed through the perceptual system (see also Freyd & Johnson, 1987; Hubbard, 2005, 2006). Indeed, empirical evidence has shown that the human visual system tends to intuitively anticipate the trajectory of stimuli that depict either implied or actual movement by overestimating the final stopping point (Freyd & Finke, 1984; Hubbard, 2005, 2006; Thornton & Hayes, 2004). Anticipatory responses of this nature, typically termed "representational momentum," may play an important functional role in helping to reduce the lag time between perception and action (Ashida, 2004; Hubbard, 2005, 2006; Kerzel & Gegenfurtner, 2003). For example, to successfully intercept or avoid a fast-moving projectile, the observer must rapidly integrate perceptions of the object's current location with predictions of its possible future location before formulating an appropriate motor response (Didierjean & Marmèche, 2005; Finke, Freyd, & Shyi, 1986; Hubbard, 2005, 2006). Given the inherent time lag that exists in the neural processing systems, the capability to alleviate the time delay between perception and action by anticipating likely future events may provide an effective means of responding in time-stressed situations (Ashida, 2004; Hubbard, 2005, 2006; Kerzel & Gegenfurtner, 2003).

✉ Adam D. Gorman
agorman@usc.edu.au

1 Movement Science–Skill Acquisition, Australian Institute of Sport, Canberra, Australia

2 School of Human Movement Studies, The University of Queensland, Brisbane, Australia

3 School of Health and Sport Sciences, University of the Sunshine Coast, 90 Sippy Downs Drive, Sippy Downs, Queensland 4556, Australia

4 Institute of Sport, Exercise and Active Living, Victoria University, Melbourne, Australia

The use of an anticipatory response is therefore likely to have considerable strategic value in the domain of team sports where performers are constantly required to make rapid decisions in an environment characterised by highly dynamic and complex sequences of play (Didierjean & Marmèche, 2005; Farrow, McCrae, Gross, & Abernethy, 2010; Gorman, Abernethy, & Farrow, 2011, 2012, 2013b; Williams & Davids, 1995; see also Ferrari, Didierjean, & Marmèche, 2008; for examples of the anticipatory effect in other domains, see Blättler, Ferrari, Didierjean, & Marmèche, 2011; Blättler, Ferrari, Didierjean, van Elslande, & Marmèche, 2010; Ferrari, Didierjean, & Marmèche, 2006). Gorman et al. (2012) provided direct evidence in support of this notion by using a pattern recall task to examine the anticipatory responses of expert and novice basketball players. Participants were asked to recall the final locations of the players displayed in patterns showing typical basketball action sequences. Recall performance was analysed by comparing the participants' response to each of the patterns that occurred in the actual playing sequence after the presented target image. By identifying the pattern that best matched the participant's response, the authors provided a temporal estimate of the extent of the anticipatory effect. Their results showed that the experts recalled both static (i.e., a single frame from a video recording of an actual basketball game) and moving patterns (i.e., a video recording of an actual basketball game) an average of 50 and 117.5 ms, respectively, further into the future compared to the novices. However, a key limitation of the study was that the participants' responses were only compared to patterns that occurred in the forward direction (i.e., patterns occurring after the target image), rather than including a comparison to both forward *and* backward patterns (where the latter refers to patterns occurring before the target image). The original method not only biased the analysis of the results by excluding the possibility of a backward displacement in the recall of the patterns, but the method was also contrary to the conventional approach used to examine representational momentum (see Hubbard, 2014).

While the aforementioned research highlights the anticipatory nature of expert pattern perception in a dynamic domain under conditions of focussed attention, the influence of diminished attention has not been examined beyond relatively simple displays with novice observers (e.g., Hayes & Freyd, 1995, 2002; Kerzel, 2003; see also Joordens, Spalek, Razmy, & van Duijn, 2004; Kerzel, 2004; Munger & Owens, 2004). For example, Hayes and Freyd (1995) found that when novices were asked to indicate the final location of a single dot moving in an implied trajectory on a screen, the extent of the anticipatory encoding was significantly less than that observed when participants had to perform the same task but with their attention divided between two dots moving in different directions. In a second experiment, participants tracked a single dot moving on a screen under both dual-task (counting to 30 by ones, twos, or threes) and single task conditions. Results once again showed that under conditions of reduced attentional focus (i.e., dual-task condition), the anticipatory effect was greater compared to conditions where attentional focus was unimpeded. Other studies in this area, using dual tasks or visual distractors (for a review, see Hubbard, 2005), have provided additional evidence to suggest that diminished attention may elicit a significantly greater anticipatory effect when attempting to pinpoint the location of moving stimuli (e.g., Hayes & Freyd, 2002; Joordens et al., 2004; for a similar example using static stimuli, see Prinzmetal, Amiri, Allen, & Edwards, 1998; but for exceptions, see Kerzel, 2003, 2004).

Hayes and Freyd (2002; see also Hayes & Freyd, 1995) concluded that focussed attention may allow the anticipatory memory representation to be halted earlier, possibly through some form of cognitive intervention such as the "cognitive resistance" described by Finke et al. (1986), whereas under conditions of diminished attention, cognitive control of the memory encoding may be reduced and so the anticipatory effect is allowed to continue without obstruction for a longer time period (see Finke et al., 1986; Joordens et al., 2004). The precise nature of the underlying mechanisms that modulate the anticipatory effect under differing attentional conditions is still a point of debate amongst researchers, but the conclusion proposed by Hayes and Freyd (2002) suggests, like a number of other studies examining representational momentum, that the anticipatory mental representation is heavily influenced by higher order cognitive involvement (Finke et al., 1986; Hubbard, 2005; Joordens et al., 2004; Reed & Vinson, 1996; Vinson & Reed, 2002; see also Hayes & Freyd, 1995; for an alternative viewpoint, see Kerzel, Jordan, & Müsseler, 2001; for further discussion of the underlying mechanisms, see Hubbard, 2005, 2010, 2014; Hubbard, Kumar, & Carp, 2009). However, while the aforementioned research provides an important initial step by using novice observers and simple displays, further research regarding the effects of attention is required using real-life action sequences showing a more complex, dynamic, and domain-specific environment with comparisons between expert and novice observers.

