Effects of anxiety on anticipation and visual search in dynamic, time-constrained situations

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Abstract

We tested the predictions of Attentional Control Theory (ACT) by examining how anxiety affects visual search strategies, performance efficiency and performance effectiveness using a dynamic, temporal-constrained anticipation task. Higher and lower skilled players viewed soccer situations under two task constraints (near vs. far situation) and were tested under high (HA) and low (LA) anxiety conditions. Response accuracy (effectiveness) and response time, perceived mental effort and eye-movements (all efficiency) were recorded. A significant increase in anxiety was evidenced by higher state anxiety ratings on the MRF-L scale. Increased anxiety led to decreased performance efficiency since response times and mental effort increased for both skill groups while response accuracy did not differ. Anxiety affected search strategies with higher skilled players showing a decrease in number of fixation locations for far situations under HA compared with LA condition when compared with lower skilled players. Findings provide support for ACT with anxiety impairing processing efficiency and, potentially, top-down attentional control across different task constraints.

Keywords: expert performance; soccer; attentional control; perceptual-cognitive skills.

Effects of anxiety on anticipation and visual search in dynamic, time-constrained situations

Negative emotions such as anxiety can affect cognitive and motor performance (Causer, Holmes, Hodges, & Williams, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007). Cognitive anxiety (or worry) induces negative expectations and concerns about potential consequences (Woodman & Hardy, 2001). Processing Efficiency Theory (PET; Eysenck & Calvo, 1992) interprets anxiety as an aversive emotional state that occurs as a result of threat. Eysenck and Calvo (1992) found that athlete's attention diverts away from primary task processing towards irrelevant or distracting stimuli. First, from a PET perspective, anxiety induces worrisome thoughts that threaten a goal, pre-empting storage in working memory leading to a decreased availability of processing resources for the primary task (Wilson, 2008). As a result of increased anxiety, the task situation becomes a dual task, with worrisome thoughts competing for attention (Wilson, 2008). Second, it is assumed that, to minimize anxiety, motivation will be increased to maintain the quality of task performance or *effectiveness* (i.e., response accuracy; Derakshan, Ansari, Hansard, Shoker & Eysenck, 2009). Increased effort leads to a loss of *efficiency* because more resources are invested to maintain the same quality of performance. Overall, it has been shown that effectiveness is less impaired than processing efficiency (Eysenck & Derakshan, 2011).

The Attentional Control Theory (ACT; Eysenck et al., 2007) was developed from PET and characterizes anxiety effects on performance more precisely, emphasizing the importance of attention by determining control in a goal-driven (top-down) and a stimulus driven (bottom-up) fashion. ACT relates to the two attentional systems identified by Corbetta and Shulmann (2002) as the explanatory basis which often interact in their functioning. The theory assumes that increased anxiety disrupts the balance between the two attentional systems and leads to increased influences of the stimulus-driven attentional system at the expense of the goal-directed attentional system. Anxious individuals have been found to attend to threat-related stimuli (Eysenck et al., 2007) showing that attention will first be allocated to detect the threat and then to identify a strategy on how to respond, leading to longer response times for the task at hand (Janelle, Singer, & Williams, 1999). As threat-related stimuli are processed first, the inhibition function of the goal-directed attentional system (usually guided by expectations, knowledge, and current goals of the anxious person) is less able to inhibit task unrelated stimuli (Eysenck et al., 2007). Moreover, the shifting function which alters attention between multiple tasks/operations (Derakshan et al., 2009; Eysenck et al., 2007) and allocates attention to task-relevant stimuli is impaired by anxiety (Wilson, 2008). Anxiety leads to alterations in attentional processing with shifts occurring in attentional orientation and gaze behavior while the efficiency of orientation (e.g., search rate) is reduced (Janelle, 2002).

In applied settings, researchers have begun to show that anxiety affects perceptual-cognitive abilities (Causer et al., 2011; Murray & Janelle, 2003; Williams, Vickers, & Rodrigues, 2002). In some of these studies, behavioral measures including the recording of gaze behaviors have identified higher search rates (Murray & Janelle, 2003; Williams et al., 2002) or an inefficient use of the fovea (Williams & Elliot, 1999) with increasing levels of anxiety. Williams et al. (2002) examined performance under anxiety in table tennis players by using high and low working memory tasks where shot strategy either varied from trial to trial (high demands) or could be held constant for a couple of trials (low demands). Longer visual tracking of the ball was reported under the high compared with the low anxiety condition. Since experts usually exhibit anticipatory saccades (e.g., towards the expected ball bounce point) monitoring ball flight with peripheral and not foveal vision, the ability to process information with peripheral vision seems to be impaired with anxiety resulting in less efficient visual search (Williams & Elliot, 1999; Williams et al., 2002). Wilson, Wood, and Vine (2009b) tested PET in penalty takers while exploring their visual search behaviors under HA and LA conditions. The speed of fixating the goalkeeper and the absolute fixation duration on this location increased in the HA condition. The authors argue that a higher reliance on top-down strategies would be beneficial to prevent decrements in performance efficiency. Similarly, Causer et al. (2011) tested shot gun shooters in a filed setting under HA and LA conditions and observed significantly higher mental effort ratings under the more aversive anxiety condition (cf., Wilson, Smith, & Holmes, 2007). In their study, besides efficiency reductions in the HA condition, performance effectiveness declined as well as showing that the effects of anxiety on performance increases when overall task demands on the central executive function (reflected by perceived effort) become higher. However, shot gun shooting is not very interactive and anticipation of events is less difficult compared to, for example, highly dynamic open-play situations in soccer.

