External Distraction and Attentional Narrowing: Visual Search Evidence

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We examined distraction and attentional narrowing in a dual-task auto-racing simulation. Participants were randomly assigned to six groups: distraction control, distraction anxiety, relevant control, relevant anxiety, central control, and central anxiety. Those in central conditions performed a driving task; the other four groups identified peripheral lights in addition to driving. Irrelevant peripheral lights were included in distraction conditions. Participants in anxiety conditions were exposed to increasing levels of anxiety via a time-to-event paradigm. In 3 sessions of 20 trials, measures of cognitive anxiety, arousal, visual search patterns, and performance were recorded. At higher levels of anxiety, the identification of peripheral lights became slower and less accurate, and significant performance decrements occurred in central and peripheral tasks. Furthermore, visual search patterns were more eccentric in the distraction anxiety group. Results suggest that drivers who are highly anxious experience an altered ability to acquire peripheral information at the perceptual level.

Key words: attentional narrowing, distraction, anxiety, visual search patterns, dual-task paradigm

Anyone associated with sport as an athlete, coach, or spectator can remember instances when the pressure of competition transcended the typical commentary that it was “just a game.” Athletes are often required to overcome excessive stressful demands and perform at their highest levels, or they “choke” under the pressure. Even the best athletes occasionally falter in stressful situations, leaving sport psychologists to question why this occurs.

Attending to, selecting, and processing the most critical environmental cues, regardless of situational stressors, is one of the most important skills required for high-level performance in sport (Abermeyth, 1993). In support of this idea, experts consistently exhibit what has been called a “cognitive advantage” over less skilled
participants and are seemingly able to process available information in a more efficient and effective manner than nonexperts (Starkes & Allard, 1993). However, largely ignored have been other relevant factors, particularly emotions, that influence attentional processes and subsequent achievement (Kremer & Scully, 1994; Moran, 1996).

Effective performance in exceptionally stressful environments is related to the impact of arousal and anxiety on the capability to maintain concentration (Moran, 1996). By not studying the interaction of emotions, attention, and performance, the generalizability of research on attention has been somewhat limited. Much still needs to be understood about dynamic sport settings in which attentional flexibility is crucial under conditions of severe time constraints and performance pressures. To empirically examine these issues, a laboratory simulation of a high-speed auto-racing task was created, and various levels of arousal and anxiety were induced. Visual search patterns were recorded as an index of potential attentional changes that might occur when individuals were presented with relevant and distracting peripheral cues while racing.

Attentional Narrowing

Of primary interest in this investigation was the peripheral (or attentional) narrowing phenomenon, which has been reported to occur under high stress levels. Though this phenomenon is intriguing, and has attracted much research interest to the present day, the underlying reasons for the narrowing (or tunnel vision effect) that is presumed to occur in stressful situations remain a mystery. Based on the findings of Bahrick, Fitts, and Rankin (1952) and others (e.g., Bruner, Matter, & Papanek, 1955; Callaway & Dembo, 1958; Callaway & Thompson, 1953; Eysenck, Granger, & Brengelman, 1957; Granger, 1953), Easterbrook (1959) produced the seminal article concerned with the concept of attentional narrowing. His primary theoretical prediction was the manner of interaction between arousal and performance in dual-task situations. Specifically, he suggested that with an increase in arousal to moderate levels, the blocking or masking of irrelevant (peripheral) cues would facilitate central task achievement. He postulated that at moderate levels of arousal, performance in tasks requiring less of a central focus (i.e., more peripheral awareness) would be less effective due to a masking of peripheral cues. Performance in central tasks would be expected to deteriorate if arousal level reached a heightened state such that the funneling effect prohibited attention to relevant cues that were integral to performance on the central task. In other words, Easterbrook suggested that the degree of facilitation or disruption in performance during dual-task situations is dependent on the range of cues needed to execute each task effectively, and how those cues are attenuated by emotional states.

Relatively few investigators have examined the effects of peripheral narrowing in sports, which is surprising considering the stressful nature of typical sport situations. An exception is a study by Landers, Wang, and Courret (1985), in which partial support was noted for peripheral narrowing with rifle shooters. Also, though not using a sport task, Williams, Tonymon, and Andersen (1990, 1991) found that decrements in the ability to detect peripheral cues occurred while individuals performed Stroop tasks under stressful conditions. The evidence was offered to substantiate a dimension of Andersen and Williams' (1988) model of athletic injury that specifies the attentional variations that predispose athletes to injuries.
Why the attentional narrowing concept has not received much attention in the sport psychology literature is unclear. However, an ideal sport context for investigating the phenomenon would be auto racing, due to the requirement for high levels of concentration and arousal regulation abilities. Though auto racing has not been studied previously, relevant work has been undertaken in “normal” driving environments with respect to attentional narrowing.

Driving

Even during routine driving, limited attentional resources can be devoted to an almost infinite number of stimuli at any point in time. As the challenge of driving becomes more difficult due to decreased visibility, bad weather, heavy traffic, mechanical malfunction, sudden unexpected obstacles, fatigue, and other factors, the need for conscious processing increases, and more attentional resources are needed to maintain requisite levels of safety and performance (Shinar, 1978).

Typically, the driver tends to focus on the central task of vehicle alignment within the functional constraints of the driving environment (e.g., speed limits and lane markers). However, when attention is drawn toward an object or event that is not in the central (or foveal) field of vision, the eyes move from the central task to focus more directly on the peripheral stimulus. Based on the information provided by the newly attended stimulus, a decision is made regarding whether or not to change driving behavior. In addition, all of these processes are often limited by extremely restrictive temporal constraints.