In particular, skill-based comparisons across both attended and unattended experimental conditions may help to determine whether experts utilise an anticipatory encoding in fundamentally different ways than do individuals with limited experience in the domain (see Goldin, 1978; Lane & Robertson, 1979; Weber & Brewer, 2003). For example, expert team-sport performers have been shown to exhibit a greater capacity to encode perceptual information under conditions where attentional resources are limited or distracted (Furley, Memmert, & Heller, 2010; Garland & Barry 1991–1992; Gorman et al., 2013a; Memmert, 2006), possibly through the rapid retrieval of pattern information in long-term memory (Ericsson & Kintsch, 1995; Garland & Barry, 1991–1992; Gobet, 1998; Gobet & Simon, 1996). In addition, given that the anticipation of a complex sporting pattern is likely to afford considerable strategic value in terms of identifying appropriate responses (Berry, Abernethy, & Côté, 2004; Farrow et al., 2010; Gorman et al., 2013b; Starkes, Allard, Lindley, & O'Reilly, 1994; Williams & Davids, 1995; see also Ferrari et al., 2006, 2008), it is possible that experts have learned (most likely implicitly) to allow the anticipatory encoding to occur unimpeded under conditions of both full and diminished attention in an attempt to maximise the extent to which they can predict the progression of a fast-paced and dynamic action sequence. Experienced performers may therefore possess the capability to process dynamic patterns with the same level of anticipatory encoding in the presence or absence of attention (see Furley et al., 2010; Garland & Barry 1991–1992; Gorman et al., 2013a; Memmert, 2006). Despite the theoretical and practical implications of such proposals, there is limited empirical evidence detailing the influence of attentional focus regarding the anticipatory encoding undertaken by experts (but see Goldin, 1978; Lane & Robertson, 1979; Weber & Brewer, 2003).

The present study examined pattern recall performance in both attended and unattended conditions to determine whether the anticipatory effect reported for novice observers when viewing simple images would also occur for experts when viewing more complex, domain-specific test stimuli that were a closer representation of the natural setting. Given that experts have previously been shown to encode information in the presence or absence of direct attention (Furley et al., 2010; Garland & Barry 1991–1992; Gorman et al., 2013a; Memmert, 2006), and have possibly learned to do so to maximise the strategic benefits of anticipating a pattern further into the future (Berry et al., 2004; Farrow et al., 2010; Starkes et al., 1994;. Williams & Davids, 1995; see also de Groot, 1965; Ferrari et al., 2008), it was predicted that the extent of the experts' anticipatory encoding would be significantly greater than that of the novices in both attended and unattended conditions. Additionally, Gorman et al. (2012) examined the magnitude of the anticipatory memory representation for the overall pattern, but there was no attempt to determine whether the effect differed across attack and defence for experts and novices (but see Gorman et al., 2013a, 2013b). Previous research has generally shown that attacking patterns are often encoded with greater accuracy compared to defensive patterns (e.g., Abernethy, Baker, & C té, 2005; Farrow, 2010; but for an example of greater recall accuracy of defensive patterns, see Allard, Graham, & Paarsalu, 1980); however, it has yet to be determined whether these differences extend to the magnitude of the anticipatory encoding. As highlighted earlier, Gorman et al. (2012) also made no attempt to account for the possibility of a backward displacement in the encoding of the patterns, thereby biasing the analysis of the results by only accounting for the possibility of a forward displacement.

Therefore, the current study examined whether the anticipatory encoding would be different for experts compared to novices across the specific attacking and defending player configurations, and whether the use of both forward *and* backward scenes would produce similar findings to those reported previously (i.e., Gorman et al., 2012). The data for the present study were from the same experiment as that described by Gorman et al. (2013a). However, the present study focussed the analyses upon the anticipatory encoding of the patterns, rather than solely examining pattern recall error which was the case in Gorman et al. (2013a). In addition, by including both forward and backward scenes, the present study analysed the anticipatory nature of the data using a new method that has not previously been applied to data collected using the pattern recall paradigm.

Method

Participants

Thirty-four participants were recruited for the study, and these were drawn from two distinct skill levels. An expert group (n = 17) comprised current or former basketball players who had played junior basketball at a regional, state, or international level. The average playing experience of the expert group was 10.32 years (SD = 3.36), and the average age was 18.35 years (SD = 1.87). A second experimental group (n = 17) was composed entirely of novices (M_{age} = 22.29 years, SD = 3.42) who reported an average of 0.9 years (SD = 1.51) of basketball-playing experience in lower levels of competition for school, recreational, or social teams. Informed written consent was obtained for all participants, and the experiment received institutional ethical clearance.

Materials

The video images used as the test stimuli were extracted from video footage (recorded at 25 frames per second) of a typical 5-on-5 basketball game between two skilled male basketball teams. The players in the test stimuli were not included as participants. The test stimuli, and the methods used to rate each clip, were either the same or similar to those used in previous research (e.g., Gorman et al., 2011, 2012, 2013a, 2013b, 2015; Ryu, Abernethy, Mann, & Poolton, 2015; Ryu, Abernethy, Mann, Poolton, & Gorman, 2013). The images were filmed from a platform attached to mobile scaffolding positioned in the centre of a basketball court which provided an elevated viewing perspective. A total of 12 different playing sequences were used for the study, with two additional clips created for use as familiarisation trials. All of the test stimuli viewed by participants comprised moving video images.

To ensure the test images were representative of the basketball patterns that occur at an elite level of competition, three highly experienced coaches, with an average of more than 40 years of coaching experience, were asked to collectively rate each of the patterns that were used for testing (Gorman et al., 2012, 2013a, 2013b, 2015; Ryu et al., 2015; Ryu et al., 2013; see also North & Williams, 2008; North, Williams, Hodges, Ward, & Ericsson, 2009). The coaches used a 10-point Likert-type scale to provide a score for the structure (i.e., the extent to which the clip was representative of the patterns occurring at an elite level) contained within the attacking patterns and another score for the defensive patterns, and these two scores were averaged to provide an overall rating for each clip. Higher scores were indicative of higher levels of structure. The coaches were requested to discuss their ratings and to reach consensus on the final allocated scores. The 12 clips that were used as the test stimuli all received a rating of 7 or above, which, as described in other research, was deemed to be an acceptable level of structure (Gorman et al., 2012, 2013a, 2013b, 2015; North & Williams, 2008; North et al., 2009).