For the examination of anxiety effects in open-play situations, it is important to create experimental tasks and conditions representing situations usually found in the game (Mann, Williams, Ward, & Janelle, 2007). In this regard, defensive players in soccer are typically exposed to open-play situations with two different task constraints: a) situations where the ball is in the other half of the field; and b) more time-constrained situations when the ball is closer to the defender (Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007). In the case of far situations, using a large field of view and being aware of movements of other players, the player in possession of the ball and potential passing opportunities are important considerations for the defender (Helsen & Pauwels, 1993, Williams, Davids, Burwitz, & Williams, 2004). It has been shown that, especially expert players can be described as “skilled scanners” because they show a more extensive visual search strategy compared to less-skilled players (Helsen & Pauwels, 1992, p.381). In contrast, for near situations, soccer defenders have to be aware of fewer information sources converting the previous 11 versus 11 situations into, for example, 3 versus 3 or 1 versus 1 situations (Vaeyens et al., 2007). Under these constraints, experts typically show lower visual search rates and potentially use peripheral vision to a greater extent (Williams & Davids, 1998). In this context, previous research in expert hockey players has shown that visual search strategies differed as a function of playing environments (Martell & Vickers, 2004). The different task constraints in soccer are expected to lead to different perceptual-cognitive strategies including different visual search strategies.

Roca, Ford, McRobert, and Williams (2013), examined how task-constraints influence perceptual-cognitive strategies using video-based simulations involving 11 versus 11 soccer sequences from a central defender's perspective where the ball was either far from the defender in the other half of the pitch or near to the defender. The underlying processes and interactions between various perceptual-cognitive skills (i.e., postural cue usage, pattern recognition, and situational probabilities) were examined across skill groups. Skilled players made more accurate anticipations and decisions than lower skilled players, with these judgments being underpinned by differences in perceptual and cognitive processes that were unique to the constraints of the task. For example, skilled players employed more fixations of shorter duration towards more informative locations in the display (i.e., opponents/teammates and free space) when viewing the far compared with near situations. In addition, the different perceptual-cognitive skills were shown to interact and differ in importance as a function of the task constraint. In the far situations, skilled players generated more thought processes related to the recognition of patterns within evolving sequences of play, whereas in the near situations more statements were made that referred to the postural orientation of teammates/opponents, followed by expectations about the event outcomes.

To effectively use these different perceptual-cognitive skills it is necessary to balance top-down and bottom-up processes in team ball sports since players interact with each other and quick decisions have to be made in regards to which locations deserve attentional priority. As soccer players are typically exposed to significant stressors including both physical fatigue as well as emotions such as anxiety, it could be that these stressors affect the perceptual processes underpinning anticipation. However, there remains a notable lack of empirical research to evaluate whether attentional control in open-play situations is affected by emotions such as anxiety when making appropriate anticipatory judgments. The direct manipulation of task-specific constraints (e.g., position of the ball and players in the field of play) presents, therefore, a valuable vehicle to examine whether anxiety affects the use of different perceptual-cognitive skills across the unique constraints presented by the task.

Combining the empirical evidence about perceptual-cognitive skills in open-play soccer situations and theoretical assumptions made by ACT, we expected that threat-related stimuli are processed first and that the inhibition function of the goal-directed attentional system (with expectations and knowledge) is less able to inhibit task unrelated stimuli (Eysenck et al., 2007). As there is no direct opponent in laboratory settings, these threat-related stimuli are most likely worrisome thoughts that compete for attention and need to be inhibited. Most relevant in open-play situations, especially in situations including a high number of players (e.g., 11 vs 11), is the shifting function to allocate attention to task-relevant stimuli. From an ACT perspective, this function should be impaired by anxiety. As it has previously been reported that an efficient visual search behavior in far situations is characterized by *high* search rates, anxiety could impair the ability to shift attention between locations. Thus, rather than increased search rates, anxiety could lead to attentional narrowing with lower search rates and longer fixation durations. In this case, longer fixations would make it harder to scan all areas of interest and, as a consequence, players could miss important information which could affect successful decision making and lead to longer response times. As these extensive visual search behaviors and the underlying cognitive abilities (especially pattern recognition) are likely to be expertise-dependent, it seems important to evaluate whether anxiety effects interact with skill level.

Consequently, in this paper, a novel attempt is made to examine whether anxiety differentially impacts on the use of visual search strategies and different perceptual-cognitive skills underpinning anticipation across different task constraints. We explore the efficacy of ACT using a dynamic time-constrained soccer task with different perceptual task demands including near and far situations, as per Roca et al. (2013) by introducing a low and a high anxiety condition. First, we hypothesize classical expertise-driven differences with high skilled players showing higher response accuracies and lower response times than the lower skilled players. Second, replicating the findings of Roca et al. (2013), we predict that the higher skilled group will show higher search rates in the far situations compared with near situations, fixate on less locations in the near compared with far situations and differ in the proportion of viewing time spent fixating different locations between the near and the far situations. If these replications are successful, we can test the effects of anxiety on performance efficiency and effectiveness based on ACT. Therefore, we predict longer processing times and higher mental effort in the HA condition for both groups, and no effects of anxiety on performance effectiveness (i.e., response accuracy) in the HA condition. Since experts are characterized by an analytical visual search behavior in complex situations, a decline in processing efficiency could be interpreted when a reduced search rate is observed in the far situations. Since near and far situations seem to require different perceptual-cognitive skills, we may find different anxiety effects between the two task constraints.