Perhaps Miura (1990) conducted the most relevant study reported to date to examine the processing of visual stimuli in both central and peripheral fields while driving. The primary purpose was to assess changes in the useful field of view (UFOV: the information-gathering area of the display) under situations of varying task demands and to determine the corresponding variation in acquisition of visual information that accompanied these changes. The study was done under actual driving conditions in which a roadway was navigated in daylight conditions. Results showed that response time (RT) to peripheral stimuli increased as the demands of the environment increased. Furthermore, eye movement eccentricity became shorter (i.e., saccadic distance was reduced), suggesting that fixations occurred closer to the actual target location to acquire necessary information. Specifically, it appears that the UFOV narrowed at each fixation point, and the latency of each fixation lengthened. Also, the detection of targets required a greater number of eye movements in more demanding driving situations. This suggests that increasing situational demands impeded peripheral visual performance. Though interesting and conceptually valuable, Miura (1990) overlooked the possibility that his findings could be attributed to the variations of arousal and anxiety that often accompany an increase in task complexity and demands (Easterbrook, 1959). Another possibility is that as driving demands increased, drivers became more susceptible to peripheral distractors.

Distraction

The influence of distractors in the context of peripheral narrowing has been largely ignored, and overall, the topic of distraction has received very little attention
from sport psychology researchers. The apparent narrowing of attention that occurs under stressful conditions could also be explained by the notion that anxious or aroused performers are more inclined to be distracted. The lack of research directed toward understanding distraction is alarming considering the necessity in many work, entertainment, sport, and other situations to ignore distractors and focus only on the most critical cues in order to perform effectively.

The typical effect of distraction is a decrease in performance quality (Moran, 1996). The most plausible explanation for this occurrence is that when one is distracted by either external or internal factors, available attentional resources decrease and inhibit processing of relevant cues. Like attentional narrowing, this idea is consistent with the limited capacity models of selective attention proposed in different forms by various theorists (e.g., Allport, 1989; Kahneman, 1973; Shiffrin & Schneider, 1977). Due to attentional capacity limitations, resources directed toward the processing of distractors reduce available resources for processing task-relevant information. Studies have indeed shown that distraction effects increase for complex rather than simple tasks and are greater as the similarity of distractors to relevant cues increases (Graydon & Eysenck, 1989).

Though empirical evidence is scarce, researchers have indicated that increases in emotionality (i.e., anxiety, worry) increase susceptibility to distraction. In support of this idea, Baumeister and Showers (1986) have suggested that increased worry causes attentional resources to be devoted to task-irrelevant cues. Also, Eysenck (1992) has provided empirical evidence that anxiety provokes people to detect stimuli that they fear, usually those that divert them from attending to relevant information.

Paradoxically, it appears that there may be two equally attractive explanations for the decrease in performance that occurs under high levels of stress. On the one hand, proponents of the attentional narrowing argument would suggest that as stress levels increase (either anxiety- or arousal-induced), the attentional field narrows to block out irrelevant cues, and then at high levels of stress, narrows further, blocking the processing of relevant information. On the other hand, defenders of the distraction argument would suggest that a widening of the attentional field occurs, such that irrelevant or distracting cues receive more attention when under lower stress levels. Evidently, a controversy exists, unless both mechanisms could be working at the same time. Perhaps increases in anxiety and/or arousal result in a narrowing of the attentional field, while at the same time, especially at higher levels of stress, narrowing actually increases susceptibility to distraction. Many theories can account for how stress affects attention and the eventual impact of attentional variation on performance, but none address specifically why this phenomenon occurs.

Visual search has been used extensively to draw cognitive inferences regarding what information is being extracted and processed during eye fixations, a concept Viviani (1990) has termed the central dogma of visual search research. Though it is presently impossible to empirically prove the central dogma, most researchers agree that eye fixations do at least reflect cognitive processing, and recent findings indicate that it is impossible to shift the point of gaze without shifting attention (Zelinsky, Rao, Hayhoe, & Ballard, 1997). Assuming the dogma to be even partially true, if an attenuation of cues in the periphery is evident, the need to pick up crucial cues during particular situations would necessitate an increase in scan path variability and fixation rate in order to compensate for peripheral
narrowing. Furthermore, if distracting visual cues were introduced, visual search strategies may be altered, resulting in increased fixation and processing of distracting stimuli, as well as a reduction of attentional resources available for central task performance (Williams & Elliott, 1997).

The selective and divided attention demands of auto racing render it an ideal task for investigation of attentional mechanisms and the visual behaviors that underlie those mechanisms. In light of these considerations, the primary objective of this investigation was to attempt to delineate the influence of arousal and cognitive anxiety on attentional capabilities (narrowing and distraction). A central driving task and a peripheral light-detection task were used to assess the influence of anxiety (as manipulated by a time-to-event paradigm and anxiety-producing instructional sets) on performance over the course of familiarization, practice, and competition sessions. Performance-related variables included (a) driving speed, (b) peripheral light-detection speed and accuracy, (c) visual search patterns, (d) physiological arousal, and (e) cognitive anxiety. It was determined whether any anxiety-induced changes in performance were due to a narrowing of the attentional field, increased distractibility, or both.