An Applied Science Laboratories eye-tracking system (Mobile Eye Mark II, Bedford, MA) was used to measure the visual search behaviours of participants. The system combined two images captured simultaneously from both a scene camera (mounted on the participant's head) and an eye camera (positioned over the participant's right eye) to produce a video recording of the visual display showing a crosshair to indicate the location of the participant's gaze. Similar visual search measurement systems have been used previously to examine the visual behaviours of individuals when viewing various sporting scenarios (e.g., Button, Dicks, Haines, Barker, & Davids, 2011; Panchuk & Vickers, 2009; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007). The recorded image (captured at 25 frames per second) was subjected to a frame-by-frame analysis to determine the percentage of time that participants spent fixating upon various locations in the display to confirm compliance with the instructional sets provided during the experiment.

Procedure

The procedure for this experiment was either the same or similar to those reported previously (e.g., Gorman et al., 2012, 2013a, 2013b, 2015; see also Furley et al., 2010; Memmert & Furley, 2007; Weber & Brewer, 2003). The test stimuli were displayed on a standard computer monitor (47.5 cm wide × 30 cm high), and participants completed the test while seated. After the eye tracker was fitted to the participant, the system was calibrated using a 9-point reference grid displayed on the same monitor used to present the test stimuli. Calibration was checked at the start and end of each test block, and adjustments were made as necessary. Each test clip was displayed for a period of 7 s, after which the players in the image disappeared from view. At this point, the task for participants was to recall the locations of the players by using a mouse-click to drag "X" and/or "O" icons representing the defending and attacking players, respectively, onto a blank basketball court showing the same viewing perspective as the original test clip. The instructional set requested that the centre point of each icon be placed on screen between the heels of the given player at the location where he was standing immediately before the players in the clip disappeared from view. Within any given trial, participants were able to reposition or delete previously placed icons before clicking on a button labelled as "OK" to move to the next clip in the test block. There were no instructions describing the speed of the response: Participants were simply asked to recall the locations of the players in the images as accurately as possible. The intention behind this instruction was to avoid the possibility of a speed–accuracy trade-off which, as described by Abernethy et al. (2005), may act to confound the results of research into pattern perception. There were three separate test blocks and these were counterbalanced across participants.

Entire recall test block In the entire recall test block, the intention was to replicate traditional recall tests where participants are required to recall the final location of all players (five attackers and five defenders) displayed in the test clip. This test condition was also designed to confirm the anticipatory encoding reported previously by Gorman et al. (2012). There were a total of 12 clips presented in this block.

Attack-only recall test block This recall condition showed the same test clips as those displayed in the entire recall test, but on this occasion, participants were instructed to only recall the attacking players from each of the 12 test images. These trials provided an indication of the extent to which participants anticipated the subsequent movements of the attacking pattern structures (termed "attended attack recall") without the requirement to also recall the defensive players. These trials also provided a priming effect to focus the attention of participants on the attacking pattern elements prior to the presentation of an additional (13th) trial in the test block. The moment the players in this additional trial disappeared from view, participants were requested to recall only the defending pattern elements onto the blank court on-screen, thus providing an indication of the capability to recall the unattended defensive pattern elements (termed "unattended defence recall"; for similar methodological approaches, see Furley et al., 2010; Memmert & Furley, 2007; Weber & Brewer, 2003).

Defence-only recall test block This test condition required participants to recall only the defensive player locations from the same test clips used in the entire recall and attack only recall test blocks. These trials provided an indication of the participants' recall performance when attention was directed towards the players comprising the defensive pattern structure (termed "attended defence recall"). In a similar manner to the attack-only recall test condition, an additional (13th) trial was included immediately after the previous defence-only trials. The moment the players in the additional trial disappeared from view, participants were asked to recall only the attacking pattern elements. This provided a measure of the participants' capability to recall the attacking pattern when attention was directed towards the locations of the defensive players (termed "unattended attack recall"). While it is possible that participants may have expected the additional (13th) trial to occur after having experienced this trial in preceding test blocks, the use of 12 priming trials immediately prior to the additional (13th) trial were included to reduce the likelihood of participants accurately determining when the additional trial would be presented.

An identical test clip was used in the unattended attack and unattended defence conditions so that these trials were directly comparable. Similarly, this test clip was also the same as that used as the fourth trial in the series of all three test blocks (all other clips in the entire recall, attack-only, and defence-only test blocks were randomly ordered) to allow direct comparisons between the two attended conditions across an identical trial and across a trial positioned in the same serial order of each test block. The use of this same trial in the entire recall condition allowed recall performance to be compared across experts and novices to ensure the clip was representative of the domain.

Data analysis

Pattern recall data The analyses used to examine the extent of the anticipatory effect were based upon those described by Gorman et al. (2012, 2013b), but to extend this approach, the analyses included both forward and backward scenes rather than limiting the analyses to only those scenes that occurred subsequent to the target image. A custom-built computer program (AIS React, n.d.) was used to apply a least squares approach to measure the extent to which participants correctly recalled the locations of the pattern structures. To achieve this, the screen was allocated coordinates of $x = 0$ and $y = 0$ at the top left, and $x = 1$ and $y = 1$ at the bottom right. The actual coordinate locations of the attacking and defending players were entered for each stimulus pattern, and the distance between these and the coordinate locations of the attacking and defending players entered by the participant for a given stimulus pattern were calculated as the Euclidean distance using the Pythagorean theorem. Therefore, the best possible recall score that could be achieved was zero (indicating a perfect match between entered and actual coordinate locations). This essentially created a 5 × 5 matrix showing all possible distances between the actual coordinate locations and the coordinates of the icons entered by the participant with the attacking and defensive patterns calculated separately. The smallest combination of distances was then calculated and averaged to provide recall error scores for the respective patterns. The recall error scores were averaged across all 12 trials in the entire recall, attended attack recall, and attended defence recall conditions to provide an overall recall error score for each participant in each of these conditions. The recall scores for attack and defence in the entire recall test were averaged to provide a single overall score for this condition. A total of eight trials (less than 2%) from the full data set of trials captured from the 34 participants were excluded from the analyses for the entire recall test data due to participants incorrectly adding or omitting pattern elements.