Method

Participants

Twenty-two male soccer players participated. Participants were assigned to the higher skilled or lower skilled group based on their playing experience. The higher skilled players (n = 11; *M* age = 18.55 years, *SD* = 2.8) were either recruited from the academy of a Premier League club in England (n = 8) or were undergraduate students with playing experience at county level or above (n = 3). Higher skilled players had been competing for an average of 4.9 years on their highest playing level which ranged from county level (n=3) or national level (n=4) to international level (n=4). Their mean number of years of soccer experience was 7.18. Players in the lower skilled group (n = 11; *M* age = 22.91 years, *SD* = 4.51) had been playing soccer either at recreational (n=4) or amateur level (n=7) for an average of 5.9 years. Their mean number of years of soccer experience was 6.18. All players had playing experience as a defender. All players reported normal or corrected to normal vision. The study was conducted in accordance with the ethical guidelines of the lead university.

Measures

The Mental Readiness Form-Likert (MRF-L). The cognitive anxiety scale of the MRF-L (Krane, 1994) was used to assess state anxiety. The one-dimensional scale (1 - 11) was displayed on the screen after every fifth trial while participants had to rate their cognitive anxiety by saying the number that matched their current thoughts ranging from calm (1) to worried (11). The scale was validated by Krane (1994) and revealed intercorrelations for the cognitive anxiety item between the MRF-L and the CSAI-2 (Martens, Burton, Vealey, Bump, & Smith, 1990) of 0.58.

The Rating Scale for Mental Effort (RSME). Mental effort (RSME, Zijlstra, 1993), which can be defined as the amount of processing resources invested in the task (Williams et al., 2002), was assessed to compare invested effort in both anxiety conditions and across tasks. It is a one-dimensional scale which requires participants to estimate the effort invested in the task. The scale ranges from 0 to 150 with three verbal anchors corresponding to 0 (not at all effortful), 75 (moderately effortful), and 150 (very effortful). The scale (0.88) provides a valid and reliable measure of mental effort (Veltman & Gaillard, 1996). The scale was displayed after participant's anticipatory response to each trial and participant's had to say how much effort they invested in the previous task by saying a corresponding number.

Response Accuracy. Response accuracy was defined as whether or not the participant correctly selected the next action of the player in possession of the ball at the moment of video occlusion, such as he passed to a player X…, shot at goal, or continued dribbling forward (Roca et al., 2011).

Response Time. Response time was defined as the time (in ms) between the point of video occlusion and the onset of the verbal response (e.g. "pass to ...", "shot…", or "dribble…"). The verbal response was recorded with the integrated microphone of the eye-tracker. The number of frames between both events was multiplied by the duration of one frame.

Visual Search Behaviors. Visual point-of-gaze was recorded using a mobile eye-tracking system (Applied Science Laboratories, Bedford, MA, USA). The eye-tracker consists of a video based monocular system that measures eye point-of-gaze with respect to a head-mounted scene camera. The system measures the relative position of the pupil and corneal reflection in relation to each other by using an infrared light source at a frame rate of 30 Hz. Moreover, a scene image is provided by the head-mounted camera. Both sources are automatically linked and result in a computed point-of-gaze superimposed as a cursor onto the scene image. The accuracy of the system is specified with ±1° visual angle, with a precision of 1° in both horizontal and vertical direction. Before the start of every condition, a five-point calibration grid was projected onto the screen and was used to adjust the eye-tracker.

A fixation was defined as the time (≥ 100ms) the eye remained stationary within 1.5° of movement tolerance (Ward, Williams, & Bennett, 2002). A new fixation location was counted every time the point of fixation switched to another a priori defined location (i.e., player in possession [PiP], ball, opponent, teammate, free space; see also Roca et al., 2011, 2013). The mean number of fixations per trial, mean fixation duration (in ms), and the mean number of fixation locations per trial were assessed. Furthermore, percentage viewing time which referred to the total viewing time spent fixating upon each area of the display (Ward et al., 2002) was also analyzed.

Test film

The test videos of 11 versus 11 defensive soccer situations were filmed from the first-person perspective of a central defender using professional and semi-professional soccer players. These stimuli were evaluated by three Union of European Football Associations (UEFA) qualified soccer coaches and a number of these clips have been used in previous published reports (for further details on the production of the video clips, see Roca et al. 2011, 2013). Each clip lasted about 5s and was occluded 120ms prior to the final action taken by the player in possession of the ball. This action could be an attacking pass, a shot on goal or the continuation of a dribble. The test film included a total of 24 offensive scenarios. An additional five clips were included as practice trials for both conditions. The 24 test trials were subdivided into equal numbers of far and near situations. The trial was counted as a far situation if the scene ended in the opponents defensive half (i.e., far away from the perspective of the defender), whereas when a trial ended in the opponents offensive half (i.e., near to the defender) the trial was identified as a near task. The order of far and near situations was randomized beforehand and kept constant across participants. An additional randomization of all clips was executed for the second condition. Those clips remained constant across participants.

Procedure

Participants were informed in written form and signed the agreement to take part in the study. After adjusting and calibrating the eye-tracking system, participants viewed each of the action sequences in a standing position at a distance of 2.80 m from a large screen (2.90 x 1.30 m), subtending a visual field of 27°(h) x 13°(v). Participants viewed five practice trials to familiarize themselves with the task procedure which required them to respond quickly and accurately after the video occlusion by deciding on the next action of the player in possession of the ball. They were instructed to say “pass to a player X…, “shot” or “dribble”. Participants were required to rate mental effort after every trial. After every fifth trial, participants had to rate state anxiety using the Mental Readiness Form-Likert (MRF-L; Krane, 1994). The quality of eye-tracker calibration was checked in advance of every trial by comparing the superimposed gaze position with the position of the red dot indicating the position of the ball at the start of each scene.