Hypotheses generated were consistent with the predictions of Easterbrook’s (1959) original cue-utilization hypothesis. Central task (driving) performance was expected to be facilitated at moderate anxiety levels and then drop off when anxiety increased. Similarly, peripheral task identification speed and accuracy were expected to systematically decrease as anxiety levels increased. In addition, distracting peripheral lights were anticipated to become more salient as anxiety increased, resulting in more fixations of longer durations to peripheral locations and an increased tendency to misidentify the relevance of peripheral lights.

Method

Participants

Female volunteers (n = 48) selected from university courses were randomly assigned into six groups. The mean age of participants was 20.13 years (SD = 3.56) and represented three ethnic categories (41 Caucasian, 4 African American, 3 Asian American). Males were excluded from participation based on research findings and pilot work indicating that they are less likely than females to report emotions, especially those of a distressful nature (Briscoe, 1985; Jones & Cale, 1989; Verbrugge, 1985). Also, only participants with normal or corrected normal vision were tested. Those with corrective eyeglasses were excluded due to the reduction in eye-fixation recording capabilities that often occurs when wearing glasses. Participants gave their informed consent prior to taking part in the experiment. The research was conducted according to the guidelines established by the American Psychological Association (1982).

Instruments and Tests

A dual-task paradigm involving both central and peripheral stimuli has routinely been used in studies of attentional narrowing to delineate the attentional resource distribution between central and peripheral locations. It should be emphasized that participants were informed that both tasks were equally important in
terms of the overall performance score, so as not to confound any findings due to changes in their probability expectations (Hockey, 1970). Furthermore, participants who were given incentives were told that awards would be based on performance in both central and peripheral tasks.

Central Task. The central task consisted of a simulated IndyCar driving task, which required each individual to navigate the racecourse by controlling steering, acceleration, and braking functions. The simulation was assembled from primarily three components: (a) racing computer software, (b) analog steering wheel and foot pedals, and (c) a video projection unit.

The racing software consisted of the Papyrus Design Group IndyCar Racing II CD (Bellevue, WA) and accompanying software. The program is a graphically refined, multi-option software package allowing external programming. For the purpose of the study, the least complex of the track options (Michigan International Speedway) was chosen, and all driving aids were selected to decrease task difficulty. The driving functions of the simulation were controlled with an analog steering wheel and braking and acceleration pedals. The realism of the simulation was enhanced further by the use of a Sharp Liquid Crystal Video Projection unit (Model #XG-H400U, Camas, WA) that projected the display image generated from a Gateway 2000 P5-166 (Sioux City, SD) computer onto a large screen to make it appear life-size (see Figure 1). To project the computer image, an Advanced Digital Systems Elite VGA-to-TV converter (Model #FFN-100, Cerritos, CA) converted the VGA image from the computer to a TV video signal that could be fed through the LCD projector.

Peripheral Tasks. Two types of peripheral stimuli were used. The first was denoted as relevant to the driving task and consisted of randomly intermittent red LEDs that were displayed in the periphery. Participants were obliged to attend to the central task (driving the car) while, concurrently, having to detect and identify (through a button-press response) the lights. A response button was mounted on

Figure 1 — Participant view when seated in racing simulation.
the steering wheel to minimize interference with driving. Participants were required to identify the presence of the light as soon as possible while continuing to perform the central driving task as accurately and quickly as possible. RT from the time of illumination to the response was recorded for each trial through the use of a Lafayette Instrument Co. electronic timer (Model #54419-A, Lafayette, IN).

The second peripheral stimulus was a green LED illuminated in the same peripheral position as the red LED of the previous description. In this manner, the visual angle from the point of expansion (POE: the middle of the display from which the visual scene expands) to the peripheral location remained constant. Participants were required to perform the central driving task while ignoring the green peripheral stimulus. The second type of stimulus was referred to as the "irrelevant" or "distracting" stimulus. Any response made to the distracting stimulus was construed as a misidentification.

Four peripheral stimuli were presented at randomly chosen landmarks of the track for each lap (20 stimuli per trial block, 80 stimuli per test session). For example, on Lap 1, stimuli were activated in either the right or left peripheral field as drivers passed the end of the pit area, as they entered the first turn, as the second set of advertisement signs came into view, and as they crossed the start/finish line. On the following laps, random assignment of peripheral light color, peripheral locations, and track landmarks denoted subsequent stimulus presentations. In this manner, any spatial and temporal biases that could confound attentional resource allocation processes were minimized.

As will become evident in the discussion of experimental conditions, two groups received only relevant stimuli and two others received a combination of relevant and distracting stimuli. In conditions where both relevant and distracting stimuli were presented, an equal number of each color were randomly presented in both the right and the left visual fields. After an illumination period of 3 s, the lights were extinguished unless a response was made before the 3-s period had ended.

Measurement Recording Devices

The following instruments were used to record eye movement data, performance on the central and peripheral tasks, and levels of cognitive anxiety and arousal.