To determine the extent to which participants encoded the players within the patterns in either a forward or backward direction in the various experimental conditions, the coordinate locations of the players in the test clips were digitised for an additional period of 2 s (50 frames) beyond the target image displayed to participants, and for an additional 1.96 s (49 frames) prior to the target image (the video images were captured at 25 frames per second, and so the frames advanced in 40-ms increments). This provided an extra set of comparison patterns, allowing the participant's response to be compared to both the original target pattern as well as to the patterns that occurred both immediately before and immediately after the target pattern. For the entire recall, attended attack recall, and attended defence recall, the smallest average error score across the 12 trials for each participant was selected. For the two unattended conditions, the smallest score for each participant was selected. These scores were then used to identify the corresponding frame in the time series to provide a temporal estimate of the extent of the displacement of memory encoding under the various experimental conditions. To apply a slightly more conservative measurement approach than that used by Gorman et al. (2012), in the event of one or more tied values for the smallest average score in the temporal sequence, the lowest of the scores, rather than the highest score as applied by Gorman et al. (2012), was used to identify the corresponding frame in the time series.

Box plots were used to identify any outliers in the data sets that were derived from the use of a single test trial (i.e., the two unattended conditions and the fourth trial in all three of the attended conditions). Values were excluded from the statistical analyses if they were beyond 1.5 times the interquartile range of the upper or lower quartiles (see Field, 2014). There were two outliers for the fourth trial in the attended attack condition (novices $n = 2$ [11.8%]); three outliers for the fourth trial in the attended defence condition (experts $n = 2$ [11.8%], novices $n = 1$ [5.9%]), 10 outliers in the unattended attack condition (experts $n = 6$ [35.3%], novices $n = 4$ [23.5%]); five outliers in the unattended defence condition (experts $n = 2$ [11.8%], novices

$n = 3$ [17.6%]); and five outliers for the fourth trial in the entire overall condition (experts $n = 2$ [11.8%], novices $n = 3$ [17.6%]).

Gaze data Analysis of the gaze behaviours was conducted to ensure that participants correctly followed the instructional sets by directing their gaze towards the assigned patterns as requested (i.e., fixating more on the attacking players when asked to recall the attacking patterns and, conversely, fixating more on the defensive players when asked to recall the defensive patterns). Data from 11 experts and nine novices were available from a consistent selection of eight test trials in each of the three test conditions as well as the trials used in the two unattended conditions. A frame-by-frame analysis was used to determine the percentage of time (in milliseconds) that participants spent fixating (a) attacking players, (b) defending players, (c) open space, or (d) other display regions that were not covered by the aforementioned categories (see also North et al., 2009). Intrarater reliability conducted on a subset of trials ($N = 16$) showed high levels of agreement ($R = .95$). Fixations were defined as a gaze behaviour that remained on the same stationary or moving object for a period of at least three frames or 120 ms (North et al., 2009; Williams, Davids, Burwitz, & Williams, 1994; Williams & Davids, 1998).

Results

Pattern recall data

The data described in this section for pattern recall error have been described previously in Gorman et al. (2013a). The data for displacement have not been reported previously. Alpha was set at $p < .05$ for all statistical analyses.

Entire recall test block An independent *t* test showed that the experts ($M = 0.0663$) exhibited significantly less recall error than the novices ($M = 0.0762$) when recalling the pattern structures of the clips presented in the entire recall test block, $t(32) = -4.24$, $p < .001$, $r = .60$. An independent *t* test comparing the recall error scores for the fourth trial presented in the entire recall test (the clip used in the two unattended trials and also as the fourth trial in the attack-attended and defence-attended conditions) showed that the experts ($M = 0.0567$) were once again able to recall the locations of the players in the image with less error than the novices ($M = 0.0734$), $t(32) = -3.51$, $p = .001$, $r = .53$.

An independent *t* test showed that the mean displacement for the experts ($M = 108.2$ ms) for the block of 12 test trials in the entire recall test condition was significantly greater than that achieved by the novices ($M = 12.9$ ms), $t(32) = 3.10$, $p = .004$, $r = .48$. The same analyses conducted on the fourth trial presented in the entire recall test showed no significant differences in the mean displacement for the experts ($M = 141.3$ ms) and novices ($M = 97.1$ ms), $t(27) = 1.60$, $p = .12$, $r = .29$, although the *p* value approached significance, and there was a large difference between the means of the two skill groups as well as a medium effect size. Collectively, these findings suggested that the stimulus patterns used in the study were representative of the domain.

Attack-only and defence-only recall test blocks To analyse the data in the attended conditions (see Fig. 1), the results from all 12 test trials in the two attended conditions were included in a Skill (expert, novice) × Element (attack, defence) repeated-measures linear mixed model (using Sidak adjustments for multiple comparisons). The analysis revealed a significant main effect for skill, $F(1, 32) = 6.56$, $p = .015$, which indicated that the experts' ($M = 57.6$ ms) displacement of the patterns was significantly greater than that of the novices ($M = -37.6$ ms). There was also a significant main effect for element, $F(1, 32) = 15.42$, $p < .001$, showing that the displacement for the attacking patterns ($M = 55.3$ ms) was significantly greater than that observed for the defensive patterns ($M = -35.3$ ms). A significant two-way interaction across skill and element, $F(1, 32) = 7.30$, $p = .011$, revealed that the experts exhibited a significantly greater displacement of the attacking patterns ($M = 134.1$ ms) compared to that exhibited by the novices ($M = -23.5$ ms), but there were no significant differences in the displacement of the defensive patterns between the two skill groups ($M_{experts} = -18.8$ ms; $M_{novices} = -51.8$ ms). In addition, the experts displaced the attacking patterns significantly further than they did the defensive patterns, whereas there were no significant differences in the extent of the displacement of the attacking and defensive patterns for the novices. Finally, the experts' displacement of the attended attacking patterns was significantly beyond zero, but the experts' displacement of the defensive patterns, and the novices' displacement of both the attacking and defensive patterns, were not significantly beyond zero (however, the novices

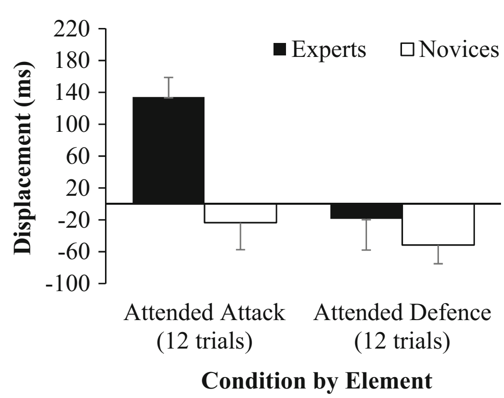

Fig. 1 Results for displacement from the attended attack and attended defence recall conditions (using all 12 test trials) for the two skill groups. Error bars show standard error

significantly displaced the attended defensive patterns beyond zero in the backward direction).