Conditions

A repeated-measures design was employed whereby each participant had to perform under two counterbalanced conditions: a low (state) and a high (state) anxiety condition. In the low anxiety condition (LA), participants were asked to anticipate the next action of the player in possession quickly and accurately. To further increase the non-evaluative nature of the task, the investigators told participants that their results would not be compared to others. Feedback was not provided during or after the LA condition (see Williams et al., 2002).

In the high anxiety condition (HA), a competitive scenario was created by telling participants that their results would be compared to other players. Moreover, it was mentioned that results would be evaluated by the coach (cf., Causer et al., 2011; Williams & Elliot, 1999; Wilson, Vine, & Wood, 2009a; Wilson et al., 2009b). To further increase anxiety, *ego-threats* were induced by making players aware of the eye-tracking camera and the HD video camera and emphasizing the importance of their results on the success of the study (see also Williams & Elliot, 1999; Wilson et al., 2007). Furthermore, two types of *false feedback* were used to increase anxiety. A high pitched auditory signal (frequency: 797 Hz; musical note: G5; duration: 1.5 s), played with a stereo audio system with both speakers behind the participant, together with a displayed green tick, indicated a correct response and a low pitched auditory signal (frequency: 71 Hz; musical note: D2; duration: 1.5 s), together with a displayed red "X", indicated a wrong response. The decision for auditory signals is based on results of Collier and Hubbard (2001) who found that high pitched tones are associated with happiness and low pitch tones with unhappiness. The false feedback was provided after the rating mental effort, so that mental effort was not based on the feedback, but on the displayed soccer situation. The tone itself should then induce worrying thoughts affecting the next situation, which started immediately after the tone. In the high anxiety condition, the pattern of correct and wrong answers was kept constant for all participants. During the 24 trials, the 12 most difficult trials were always followed by a low pitched signal. Players were told beforehand that their results would be compared to those of other players. After every fifth trial, a distribution was shown to the players indicating that their results were below average (second type of false feedback, similarly used in Wilson et al., 2009a, b). The difference between achieved results and the displayed average results was progressively increased. After completing the second condition of the study, participants were debriefed about the deception and the aim of the study was explained to them in detail.

Data Analysis

Eye-tracking data were analyzed using 'ASL-results plus Gaze Map'. The software automatically identified point-of-gaze with x- and y-coordinates and calculates the number of fixations as well as the fixation duration (by identifying fixation onset and offset for each fixation) for every trial. The aggregated data were then exported into a csv-file for each participant and anxiety condition. The location of each detected fixation was assigned based on fixation onset and offset values, using the automatically computed point-of-gaze in the scene image in the Gazetracker software. All dependent variables were averaged for every participant, anxiety condition and task constraints separately. Statistical analyses were conducted with IBM SPSS Statistics 22. Two participants (one from each group) were excluded from analysis of the visual search behavior due to a loss of point of fixation in the HA condition in over 25% of the trials. In contrast to Roca et al. (2011, 2013), the visual search behavior of all successfully recorded trials was examined for each of the 10 participants per group. Overall, less than 2% of the trials could not be analyzed in regards to fixation location because the point of fixation could not be displayed.

Response accuracy, response time, and mental effort were statistically analyzed using an anxiety condition (low/high) x task constraint (near/far) repeated measures ANOVA with expertise as the between-group factor (higher-skilled/lower skilled). In regard to the variable percentage viewing time, an additional fourth factor (fixation location) was included (ANOVA: anxiety condition x task constraint x fixation location x group). Significant interactions were evaluated using Bonferroni-corrected post-hoc tests. The effect sizes were calculated using partial eta squared values (η_p^2). A significance level was set at $p < .05$ (*) for all statistical analyses. High significance will be reported if $p < .01$ (**). As large effect sizes ($f = 0.4$) were expected (based on Roca et al., 2013) and α was set to .05 ($\beta = .10$) A priori calculations of optimal sample sizes (G*Power 3; see Faul, Erdfelder, Lang, & Buchner, 2009) indicated that a sample of 20 participants provided sufficient power.

Results

Anxiety Manipulation

A main effect for anxiety was observed, $F(1,20) = 13.13$, , $p < .01$, $\eta_p^2 = .40$. Players reported higher cognitive state anxiety in the HA ($M = 4.49$, $SD = 1.31$) compared to the LA condition ($M = 3.17$, $SD = .87$). There was no group main effect, $F(1,20) = 1.98$, $p < .01$, $\eta_p^2 = .09$, and no interaction between group and anxiety, $F(1,20) = 0.0$, $p = .98$, $\eta_p^2 = .00$. The time course of mean anxiety ratings per group is illustrated in Figure 1.

Insert Figure 1 about here

Response Accuracy

A significant main effect was observed for group, $F(1,20) = 23.93$, $p < .01$, $\eta_p^2 = .55$. The higher skilled group recorded higher accuracy scores ($M = 70.46\%$, $SD = 9.91$) than the lower skilled group ($M = 49.77\%$, $SD = 9.91$). There was no main effect for anxiety, $F(1,20) = 0.06$, $p = .81$, $\eta_p^2 = .00$, and no main effect for task constraint, $F(1,20) = 0.06$, $p = .81$, $\eta_p^2 = .00$. None of the interactions reached significance (all $p > .29$). The average response accuracies are presented in Table 1.