Eye Movement Measures. An Applied Science Laboratories (ASL, Waltham, MA) 4000 SU eye movement system was used to collect eye movement information. The 4000 SU system is a video-based monocular corneal reflection system that measures the point of gaze relative to video images recorded by a headband-mounted scene camera. The system has the capability to measure pupil position and corneal reflex, which are used to compute visual gaze with respect to the optics. Data from the left pupil and cornea were processed by a Gateway 2000 IBM-compatible P5-133 computer and superimposed in the video image recorded by the headband-mounted scene camera. In this respect, the exact point of gaze at all times could be evaluated frame by frame with respect to the visual display. System accuracy was ±1° visual angle with precision of 1° in both vertical and horizontal fields. Also, after calibration with the head-mounted scene camera, free movement of the head and eyes was permitted. Recalibration of the eye-monitoring equipment was performed following each trial block to ensure the integrity of visual search data.
Visual search data were analyzed in a frame-by-frame manner according to the procedures outlined by Williams, Davids, Burwitz, and Williams (1994). The primary eye movement measures of interest were exogenous saccades to peripheral lights, fixation location, and search rate. Exogenous saccades were recorded on-line following the presentation of each of the peripheral lights operationalized as saccades that were stimulus driven (i.e., the presentation of the stimulus caused a saccade to that location). Fixation location refers to the area in the display where the eye fixates during completion of the tasks. Fixation location was coded for simplification into four primary areas: (a) central locations (within 6° of the POE), (b) relevant peripheral locations (i.e., the speedometer and rear-view mirrors), and (c) irrelevant areas (outside the central and peripheral locations). Search rate consisted of the number of fixations and the mean duration of each. Fixations were operationalized as a pause in search during which the eye remained stationary for a period equal to or in excess of three video frames (100 ms) (Williams et al., 1994).

**Central Task Performance Measure.** The central task measure of interest was mean lap speed per session. Speed was recorded on completion of each lap based on the average speed presented on the screen (automatically calculated by the simulator) and was obtained by viewing the videotape recording from the scene camera.

**Peripheral Task Performance Measures.** On presentation of each peripheral stimulus, the response button (mounted on the steering wheel) was depressed to indicate recognition of the stimulus. Response time was operationalized as the time between presentation of the stimulus and the button press. Misidentifications (as described earlier) were also recorded.

**Cognitive Anxiety Measure.** Cognitive anxiety was manipulated through the use of a time-to-event paradigm and anxiety-inducing instructional sets (described later) and was measured before each test session with the Competitive State Anxiety Inventory-2 (CSAI-2: Martens, Burton, Vealey, Bump, & Smith, 1990). The CSAI-2 has been shown to be a valid and reliable measure of cognitive anxiety, somatic anxiety, and self-confidence and has been used repeatedly to assess the independent contribution of these constructs to the stress response.

**Physiological Arousal Measure.** Physiological arousal was assessed through measurement of heart rate by a Polar (Model Accurex II, Woodbury, NY) heart rate monitor (HRM). Resting heart rate (HR) baselines were obtained prior to performance of the initial five trial blocks during the familiarization session. Session HR averages were computed from data recorded after each trial block during the three sessions. A difference score was calculated for these sessions by subtracting the baseline rates from the data obtained during the test sessions. The difference scores were then used for analysis. Though HR is not a uniform or infallible measure of arousal, due to individual response stereotypes (Lacey & Lacey, 1958), it has been recorded extensively as a measure of arousal (e.g., Fazey & Hardy, 1988; Hardy, 1996; Hardy, Parfit, & Pates, 1994; Parfitt, Hardy, & Pates, 1995).

**Procedure**

On entering the Motor Behavior Laboratory for testing, participants were informed that the general purpose of the experiment was to assess their eye movements as they drove a simulated race car under different task conditions. They were then asked to read and sign an informed consent form, and questions regarding
the study were answered. The HRM was then fitted, and a 1-min initial baseline HR was recorded before completing the CSAI-2 (Martens et al., 1990). After recording the baseline HR and completing the CSAI-2, last-minute instructions regarding driving strategy were given and participants were seated at the driving apparatus.

The extent of the peripheral visual field was then tested by illuminating LEDs in the peripheral location and asking participants to respond by naming the color of the LED when each light was illuminated. The specific location of peripheral stimuli was determined individually for each session due to variability between participants with regard to peripheral visual acuity. Peripheral stimuli positions coincided with the farthest distance from the POE in which color discrimination was still possible. This was operationalized as the point at which participants were able to achieve a 100% hit rate on five presented colors, and any movement beyond that point resulted in a lower hit rate.

After completing the peripheral-stimulus identification check, participants were outfitted in an ASL 4000SU eye-movement-tracking system, which was then calibrated using a simple 9-point reference grid. In this manner, each participant’s exact point of gaze corresponded to the fixation point as indicated by a cursor. Three test sessions were then completed according to specific experimental considerations based on random group assignment. The first session occurred on the initial visit to the laboratory, and the second and third sessions took place 2 days later.

**Experimental Groups**

Participants were randomly assigned to six groups (see Table 1). Three of the six groups (the anxiety groups) were exposed to multiple variations of anxiety and task conditions according to the time-to-event paradigm and various instructional sets. The other three groups were control groups, used to ensure that changes in the other experimental conditions were due to anxiety manipulations and not mere practice effects or other confounding variables. Thus, anxiety and control groups were assigned for each task condition.

**Control Groups.** The first control group (central control) performed the central task without a peripheral task to perform concurrently. The second control group (relevant control) performed both the central and the peripheral tasks, with the peripheral stimuli being the relevant (red) LEDs. The third control group (distraction control) performed both central and the peripheral tasks, similar to the second group, but the peripheral stimuli consisted of both task-relevant (red LEDs) stimuli and task-irrelevant (green LEDs) stimuli.