To compare the data for the attended and unattended conditions across an identical test clip (see Fig. 2), a Skill (expert, novice) × Condition (attended, unattended) × Element (attack, defence) repeated-measures linear mixed model (with Sidak adjustments) was conducted using only the results obtained from the fourth trial in the two attended conditions, and the results for the single trial used in the two unattended conditions. There was a significant main effect for condition, $F(1, 80.92) = 11.08$, $p = .001$, indicating that the displacement for the attended patterns ($M = 201.6$ ms) was significantly greater than that shown for the unattended patterns ($M = 84.9$ ms). There was no significant main effect for skill, $F(1, 30.75) = 0.50$, $p = .49$, or element, $F(1, 81.67) = 0.02$, $p = .89$. However, a significant Skill × Condition interaction, $F(1, 80.92) = 8.34$, $p = .005$, revealed that the novices displaced the attended patterns ($M = 236.5$ ms) to a significantly greater extent than they displaced the unattended patterns ($M = 18.5$ ms), and the difference between the experts ($M = 151.2$ ms) and novices ($M = 18.5$ ms) for the displacement of the unattended pattern elements approached significance ($p = .15$). The experts' and novices' displacement for the attended attacking patterns was significantly beyond zero, but only the experts' displacement of the unattended attacking and defensive patterns was beyond zero. The novices, but not the experts, displaced the attended defensive patterns significantly beyond zero.

Gaze data

The gaze data are the same as those described by Gorman et al. (2013a). Multivariate analysis of variance (MANOVA) tests comparing experts' and novices' percentage of viewing time for the various display features (attackers, defenders, and space—the "other" category was removed due to insufficient data) in the attack-only, defence-only, and two unattended conditions revealed no significant differences between the two skill levels in the distribution of gaze. This suggests that any skill-related differences in the results for anticipatory encoding were unlikely to be due to differences in visual search behaviours.

One-sample t tests showed that the percentage of time that each skill group spent fixating the attacking and defending pattern elements in the attack-only and defence-only conditions, respectively, was significantly more than the percentage of time that participants fixated upon the other features contained within the test clips. Similarly, both skill groups maintained their fixations on the assigned pattern elements in the critical unattended trials with no significant differences in the percentage of time spent fixating the attacking and defensive elements in the unattended attack and unattended defence trials, respectively, compared to the corresponding attended trials. This confirmed that participants correctly followed the experimental protocols by focussing attention on the allocated pattern elements. It also confirms that despite the possibility of participants predicting a second "unexpected" trial to occur, after having experienced this trial at a previous point in the test, participants maintained their attentional focus upon the pattern elements that were described in the instructional sets. It seems that the use of several priming trials immediately prior to the additional (13th) trial helped to prevent any issues associated with the use of two "unexpected" test trials.

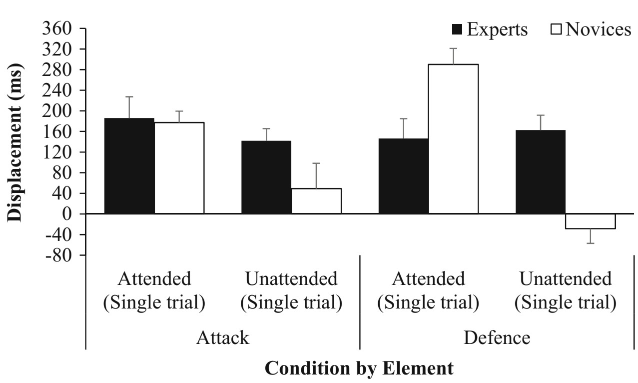

Fig. 2 Results for displacement for the matching single attended and single unattended trials for attack and defence recall conditions across the two skill groups. Error bars show standard error

Discussion

The anticipatory nature of expert pattern perception has been reported in several investigations under conditions of focussed attention (Didierjean & Marmèche, 2005; Ferrari et al., 2006; Gorman et al., 2011, 2012, 2013b), but the influence of diminished attention on the memory encoding has not been extensively examined beyond the use of simplified objects with novice observers in relatively predictable contexts (e.g., Hayes & Freyd, 1995, 2002; Kerzel, 2003). The present study used a pattern recall task to compare the magnitude of the anticipatory encoding across expert and novice basketball players after they encoded dynamic action sequences under conditions of both full (attended condition) and diminished (unattended condition) attention. An important addition to the study was the inclusion of both forward *and* backward scenes, which is an approach that has not previously been applied to data collected using the pattern recall paradigm when examining anticipatory encoding.

The results for the attended patterns that included 12 test trials, when analysed separately from the unattended patterns, revealed a significantly greater forward displacement for the experts compared to the extent of the displacement observed for the novices. The tendency for expert sports performers to apply an anticipatory encoding of information during a pattern recall task has been shown previously (e.g., Gorman et al., 2012, 2013b), but this is the first time that such an effect has been shown for a pattern recall task when both forward *and* backward scenes have been included in the research design. While the use of forward and backward scenes has been used for some time in recognition-based paradigms (e.g., Freyd & Finke, 1984; Kelly & Freyd, 1987; see also Didierjean & Marmèche, 2005), the analysis of anticipatory encodings using the pattern recall paradigm have been limited to only comparing the participants' response pattern to scenes occurring subsequent to the target pattern (e.g., Gorman et al., 2012). An example of the potential influence of this methodological change is demonstrated by a comparison between the present study and a similar study conducted by Gorman et al. (2012). In their earlier research, Gorman et al. reported mean displacements of 185.0 ms for experts and 67.5 ms for novices for a task that required participants to recall the entire pattern structure of a moving basketball action sequence presented using video. The corresponding results for the present study for the entire recall task were 108.2 ms and 12.9 ms for experts and novices, respectively, which equates to decreases in the extent of the displacement between the two studies of 41.5% for the experts and 80.9% for the novices. It seems that the use of scenes occurring prior to the target image, in conjunction with scenes occurring subsequent to the target image, provided a more precise measurement method that may be an important methodological consideration for future research using the pattern recall paradigm to examine anticipatory encoding.