Response Time

The ANOVA indicated significant main effects for anxiety, $F(1,20) = 9.29$, $\eta_p^2 = .31$, $p < .01$, task constraint, $F(1,20) = 31.30$, $p < .01$, $\eta_p^2 = .61$, and group, $F(1,20) = 11.32$, , $p < .01$, $\eta_p^2 = .36$. Participants took longer time to respond under HA compared with LA conditions. Moreover, participants took longer to respond in the far situations compared with the near situations. Furthermore, the main effect for group shows that higher skilled players responded earlier than the lower skilled players. A Task Constraint x Group interaction was observed, $F(1,20) = 12.05$, $\eta_p^2 = .38$, $p < .01$.The lower skilled group responded later for the far situations compared with near situations ($p < .01$), while the higher skilled group did not show significant differences in response time between the two task constraints ($p = .15$). All other interactions were not significant (all $p > .20$). The average response times are presented in Table 1.

The Rating Scale of Mental Effort (RSME)

The ANOVA revealed a significant main effect for anxiety, $F(1,20) = 13.77$, $p < .01$, $\eta_p^2 = .41$, task constraint, $F(1,20) = 8.17$, $p < .05$, $\eta_p^2 = .29$, and group, $F(1,20) = 6.55$, , $p < .05$, $\eta_p^2 = .25$. Participants reported higher mental effort scores in the HA compared with the LA condition and rated effort to be higher for far situations in comparison with near situations. The higher skilled group reported lower mental effort than the lower skilled group. A significant interaction for Anxiety x Task Constraint was observed, $F(1,20) = 7.33$, $p < .05$, $\eta_p^2 = .27$. During the LA condition, players showed greater mental effort ratings for the far situations as compared with near situations ($p < .01$), while mental effort increased in the HA condition for the far and near situations without significant differences between the two task constraints ($p = .29$). No other significant interaction could be observed (all $p > .14$). The average RSME ratings are presented in Table 1.

Insert Table 1 about here

Visual Search Behaviours

Visual search rate. The ANOVA showed a significant main effect in mean number of fixations per trial for task constraint, $F(1,18) = 33.22$, $p < .01$, $\eta_p^2 = .65$,. Players employed fewer fixations in the near ($M = 10.33$, $SD = 0.87$) compared with the far situations ($M = 11.40$, $SD = 1.02$, $p < .01$). No effects were found for mean fixation duration (all $p > .18$). ANOVA for the mean number of fixation locations revealed significant main effects for anxiety, $F(1,18) = 9.25$, $p < .01$, $\eta_p^2 = .34$; task constraint, $F(1,18) = 14.42$, $p < .01$, $\eta_p^2 = .45$, and group, $F(1,18) = 10.40$, , $p < .01$, $\eta_p^2 = .37$. The anxiety main effect shows that participants fixated fewer locations in the HA (*M* = 6.21, *SD* = 0.93) compared with the LA condition (*M* = 6.93, *SD* = 0.79), while the task constraint main effect indicated more fixated locations in the far (*M* = 11.40, *SD* = 1.02) compared with the near situations (*M* = 10.33, *SD* = 0.87). The main effect for group showed that lower skilled players fixated fewer locations (*M* = 5.78, *SD* = 1.10) than the higher skilled players (*M* = 7.36, *SD* = 1.10). Significant two-way interactions were found for Task Constraint x Group, $F(1,18) = 8.38$, $p < .05$, $\eta_p^2 = .32$, and Anxiety x Task Constraint, $F(1,18) = 21.08$, $p < .01$, $\eta_p^2 = .54$. The first interaction indicates that higher skilled players fixated more locations in the far situations (*M* = 8.00, *SD* = 1.00) compared with lower skilled players (*M* = 5.87, *SD* = 1.10). The latter two-way interaction shows that the number of fixated locations in the HA condition was higher in the far situation (*M* = 7.67, *SD* = 0.74) compared with the near situation (*M* = 6.19, *SD* = 0.92, $p < .01$) but no differences between task constraints in the LA condition ($p = .97$). However, the reported main and interaction effects were superseded by a significant three-way interaction for Anxiety x Task Constraint x Group, $F(1,18) = 7.37$, $p < .05$, $\eta_p^2 = .29$. Higher skilled players fixated fewer locations in the far situations under the HA condition (*M* = 6.69, *SD* = 1.29) compared with LA condition (*M* = 9.16, *SD* = 1.05; $p < .01$), whereas the lower skilled players did not show this effect (LA_far: *M* = 6.16, *SD* = 1.05 vs. HA_far: *M* = 5.57, *SD* = 1.52, $p = .19$). For the near situations neither the higher skilled ($p = .99$) nor the lower skilled players ($p = .95$) differed between HA and LA condition in terms of the number of fixated locations. These data are presented in Figure 2.

Insert Figure 2 about here

Percentage of viewing time. ANOVA revealed a significant main effect for fixation location, $F(1,18) = 366.88$, $p < .01$, $\eta_p^2 = .95$. Participants spent significantly more time fixating on the player in possession of the ball (*M* = 51.09%, *SD* = 4.40) in comparison to any other location. This effect was followed by viewing time being spent on the ball (*M* = 21.66%, *SD* = 3.69) and opponents (*M* = 17.10%, *SD* = 3.17), respectively. Less time was spent viewing teammates (*M* = 5.05%, *SD* = 1.00) and free space (*M* = 3.53%, *SD* = 0.67), with these differing significantly from all other viewing locations. There was also a significant Fixation Location x Group interaction effect, $F(1,18) = 18.53$, $p < .01$, $\eta_p^2 = .51$. Post hoc testing showed that the higher skilled group spent more time fixating on the opponents (*M* = 21.70%, *SD* = 4.48), teammates (*M* = 6.30%, *SD* = 1.41), and free space (*M* = 4.50 %, *SD* = 0.95) compared to their lower skilled counterparts (*M* = 12.50 %, *SD* = 4.48; *M* = 3.78 %, *SD* = 1.41 and *M* = 2.55%, *SD* = 0.95, respectively; all $p < .01$). In contrast, lower skilled players spent a higher proportion of time fixating on the ball (*M* = 28.78%, *SD* = 5.22) compared with skilled players (*M* = 14.55%, *SD* = 5.22, $p < .01$).