**Anxiety Groups.** A time-to-event paradigm was used to establish a sequence of sessions leading to a competitive event in the final session. In the context of sport, this is similar to the athlete who has a preparation period leading up to the actual game or event of importance (Hardy, 1996). The groups that experienced the anxiety manipulations completed three sessions denoted as a familiarization session, a practice session, and a competition session. The familiarization session was operationalized as the low-anxiety condition, the practice session was the moderate-anxiety condition, and the competition session was the high-anxiety condition.

Similar to control conditions, those in anxiety groups performed either no peripheral tasks while driving, the relevant peripheral task while driving, or both
Table 1  Research Design

<table>
<thead>
<tr>
<th>Task type</th>
<th>Groups</th>
<th>Familiarization, Session 1</th>
<th>Practice, Session 2</th>
<th>Competition, Session 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>control</td>
<td>low anxiety</td>
<td>low anxiety</td>
<td>low anxiety</td>
</tr>
<tr>
<td>Relevant</td>
<td>control</td>
<td>low anxiety</td>
<td>low anxiety</td>
<td>low anxiety</td>
</tr>
<tr>
<td>Distraction</td>
<td>control</td>
<td>low anxiety</td>
<td>low anxiety</td>
<td>low anxiety</td>
</tr>
<tr>
<td>Central</td>
<td>anxiety</td>
<td>low anxiety</td>
<td>moderate anxiety</td>
<td>high anxiety</td>
</tr>
<tr>
<td>Relevant</td>
<td>anxiety</td>
<td>low anxiety</td>
<td>moderate anxiety</td>
<td>high anxiety</td>
</tr>
<tr>
<td>Distraction</td>
<td>anxiety</td>
<td>low anxiety</td>
<td>moderate anxiety</td>
<td>high anxiety</td>
</tr>
</tbody>
</table>


the relevant and the irrelevant peripheral tasks while driving. The groups were called the central anxiety, relevant anxiety, and distraction anxiety groups.

In total, participants were required to complete 20 laps of the simulated 2-mile (3.2-km) course quickly and accurately during each test session. A trial block condition was established in which there were four trial blocks for each test session with five trials (laps) per block. On completion of the study, participants were asked to leave the testing area, were debriefed as to the specific manipulations that were used, and were told the true purpose of the study. They were then asked to complete a short postexperiment questionnaire as a manipulation check (to assess whether the anxiety manipulations were effective and to assess general feelings of driving efficacy). Finally, they were given the opportunity to ask any questions related to the study. All participants received full credit for participation regardless of performance on the task, and the best performer received a $50 award.

Data Analysis

Although cell sizes were relatively small (n = 8), they were sufficiently powerful given the repeated-measures design employed. A preliminary mixed-model 6×3 (Group×Session) multivariate analysis of variance (MANOVA) with repeated measures on the last factor provided the initial analysis of cognitive anxiety, arousal, lap speed, fixation location, and search rate. Following the MANOVA, cognitive anxiety, arousal, lap speed, search rate, and fixation location were evaluated with separate 6×3 (Group×Session) mixed-model factorial ANOVAs with repeated measures on the last factor. Also, because RT and exogenous-saccades data were not collected from the two central groups, separate 4×3 (Group×Session) mixed-model factorial ANOVAs with repeated measures on the last factor were used to analyze data from the four remaining groups. All visual search data used for analysis were taken from the middle (third) trial of each trial block completed during the three sessions. Finally, two-way chi-square analyses were conducted on the frequency of misidentifications.
Results

For all statistical analyses performed, alpha was set at .05. Tukey’s HSD post hoc analysis was applied to evaluate main effects, and simple effects tests were performed following any significant interactions. Means and standard deviations for cognitive anxiety and arousal, performance measures, and visual search measures are presented in Tables 2, 3, and 4, respectively. The two-way mixed-model MANOVA yielded significant group, Wilks’s lambda = .32, $F(25, 142.67) = 2.046, p < .01$, and session, Wilks’s lambda = .114, $F(10, 33) = 25.76, p < .01$, differences, as well as a significant group by session interaction, Wilks’s lambda = .015, $F(50, 153.87) = 4.616, p < .01$. Given the significant effects obtained with the MANOVA, the remainder of this section describes the follow-up univariate tests and post hoc procedures.

Anxiety and Arousal

Cognitive Anxiety. Analysis of cognitive anxiety revealed a significant main effect for session, $F(2, 84) = 11.95, p < .001$. More important, however, was the significant group by session interaction, $F(10, 84) = 6.50, p < .001$. Simple effects analysis revealed that the anxiety groups significantly increased in cognitive anxiety levels during the competition session, but the control groups remained stable across the three test sessions. No other significant effects were found for anxiety (see Table 2).

Heart Rate. Analysis of HR indicated a significant main effect for group, $F(5, 42) = 17.31, p < .001$, and session, $F(2, 84) = 42.87, p < .001$. The relationships were described more accurately, however, by the significant group by session interaction, $F(10, 84) = 29.04, p < .001$. Simple effects analysis revealed that the three anxiety groups exhibited significant increases in HR in Session 3 in comparison with the three control groups, which remained stable or experienced decreases in HR (see Table 2). No other differences were found.

Central Task Performance

Lap Speed. The analysis of lap speed yielded a significant main effect for session, $F(2, 84) = 70.83, p < .001$. A more meaningful finding, however, was the significant group by session interaction, $F(10, 84) = 3.63, p < .001$. Figure 2 graphically illustrates this result. Simple effects analyses revealed an interaction between two of the anxiety groups and the control groups. Specifically, the distraction anxiety group and the central anxiety group exhibited a significant increase in speed from Session 1 to Session 2, and then a significant decrease in speed from Session 2 to Session 3. Conversely, all control groups improved significantly from Session 1 to Session 3 (see Table 3).