The results obtained from the analyses that examined the results from the single trial used in the unattended conditions and the fourth trial used in the attended conditions, also revealed an expertise effect. The results showed a tendency for the experts (M = 151.2 ms) to displace the unattended patterns in the forward direction to a greater extent than that exhibited by the novices (M = 18.5 ms), although it should be noted that this result approached significance (p = .15), despite the large differences in the means between the two skill groups. Gorman et al. (2013a) found that expert basketball players recalled the unattended portion of a basketball pattern with significantly greater accuracy than their novice counterparts. Collectively, these results not only suggest that experts encode the unattended portions of a pattern with greater accuracy than do lesser skilled individuals (Gorman et al., 2013), but they also suggest that experts often encode those patterns using an anticipatory process whereby the elements within the image are recalled forward of their original location. This result is in line with a number of previous studies that have highlighted the tendency of experienced individuals to intuitively predict the progression of a dynamic pattern beyond that observed for lesser skilled observers (Didierjean & Marmèche, 2005; Gorman et al., 2011, 2012, 2013b; see also Blättler et al., 2011; Blättler et al., 2010), but it is the first time that the anticipatory effect has been shown to occur for patterns that are outside the expert's attentional focus.

In contrast, the novices' forward displacement of the patterns, for the analyses that compared the single trials from the attended and unattended conditions, were isolated solely to the attended patterns, with only the experts displacing the unattended patterns significantly beyond zero. Previous research has shown that novices are capable of representing and processing a variety of perceptual details from relatively simple images in the absence of direct attention (Chun & Jiang, 1998; Fernandez-Duque & Thornton, 2000; Green & Flowers, 1991; Thornton & Fernandez-Duque, 2000). Moreover, Hayes and Freyd (1995, 2002) found greater forward memory displacements under conditions of reduced attentional focus, compared to those observed under full attentional focus, for novices who were observing simple images. However, the results from the present study suggest that when the images depict more complex and domain-specific information, a reduced attentional focus, relative to a full attentional focus, is only likely to result in a forward memory displacement when the observers have substantial prior experience in the domain from which the images have been extracted. The expert advantage in memory-based tasks for unattended pattern elements may be facilitated by the rapid retrieval of pattern information from long-term memory (Ericsson & Kintsch, 1995; Gobet, 1998; Gobet & Simon, 1996;). The template theory espoused by Gobet and Simon (1996) suggests that patterns are stored in memory structures called templates, which contain slots that can store additional information as well as provide strategic details on potential responses (Gobet, 1998; Gobet & Simon, 1996; see also Ferrari et al., 2006). The use of long-term memory structures that can help identify likely future events may facilitate the processing and anticipation of pattern information without overwhelming the limited capacity of short-term memory (Miller, 1956), thereby providing a possible mechanism that may allow experts to encode and anticipate pattern structures when attentional resources are impeded (see Gobet, 1998, Gobet & Simon, 1996; see also Ericsson & Kintsch, 1995).

The specific examination of the attacking and defensive pattern structures was designed to determine whether the magnitude of the displacement of the patterns varied between experts and novices for specific structural features under differing levels of attentional focus. In general, and in line with previous research (see Gorman et al., 2013b), the experts' forward displacement of the patterns tended to be most pronounced for the attacking pattern structures, although the specific nature of the displacements appeared to be influenced by the attentional focus and the nature of the statistical analyses. For example, in the attended conditions that used 12 test trials, the experts significantly advanced the attacking patterns further into the future than did the novices, and only the experts advanced the attended attacking patterns beyond zero. The experts also advanced the attended attacking patterns significantly further than they advanced the attended defensive patterns. In the same test condition, neither the experts nor the novices advanced the attended defensive patterns significantly beyond zero, and there were also no significant differences between the two skill groups for the displacement of the attended defensive patterns. However, the results for the attended data obtained from the statistical analyses that compared the single trials from the attended and unattended conditions revealed slightly different findings with both skill groups advancing the attended attacking patterns beyond zero, and the novices, but not the experts, advancing the attended defensive patterns beyond zero. For the unattended data, the experts, but not the novices, advanced both the attacking and defensive patterns significantly beyond zero.

The discrepancies in the findings related to the attended data are most likely due to the differences and limitations associated with the methodological design. In one analysis, the attended data were extracted from 12 test trials, whereas in the other, the data were extracted from a single test trial. Moreover, the stringent screening of outliers in the data that used a single trial, which equated to the removal of just under 15% of the total data set, is also likely to have influenced the nature of the results. While single test trials have been used previously in similar studies (e.g., Furley et al., 2010; Gorman et al., 2013a; Memmert & Furley, 2007), future research in this area should consider including additional test trials wherever possible. A general explanation for the differences in displacement observed for the attacking and defending pattern elements may be related to the nature of a typical attacking structure in basketball (Moore & White, 1980; Wooden, 1988). Given that experienced teams are often encouraged to implement their attacking plays with less structure and greater flexibility in an attempt to destabilise the defensive team, an attacking pattern may contain more unpredictable movements compared to a typical defensive pattern (Moore & White, 1980; Williams, Davids, Burwitz, & Williams, 1993; Wooden, 1988). The experts' capability to draw upon their domain-specific understanding of the relational information underpinning the movements of players in an attacking sequence may have allowed them to anticipate the more variable movements of the attacking players to a greater extent than that exhibited by the novices (Didierjean & Marmèche, 2005; Gorman et al., 2011, 2012, 2013a, 2013b; Moore & White, 1980; Williams, Hodges, North, & Barton, 2006; Williams et al., 1993; Wooden, 1988). In contrast, a typical defensive pattern is often more predictable because players are essentially attempting to maintain as much stability in their playing structure as possible to avoid creating scoring opportunities for their opponents (Williams et al., 1993). This may explain why similar levels of anticipatory encoding occurred for both experts and novices when recalling the defensive patterns. However, given that the experts anticipated the defensive and attacking patterns significantly further than the novices in the unattended conditions, it seems likely that the experts were able to draw upon long-term memory structures (Ericsson & Kintsch, 1995; Gobet & Simon, 1996) to encode pattern elements in the absence of focussed attention (see also Gorman et al., 2013a). While skill-related differences in the anticipatory encoding of specific pattern structures under differing attentional manipulations have not previously been examined, it is recommended that future studies be directed towards confirming the validity of these conclusions.