A significant Fixation Location x Task Constraint interaction was observed, $F(1,18) = 35.05$, $p < .01$, $\eta_p^2 = .66$. The ball was fixated more in the near (*M* = 27.13%, *SD* = 4.34) compared to the far situations (*M* = 16.20%, *SD* = 3.65), while in the far situations the locations of opponents (*M* = 19.25%, *SD* = 3.32), teammates (*M* = 6.65%, *SD* = 1.63), and free space (*M* = 5.13, *SD* = 1.31) were viewed for longer than in the near situations (*M* = 14.95%, *SD* = 3.67; *M* = 3.45%, *SD* = 1.03 and *M* = 1.93%, *SD* = 0.94; all $p < .01$), respectively. Moreover, the three-way interaction Fixation Location x Task Constraint x Group was significant, $F(1,18) = 13.27$, $p < .01$, $\eta_p^2 = .78$. The higher skilled group showed significant differences for all viewing areas between the two task constraints (all p < .01), while the lower skilled group only showed significant differences for time spent viewing the player in possession of the ball ($p = .01$) and ball ($p < .01$). All other main or interaction effects failed to reach significance (all $p > .07$). The mean data for percentage viewing time are presented in Figure 3.

Insert Figure 3 about here

Discussion

We tested the predictions of ACT and examined the effects of anxiety on processing efficiency and effectiveness using multiple dependent-measures and realistic simulations of dynamic, time-constrained anticipation situations. It was assumed, based on ACT, that performance efficiency would decrease in the HA condition (i.e., higher response times and mental effort ratings) while performance effectiveness (i.e., response accuracy) would not differ between the anxiety conditions. A particularly novel aspect of this study was the manipulation of different task constraints (i.e., near vs. far situations). We hypothesized that anxiety would differentially impact on the perceptual-cognitive skills underpinning anticipation and that these effects could vary across different task constraints. Our prediction was based on previous published reports where differences in visual search behaviors have been reported across these two task constraints (see Roca et al., 2013; Vaeyens et al., 2007). Additionally, we expected to find expertise-based differences including faster response times and higher response accuracies for the higher skilled when compared with the lower skilled players (Mann et al., 2007; Roca et al., 2011, 2013).

Anxiety was successfully increased with a combination of manipulations (i.e., ego threats, competitive environment, and false feedback) leading to higher ratings of anxiety across conditions. Moreover, the inclusion of false feedback had a particularly pronounced effect on anxiety levels. The MRF-L ratings (Figure 1) suggest that anxiety increased when participants dropped behind illustrated average results (i.e., performance accuracies) of players tested in former studies (false feedback manipulation). The absolute anxiety ratings are low, but comparable with those reported by Cocks, Jackson, Bishop, and Williams (2015) and Wilson et al. (2007), especially, in case of the Wilson study, for their low trait-anxious individuals. It could be the case that participants in our study showed higher levels of state anxiety but are more likely to have lower trait anxiety. Although other studies have used the same anxiety-inducing manipulations, there is clearly a difference to environments normally experienced in the game (e.g., crowd, other players, different kinds of time pressure) which would be hard to recreate under controlled laboratory settings.

The predictions of ACT are confirmed since performance accuracy (effectiveness) did not differ between HA and LA conditions across participants while response times and mental effort increased for the HA condition indicating a decrease in processing efficiency. Findings for the effect of anxiety on mental effort support previous work (e.g., Causer et al., 2011; Wilson et al., 2009a, b) and provide further evidence to highlight the moderating role of effort under HA conditions (Wilson, Smith, Chattington, Ford, & Marple-Horvat, 2006). The effort compensating process seems to be necessary to prevent performance dropping below a certain level (Zijlstra, 1993), while increasing motivation to cope with the task (Wilson et al., 2009b). Just as in other sporting domains (Causer et al., 2011; Murray & Janelle, 2003) performance accuracy did not differ between anxiety conditions emphasizing the role of mental effort in dynamic, temporally-constrained anticipation tasks. Since anxiety leads to an allocation of attention to threat-related stimuli (Eysenck et al., 2007), the response times show that it takes participants longer to identify a strategy on how to respond to the task at hand. Skill-based differences for response time and mental effort were observed with lower skilled players reporting longer response times and higher mental effort ratings than the higher skilled group. These results could be explained by the higher skilled players more refined domain-specific perceptual and cognitive skills (Mann et al., 2007; Ward & Williams, 2003).

The visual search behaviors differed between the two groups as a function of task constraints and levels of anxiety. As expected, higher skilled players employed a greater number of fixations towards more informative locations (i.e., opponents/teammates and free space) when viewing the far compared to the near task condition (Roca et al., 2013). The higher search rates seem to be beneficial in 11 versus 11 situations (Helsen & Pauwels, 1992; Roca et al., 2011, 2013; Williams et al., 1994), especially when the ball is far away from the defender (Roca et al., 2013). It has been assumed by Williams (2000) that in complex defensive situations with less time pressure on defenders there might be time to use a more extensive visual search to analyze the displayed situation. This more exhaustive strategy allows players to be aware of a number of sources of information (e.g., location of ball, own position, and/or movements of attacking players and teammates) and, potentially, facilitates pattern recognition (Roca et al., 2013).