Peripheral Task Performance

Response Time. The analysis of RT indicated a significant main effect for group, $F(3, 28) = 6.29, p < .01$. More important, however, was the significant group by session interaction, $F(6, 56) = 6.76, p < .001$. Simple effects tests suggested that the distraction anxiety group exhibited higher RTs than the relevant control group in Session 2. Furthermore, in Session 3, the distraction anxiety group
Table 2  Means and Standard Deviations of Cognitive Anxiety and Arousal Measures Across Sessions 1–3

<table>
<thead>
<tr>
<th>Group</th>
<th>Cognitive Anxiety Session 2</th>
<th>Session 3</th>
<th>HR Change(^1) Session 2</th>
<th>Session 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Session 1</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>D-C</td>
<td>10.37(^a)</td>
<td>1.76</td>
<td>11.00(^a)</td>
<td>2.56</td>
</tr>
<tr>
<td>D-A</td>
<td>13.12(^{ab})</td>
<td>4.22</td>
<td>14.37(^b)</td>
<td>3.85</td>
</tr>
<tr>
<td>R-C</td>
<td>14.50(^b)</td>
<td>4.10</td>
<td>13.5(^{ab})</td>
<td>4.62</td>
</tr>
<tr>
<td>R-A</td>
<td>13.00(^{ab})</td>
<td>4.47</td>
<td>14.00(^{ab})</td>
<td>5.65</td>
</tr>
<tr>
<td>C-C</td>
<td>13.37(^{ab})</td>
<td>3.37</td>
<td>11.12(^a)</td>
<td>2.53</td>
</tr>
<tr>
<td>C-A</td>
<td>10.62(^a)</td>
<td>1.40</td>
<td>11.50(^a)</td>
<td>3.77</td>
</tr>
</tbody>
</table>

Note. Means having common superscripts do not differ significantly according to post hoc analyses.

\(^1\)HR change values (means, standard deviations) were calculated in comparison with baseline rate (D-C = 89.75, 7.44; D-A = 7.88, 9.45; R-C = 81.63, 17.90; R-A = 77.38, 7.78; C-C = 87.63, 9.88; C-A = 86.50, 9.40). D-C = distraction control; D-A = distraction anxiety; R-C = relevant control; R-A = relevant anxiety; C-C = central control; C-A = central anxiety.
| Group | Session 1 | | Lap Speed | Session 2 | | Session 3 | | Session 1 | | Response Time | Session 2 | | Session 3 |
|-------|-----------|----------------|----------|----------------|----------|----------------|----------|----------------|----------|----------------|----------|----------------|
|       | M        | SD      | M       | SD      | M       | SD      | M       | SD      | M       | SD      | M       | SD      |
| D-C   | 161.87\textsubscript{a} | 16.90   | 170.58\textsubscript{b} | 16.17   | 184.95\textsubscript{c} | 9.95   | 679.84\textsubscript{d} | 74.29   | 628.54\textsubscript{e} | 46.33   | 576.18\textsubscript{b} | 53.49   |
| D-A   | 170.54\textsubscript{b} | 8.74    | 185.52\textsubscript{c} | 12.86   | 176.50\textsubscript{b} | 17.51  | 676.81\textsubscript{d} | 81.40   | 672.98\textsubscript{d} | 76.66   | 730.09\textsubscript{c} | 62.12   |
| R-C   | 161.88\textsubscript{a} | 9.43    | 181.50\textsubscript{b,c} | 8.57    | 185.56\textsubscript{e,d} | 7.20   | 603.25\textsubscript{b,c} | 96.37   | 543.07\textsubscript{e} | 72.21   | 513.88\textsubscript{a} | 69.64   |
| R-A   | 160.83\textsubscript{a} | 15.30   | 182.04\textsubscript{b,c} | 15.62   | 185.92\textsubscript{e,d} | 10.16  | 602.27\textsubscript{b,c} | 86.99   | 611.48\textsubscript{b,c} | 70.24   | 647.98\textsubscript{e,d} | 92.73   |
| C-C   | 166.53\textsubscript{a} | 17.91   | 184.51\textsubscript{c} | 9.94    | 190.40\textsubscript{d} | 6.73   | 679.84\textsubscript{d} | 74.29   | 628.54\textsubscript{e} | 46.33   | 576.18\textsubscript{b} | 53.49   |
| C-A   | 175.46\textsubscript{b} | 11.94   | 190.45\textsubscript{d} | 7.91    | 182.26\textsubscript{b,c} | 4.85   | 676.81\textsubscript{d} | 81.40   | 672.98\textsubscript{d} | 76.66   | 730.09\textsubscript{c} | 62.12   |

Note. Means having common superscripts do not differ significantly according to post hoc analyses.