In summary, the results showed that the inclusion of both forward and backward scenes in the analysis of a pattern recall task provided a more precise measurement of the anticipatory encodings of both expert and novice observers, suggesting that a similar approach should be considered for use in future research. The mean forward displacement of both the attended and unattended patterns tended to be significantly greater for the experts compared to the novices, with this effect generally being more pronounced for the attacking patterns than for the defensive patterns. Additional research in this domain is recommended to both confirm and extend the present findings. In particular, it is necessary to further explore the effects of attentional focus on the anticipatory encoding of specific pattern features as well as including a larger sample of test trials when examining the unattended recall of pattern information.

Acknowledgements The authors appreciate the assistance of Colin Mackintosh, Emma Knight, and Chris Barnes. Thank you to the coaches and participants for making their time available for the research. The authors also wish to acknowledge the support provided by the Australian Institute of Sport. The recall data and gaze data from this study were presented as a poster at the North American Society for the Psychology of Sport and Physical Activity (please see Gorman, Abernethy, & Farrow, 2012). Parts of the information reported in this article have been reported previously (see the Introduction, Method, and Results sections for details and references).

References

Abernethy, B., Baker, J., & Côté, J. (2005). Transfer of pattern recall skills may contribute to the development of sport expertise. *Applied Cognitive Psychology, 19*, 705–718.

AIS React (n.d.) (Version 7.7) [Computer program]. Belconnen, ACT, Australia: Australian Institute of Sport.

Allard, F., Graham, S., & Paarsalu, M. E. (1980). Perception in sport: Basketball. *Journal of Sport Psychology, 2*, 14–21.

Ashida, H. (2004). Action-specific extrapolation of target motion in human visual system. *Neuropsychologia, 42*, 1515–1524.

Berry, J., Abernethy, B., & Côté, J. (2004). The contribution of pattern recognition and prediction skills to expert game-based decision-making in Australian Rules football [Abstract]. *Journal of Sports Sciences, 22*, 566.

Blättler, C., Ferrari, V., Didierjean, A., & Marmèche, E. (2011). Representational momentum in aviation. *Journal of Experimental Psychology: Human Perception and Performance, 37*, 1569–1577.

Blättler, C., Ferrari, V., Didierjean, A., van Elslande, P., & Marmèche, E. (2010). Can expertise modulate representational momentum? *Visual Cognition, 18*, 1253–1273.

Button, C., Dicks, M., Haines, R., Barker, R., & Davids, K. (2011). Statistical modelling of gaze behaviour as categorical time series: What you should watch to save soccer penalties. *Cognitive Processing, 12*, 235-244.

Chun, M. M., & Jiang, Y. (1998). Contextual cueing: Implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology, 36*, 28–71.

de Groot, A. D. (1965). *Thought and choice in chess.* The Hague, The Netherlands: Mouton.

Didierjean, A., & Marmèche, E. (2005). Anticipatory representation of visual basketball scenes by novice and expert players. *Visual Cognition, 12*, 265–283.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*, 211–245.

Farrow, D. (2010). A multi-factorial examination of the development of skill expertise in high performance netball. *Talent Development & Excellence, 2*, 123–135.

Farrow, D., McCrae, J., Gross, J., & Abernethy, B. (2010). Revisiting the relationship between pattern recall and anticipatory skill. *International Journal of Sport Psychology, 41*, 91–106.

Fernandez-Duque, D., & Thornton, I. M. (2000). Change detection without awareness: Do explicit reports underestimate the representation of change in the visual system? *Visual Cognition, 7*, 323–344.

Ferrari, V., Didierjean, A., & Marmèche, E. (2006). Dynamic perception in chess. *The Quarterly Journal of Experimental Psychology, 59*, 397–410.

Ferrari, V., Didierjean, A., & Marmèche, E. (2008). Effect of expertise on strategic perception: The example of chess. *The Quarterly Journal of Experimental Psychology, 61*, 1265–1280.

Field, A. (2014). *Discovering statistics using IBM SPSS statistics* (4th ed.). Los Angeles, CA: Sage.

Finke, R. A., Freyd, J. J., & Shyi, G. C.-W. (1986). Implied velocity and acceleration induce transformations of visual memory. *Journal of Experimental Psychology: General, 115*, 175–188.

Freyd, J. J., & Finke, R. A. (1984). Representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*, 126–132.

Freyd, J. J., & Johnson, J. Q. (1987). Probing the time course of representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*, 259–268.

Furley, P., Memmert, D., & Heller, C. (2010). The dark side of visual awareness in sport: Inattentional blindness in a real-world basketball task. *Attention, Perception, & Psychophysics, 72*, 1327–1337.

Garland, D. J., & Barry, J. R. (1991–1992). Effects of interpolated processing on experts' recall of schematic information. *Current Psychology: Research & Reviews, 10*, 273–280.

Gobet, F. (1998). Expert memory: A comparison of four theories. *Cognition, 66*, 115–152.

Gobet, F., & Simon, H. A. (1996). Templates in chess memory: A mechanism for recalling several boards. *Cognitive Psychology, 31*, 1–40.

Goldin, S. E. (1978). Effects of orienting tasks on recognition of chess positions. *American Journal of Psychology, 91*, 659–671.

Gorman, A. D., Abernethy, B., & Farrow, D. (2011). Investigating the anticipatory nature of pattern perception in sport. *Memory & Cognition, 39,* 894–901.

Gorman, A. D., Abernethy, B., & Farrow, D. (2012). Classical pattern recall tests and the prospective nature of expert performance. *The Quarterly Journal of Experimental Psychology, 65*, 1151–1160.

Gorman, A. D., Abernethy, B., & Farrow, D. (2013a). The expert advantage in dynamic pattern recall persists across both attended and unattended display elements. *Attention, Perception, & Psychophysics, 75*, 835–844.

Gorman, A. D., Abernethy, B., & Farrow, D. (2013b). Is the relationship between pattern recall and decision-making influenced by anticipatory recall? *The Quarterly Journal of Experimental Psychology, 66*, 2219–2236.

Gorman, A. D., Abernethy, B., & Farrow, D. (2015). Evidence of different underlying processes in pattern recall and decision-making. *The Quarterly Journal of Experimental Psychology, 68,* 1813–1831.

Green, T. D., & Flowers, J. H. (1991). Implicit versus explicit learning processes in a probabilistic, continuous fine-motor catching task. *Journal of Motor Behavior, 23*, 293–300.