In regards to the effects of anxiety, researchers have reported changes in the efficiency of gaze behaviors with increasing levels of anxiety (Janelle, 2002; Murray & Janelle, 2003; Williams & Elliot, 1999; Williams et al., 2002). In our study, anxiety was observed to affect visual search as a function of the task constraints for the higher skilled group when making anticipation judgments. In the far situations, a high visual search rate and the use of foveal vision would be beneficial since detailed information is required and foveal vision has, compared to peripheral vision, a higher resolution making an analytical search behavior appropriate. The reduced number of fixated locations could, therefore, be interpreted as inefficient use of the fovea under HA conditions (Williams & Elliot, 1999). In particular, higher skilled players showed a significant decrease in number of fixation locations for the far situations under the HA as compared to the LA condition. These findings provide support for previous research (e.g., Williams et al., 2002; Wilson et al., 2009b) in which longer visual fixations on specific locations in the display were found under HA compared with LA conditions. From an ACT perspective, one explanation for fixating fewer locations when anxious could be the difficulty in shifting attention between locations. It could be the case that the shifting function is impaired by worrying thoughts (Derakshan et al., 2009). Besides the impaired shifting function, the inhibition of worrying thoughts could be reduced in the HA condition (Derakshan et al., 2009), leading to a less efficient visual search behaviors during dynamic temporal-constrained situations, resulting in longer response times and higher mental effort. However, as performance effectiveness did not change, the ACT prediction of reduced processing efficiency with constant effectiveness is supported. In the lower skilled group, the data suggest that top-down and bottom-up processes would still be in balance. Since Roca et al. (2013) reported that less skilled players employ less cognitive statements and these memory representations are assumed to guide the visual search behavior (Roca et al., 2011, 2013), it could be the case that lower skilled players generally rely more on the stimulus-driven attentional system, making worrying thoughts less influential and the visual search behavior more robust.

Although we did not directly measure different perceptual-cognitive skills (i.e., postural cue usage, pattern recognition, and situational probabilities) in this study (as per Roca et al., 2013), it could be suggested, based on the results, that anxiety appears to impact upon the use of these skills across different task constraints. Under HA the higher skilled players shifted attentional control from broad (i.e., more fixations and towards more disparate areas of the display) to narrow (i.e., less fixations and mainly towards the player in possession of the ball and the ball itself) in the far situations. Thus, greater levels of anxiety appear to have had a negative effect on higher level cognitive function, particularly in relation to the ability to recognize familiarity and structure in the evolving patterns of play across task constraints. This latter finding is important since the differential effect of anxiety on how the various perceptual-cognitive skills interact has recently been documented in the literature in a study by Cocks et al. (2015). The underlying assumption is that a number of different and/or additional constraints affect how influential different perceptual-cognitive skills are at any given moment when making anticipation judgments.

There are some limitations in the current study that should be acknowledged. First, a larger sample size should be used to reliably examine interaction effects between anxiety, task constraints and expertise. Although expert players are sometimes hard to access, future researchers should try to increase the number of participants to ensure adequate statistical power. Furthermore, perceptual-cognitive skills such as postural cue usage, pattern recognition, and situational probabilities need to be further tested under HA and LA conditions to verify the potential explanations of observed anxiety effects in this study. Moreover, it is advised to first, identify stressors experienced in real game situations for the individual and then manipulate these stressors in controlled laboratory settings to further increase anxiety effects.

In sum, anxiety effects on processing effectiveness and processing efficiency were examined for higher skilled and lower skilled soccer players using complex 11 versus 11 soccer situations with varying (perceptual) task demands in near and far situations. The predictions of ACT were supported for both groups since performance effectiveness did not differ across LA and HA conditions while performance efficiency was decreased for both groups in the HA condition only. The latter finding was apparently based on higher ratings of mental effort and longer response times. The results reveal expertise differences in regard to anxiety effects since the number of fixated locations decreased in the higher skilled group for the far situations. Since experts have superior pattern recognition abilities than less experienced players, it is suggested that attentional processes are particularly impaired by anxiety. Our data provide support for ACT predictions using a novel highly dynamic temporal-constrained task with implications for theory and practice across domains.

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Figure 1

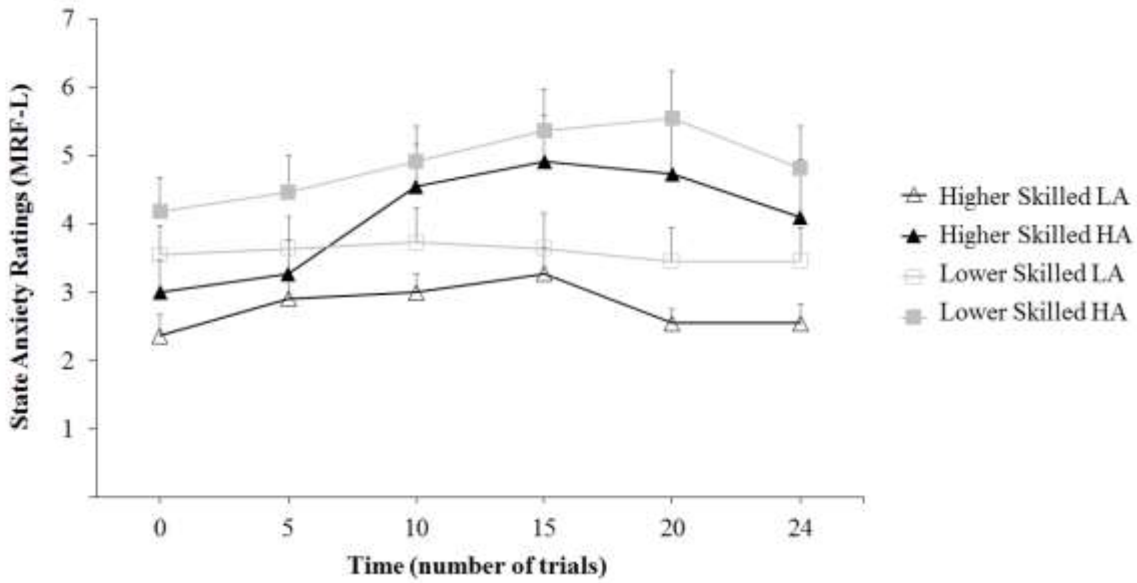

Figure 1. State of anxiety ratings (*M* and *SE*) across test trials per group in low (LA) and high (HA) anxiety conditions.