D-C = distraction control; D-A = distraction anxiety; R-C = relevant control; R-A = relevant anxiety; C-C = central control; C-A = central anxiety.
Table 4  Means and Standard Deviations of Visual Search Measures Across Sessions 1–3

<table>
<thead>
<tr>
<th>Group</th>
<th>Exogenous Saccades</th>
<th>Fixations Off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Session 1</td>
<td>Session 2</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>D-C</td>
<td>9.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.29</td>
</tr>
<tr>
<td>D-A</td>
<td>10.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.78</td>
</tr>
<tr>
<td>R-C</td>
<td>3.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.10</td>
</tr>
<tr>
<td>R-A</td>
<td>2.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.06</td>
</tr>
<tr>
<td>C-C</td>
<td>1.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>C-A</td>
<td>5.00&lt;sup&gt;c&lt;/sup&gt;&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.36</td>
</tr>
</tbody>
</table>

Note. Means having common superscripts do not differ significantly according to post hoc analyses.
D-C = distraction control; D-A = distraction anxiety; R-C = relevant control; R-A = relevant anxiety; C-C = central control; C-A = central anxiety.
responded more slowly to peripheral stimuli than did the other groups. Similarly, in Session 3, the relevant anxiety group showed longer response times than did the relevant control group (see Figure 3).

**Misidentifications.** Chi-square analyses on misidentification data revealed a significant increase, χ²(2) = 4.72, p < .05, in the misidentification frequency only for those in the distraction anxiety condition (M = 7.88, SD = 4.99) during the competition session.

**Visual Search Data**

**Exogenous Saccades.** Analysis of exogenous saccades yielded significant main effects for group, F(3, 28) = 21.55, p < .001, and session, F(2, 56) = 18.77, p < .001. However, a more meaningful finding was the significant group by session interaction, F(6, 56) = 23.73, p < .001. Simple effects tests indicated that in Session
1, the distraction groups demonstrated significantly more saccades to peripheral stimuli than did the relevant groups. In Sessions 2 and 3, although the distraction control, relevant control, and relevant anxiety groups exhibited similar saccadic activity, the distraction anxiety group made significantly more saccades to peripheral stimuli (see Figure 4).

**Fixation Location.** Of the locations of interest, the only differences between groups were found with respect to the number of fixations that occurred off the screen. Analysis of fixation location data yielded a significant group by session interaction, $F(10, 84) = 1.97, p < .05$. Simple effects tests indicated that all groups exhibited similar fixation location tendencies during the first two sessions, with the exception of the relevant and distraction anxiety groups that fixated more frequently to the periphery. However, in Sessions 2 and 3 the distraction control, relevant control, and relevant anxiety groups demonstrated fewer fixations to peripheral locations than did the distraction anxiety group.

**Search Rate.** No significant differences were found across conditions in mean fixation duration or the number of fixations.

### Discussion

This investigation was undertaken to further our understanding of the ability to attend to and process the most relevant cues, make appropriate decisions, and perform effectively under competitively anxious conditions. Findings generally confirmed the notion that distraction and attentional narrowing occurred concurrently, leading to inefficient visual search patterns and decrements in performance on central and peripheral tasks.

**Cognitive Anxiety and Arousal**

Cognitive anxiety scores generally reflected the intended level at each stage of the time-to-event paradigm. Similarly, arousal levels were very consistent with
predicted levels. The significant increases in cognitive anxiety and HR were indicative that the time-to-event paradigm and anxiety-induction manipulations used were effective. Aside from the increases experienced by the anxiety groups, it is important to note the control groups’ respective decrease in anxiety and arousal levels. This effect was also expected, as control group participants were unaware of any costs and benefits for performing the task. They had no reason to fear any consequence of performing poorly (except perhaps embarrassment) and had no incentives to perform well. Evidently, as the experiment progressed, a level of familiarity with experimental conditions was achieved, reducing anxiety levels. Furthermore, as extensive practice was provided on the task, it appears that a comfort state was realized, leading to an increase in lap speed.

Dual-Task Performance

It was postulated that the ability to effectively drive the car (the central task) would be related to the specified predictions of the cue-utilization hypothesis. More directly, driving skill was expected to increase under moderate levels of anxiety and/or arousal (in comparison with baseline levels) and to decrease at high levels of activation. Results confirmed the hypotheses for the distraction anxiety and central anxiety groups but not for the relevant anxiety group. Control groups exhibited sequential increases in lap speed from Sessions 1 to 3, and, as expected, the central control group displayed the fastest competition session speed.

Central driving task performance was not totally consistent with predictions associated with the concept of attentional narrowing. The lack of a performance decrease during the high-anxiety session by those who were merely required to identify relevant cues is inconsistent with the predictions of the model. A recent investigation by Yoo (1996), however, showed similar trends. In Yoo’s study, performance in the central task (a pursuit rotor) did not change as a result of higher overall levels of cognitive anxiety. Data from other studies (e.g., Bacon, 1974; Wachtel, 1968) have been similar. That is, although peripheral task performance was affected in predicted directions, central task performance was not detrimentally influenced. Our investigation may provide clues as to why the findings on central task performance have been somewhat equivocal. As will be addressed in more depth later, evidence suggests that distraction caused by irrelevant peripheral stimuli may have an effect on central driving proficiency above and beyond that described in the original framework of the attentional narrowing concept.

Peripheral Task Performance. The distraction anxiety group demonstrated the slowest response time in the competition session. Not only was this a significant difference in comparison with other groups that were required to identify peripheral lights but it was quite dramatic. The relevant control group displayed an advantage of more than 200 ms over the distraction anxiety group during the competition session.

In addition, the distraction anxiety group misidentified more peripheral lights than did any other group under higher levels of anxiety. Findings are not surprising in this respect. Virtually all published research dealing with attentional narrowing has clearly shown a detriment in performance on peripheral tasks as anxiety levels increase (e.g., Yoo, 1996). The unique contribution of the performance data summarized here, however, is the impact of distractors on peripheral task performance.
Specifically, distractors become even more devastating at high activation levels, resulting in longer response times and more misidentifications.