Hayes, A., & Freyd, J. J. (1995). *Attention and representational momentum.* Paper presented at the 36th Annual Meeting of the Psychonomic Society, Los Angeles, CA.

Hayes, A. E., & Freyd, J. J. (2002). Representational momentum when attention is divided. *Visual Cognition, 9*, 8–27.

Hubbard, T. L. (2005). Representational momentum and related displacements: A review of the findings. *Psychonomic Bulletin & Review, 12*, 822–851.

Hubbard, T. L. (2006). Bridging the gap: Possible roles and contributions of representational momentum. *Psicológica, 27*, 1–34.

Hubbard, T. L. (2010). Approaches to representational momentum: Theories and models. In R. Nijhawan & B. Khurana (Eds.), *Space and time in perception and action* (pp. 338–365). Cambridge, UK: Cambridge University Press.

Hubbard, T. L. (2014). Forms of momentum across space: Representational, operational, and attentional. *Psychonomic Bulletin & Review, 21*, 1371–1403.

Hubbard, T. L., Kumar, A. M., & Carp, C. L. (2009). Effects of spatial cueing on representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*, 666–677.

Joordens, S., Spalek, T. M., Razmy, S., & van Duijn, M. (2004). A Clockwork Orange: Compensation opposing momentum in memory for location. *Memory & Cognition, 32*, 39–50.

Kelly, M. H., & Freyd, J. J. (1987). Explorations of representational momentum. *Cognitive Psychology, 19*, 369–401.

Kerzel, D. (2003). Attention maintains mental extrapolation of target position: Irrelevant distractors eliminate forward displacement after implied motion. *Cognition, 88*, 109–131.

Kerzel, D. (2004). Attentional load modulates mislocalization of moving stimuli, but does not eliminate the error. *Psychonomic Bulletin & Review, 11*, 848–853.

Kerzel, D., & Gegenfurtner, K. R. (2003). Neuronal processing delays are compensated in the sensorimotor branch of the visual system. *Current Biology, 13*, 1975–1978.

Kerzel, D., Jordan, J. S., & Müsseler, J. (2001). The role of perception in the mislocalization of the final position of a moving target. *Journal of Experimental Psychology: Human Perception and Performance, 27*, 829–840.

Lane, D. M., & Robertson, L. (1979). The generality of the levels of processing hypothesis: An application for memory to chess positions. *Memory & Cognition, 7*, 253–256.

Memmert, D. (2006). The effects of eye movements, age, and expertise on inattentional blindness. *Consciousness and Cognition, 15*, 620–627.

Memmert, D., & Furley, P. (2007). "I spy with my little eye!": Breadth of attention, inattentional blindness, and tactical decision making in team sports. *Journal of Sport & Exercise Psychology, 29*, 365–381.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81–97.

Moore, B. J., & White, J. O. (1980). *Basketball: Theory and practice.* Dubuque, IA: William C. Brown.

Munger, M., & Owens, T. R. (2004). Representational momentum and the flash-lag effect. *Visual Cognition, 11*, 81–103.

North, J. S., & Williams, (2008). Identifying the critical time period for information extraction when recognizing sequences of play. *Research Quarterly for Exercise and Sport, 79*, 268–273.

North, J. S., Williams, Hodges, N., Ward, P., & Ericsson, K. A. (2009). Perceiving patterns in dynamic action sequences: Investigating the processes underpinning stimulus recognition and anticipation skill. *Applied Cognitive Psychology, 23*, 878–894.

Panchuk, D., & Vickers, J. N. (2009). Using spatial occlusion to explore the control strategies used in rapid interceptive actions: Predictive or prospective control? *Journal of Sports Sciences, 27*, 1249–1260.

Prinzmetal, W., Amiri, H., Allen, K., & Edwards, T. (1998). Phenomenology of attention: 1. Color, location, orientation, and spatial frequency. *Journal of Experimental Psychology: Human Perception and Performance, 24*, 261–282.

Reed, C. L., & Vinson, N. G. (1996). Conceptual effects on representational momentum. *Journal of Experimental Psychology: Human Perception and Performance, 22*, 839–850.

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 clearer picture. *Journal of Experimental Psychology: Human Perception and Performance, 41*, 167–185.

Ryu, D., Abernethy, B., Mann, D. L., Poolton, J. M., & Gorman, A. D. (2013). The role of central and peripheral vision in expert decision making. *Perception, 42*, 591–607.

Starkes, J., Allard, F., Lindley, S., & O'Reilly, K. (1994). Abilities and skill in basketball. *International Journal of Sport Psychology, 25*, 249–265.

Thornton, I. M., & Fernandez-Duque, D. (2000). An implicit measure of undetected change. *Spatial Vision, 14*, 21–44.

Thornton, I. M., & Hayes, A. E. (2004). Anticipating action in complex scenes. *Visual Cognition, 11*, 341–370.

Vaeyens, R., Lenoir, Williams, Mazyn, L., & Philippaerts, R. M. (2007). The effects of task constraints on search behaviour and decision-making skill in youth soccer players. *Journal of Sport & Exercise Psychology, 29*, 147–169.

Vinson, N. G., & Reed, C. L. (2002). Sources of object-specific effects in representational momentum. *Visual Cognition, 9*, 41–65.

Weber, N., & Brewer, N. (2003). Expert memory: The interaction of stimulus structure, attention, and expertise. *Applied Cognitive Psychology, 17*, 295–308.

Williams, & Davids, K. (1998). Visual search strategy, selective attention, and expertise in soccer. *Research Quarterly for Exercise and Sport, 69*, 111–128.

Williams, Davids, K., Burwitz, L., & Williams, J. G. (1994). Visual search strategies in experienced and inexperienced soccer players. *Research Quarterly for Exercise and Sport, 65*, 127-135.

Williams, Hodges, N. J., North, J. S., & Barton, G. (2006). Perceiving patterns of play in dynamic sport tasks: Investigating the essential information underlying skilled performance. *Perception, 35*, 317–332.

Williams, & Davids, K. (1995). Declarative knowledge in sport: A by-product of experience or a characteristic of expertise? *Journal of Sport and Exercise Psychology, 17*, 259–275.

Williams, Davids, K., Burwitz, L., & Williams, J. (1993). Cognitive knowledge and soccer performance. *Perceptual and Motor Skills, 76*, 579–593.

Wooden, J. R. (1988). *Practical modern basketball* (3rd ed.). New York, NY: Macmillan.