Figure 2

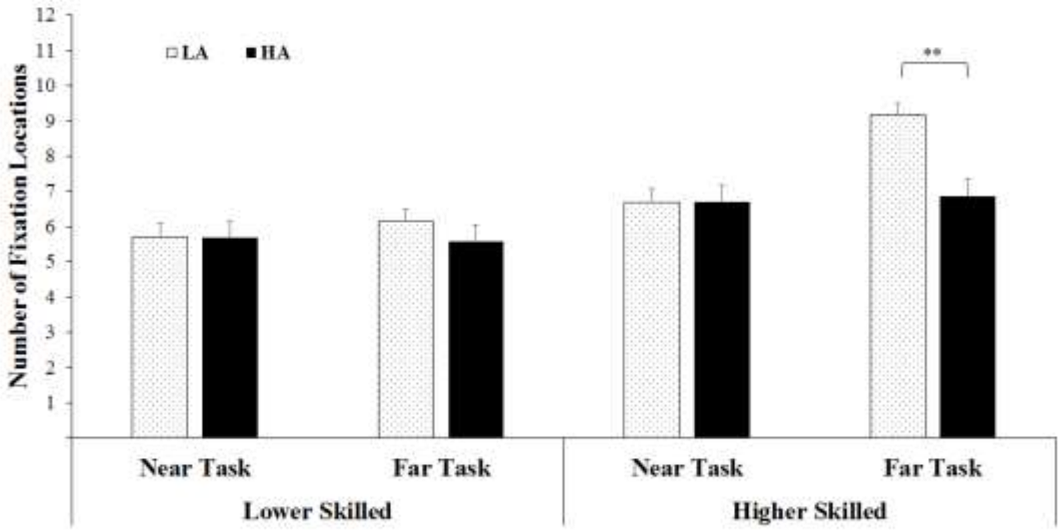

Figure 2. Number of fixation locations (*M* and *SE*) per group and task constraint in low (LA) and high (HA) anxiety conditions. **$p < .01$

Figure 3

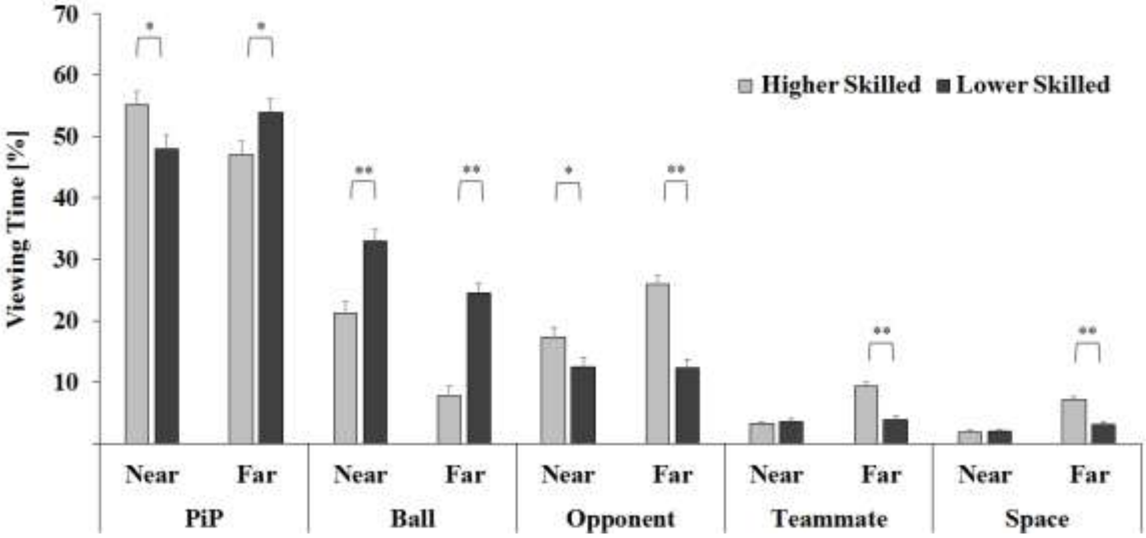

Figure 3. Percentage time (*M* and *SE*) spent viewing each location across task constraint for higher skilled and lower skilled players. (*PiP*, player in possession of the ball) *p < .05, **p < .01

Table 1

Table 1. Group response accuracy, response time and mental effort ratings (*M* and *SE*) across task constraints and anxiety conditions

Group	Anxiety Condition	Task Constraint	Response Accuracy (%)	Response Times (ms)	Mental Effort
Higher Skilled	HA	near	68 (5)	1505 (253)	41 (4)
		far	74 (2)	1602 (236)	40 (4)
	LA	near	69 (5)	1155 (139)	33 (5)
		far	70 (1)	1388 (139)	37 (5)
Lower Skilled	HA	near	50 (3)	2232 (250)	56 (6)
		far	48 (4)	3027 (266)	60 (4)
	LA	near	50 (5)	1858 (230)	49 (6)
		far	49 (5)	2473 (309)	55 (5)