**Visual Search Data**

It was expected that the distraction anxiety group would exhibit the most gaze behavior patterns toward the periphery due to the decrement in the ability to discriminate peripheral stimuli as the attentional field narrowed. In line with these expectations, the distraction anxiety group dramatically increased saccadic and fixation activity to peripheral locations, especially in the high-anxiety condition. These results provide substantial support for the changes in performance that were predicted by the attentional narrowing phenomenon and reinforce the idea that the narrowing phenomenon can be reflected in alterations of visual search patterns (cf., Williams & Elliott, 1997). Furthermore, changes in visual search patterns implicate perceptual mechanisms as a primary factor responsible for attentional narrowing. Perhaps more than any of the other indices, the visual search information implicates visual distraction as an underlying mechanism for the performance changes that occur at high levels of anxiety and arousal in reactive, high-speed sports tasks. Although exogenous saccades may not be direct indicators of visual attention (Pashler & O’Brien, 1993), they do indicate a shift in visual gaze from the central task toward irrelevant cues. By quadrupling the number of saccades to peripheral areas (as was the case for the distraction anxiety group), less time was spent fixating the central task. Taken together with the increase in the number of fixations to peripheral areas, it appears that higher levels of activation increase the need to acquire information from cues outside the central field of view through the use of eye movements, and thereby detrimentally influence central task performance.

Another interesting finding was that as the number of exogenous saccades and fixations to peripheral areas increased, there was a corresponding increase in response time. A different response style may have been adopted during the final test session. Specifically, drivers tended to fixate more on peripheral lights in order to effectively discriminate the relevance of the light before responding. In earlier sessions, fewer shifts in gaze were made to the periphery, yet response accuracy was greater, and response time was faster. Each of the findings points not only to narrowing, but to an increased tendency to be distracted by other cues when drivers were highly activated.

**Implications**

One of the primary contributions of this study to the literature dealing with attentional mechanisms and performance is the inclusion of experimental conditions in which distractors were present along with relevant stimuli in peripheral locations. By including distractors in the testing environment, it was possible to investigate whether attentional narrowing was the singular determinant of task proficiency changes at high anxiety levels or whether distraction played a significant role in performance fluctuations. Numerous lines of evidence converge to indicate that distraction was present at high levels of anxiety. First, performance on the peripheral-light detection task was far worse under high anxiety levels when distraction cues were present. Not
only was more time required to identify the presence of relevant stimuli, but also
the number of misidentified stimuli increased. Furthermore, driving performance
was greatly hindered when irrelevant cues were present during the competition
session, while this was not the case in other dual-task conditions. Although not a
direct indication of an increase in distraction during the competition session, it
appears as though the need to direct more attention to peripheral stimuli may have
absorbed resources that were necessary for central driving task proficiency.

Perhaps most convincing when attempting to argue a case for the role of
distraction, however, was the increased number of fixations and saccades made to
peripheral locations during the final, and highest-, anxiety-producing situation.
During this session, increased saccadic activity appeared to detract attention from
the central task and led to more driving errors and slower lap speeds. Wegner
(1994, 1997) and Moran (1996), among others, suggest that higher stress levels
increase the propensity to be distracted. However, virtually no empirical evidence
existed to support this notion. By including distracting stimuli in the experimental
protocol, not only was the task rendered more ecologically valid but answers were
provided to verify speculation on this topic. In this vein, the tenets of the attentional
narrowing concept should be revised to incorporate the role of distraction in per-
formance changes. The results of this study do not contradict the attentional nar-
rowing phenomenon but add a dimension to it that provides further explanation
for the influence of attentional changes on task proficiency.

Questions remain unanswered, however, with respect to the specific pro-
cesses that are altered as a function of elevated cognitive anxiety levels. Because
changes in performance were noticed not only in the dual-task situation when
distractors were present but also in the single-task situation, it is unclear what
mechanisms are being affected. Perhaps at high anxiety levels in the single-task
scenario, participants become more internally rather than externally distracted by
worrisome thoughts and concerns (Moran, 1996).

Another goal of this investigation was to determine whether performance changes
under higher levels of activation are due to the perceptual alterations in visual selec-
tive attention or other nonperceptual factors during the processing of relevant and
irrelevant stimuli. In other words, what explanation accounts for the information-
processing differences that occur under high levels of activation, leading to perfor-
man c e changes? It was proposed that changes in visual search patterns would offer
some clues as to where these processing decrements occur and would provide
insight into the apparent lack of effective cue utilization at high activation levels.

Differences existed among groups with respect to visual search patterns. At
high levels of anxiety and arousal, the number of fixations to the periphery and to
distracting stimuli increased. As emphasized earlier, this provides sound evidence
for the idea that perceptual mechanisms are changed that predispose performers to
process irrelevant information. Our findings are relatively consistent with the typi-
cal search patterns of better performers across various sports. The best performers
tend to exhibit fewer fixations of longer duration to the most relevant areas of the
display (Abernethy, 1988; Singer, Cauraugh, Chen, Steinberg, & Frehlich, 1996;
Vickers, 1996). Though expertise was not a factor of interest in the present investi-
gation, data indicate that the best driving performance was exhibited when visual
search patterns were less variable and more focused on the most informative driv-
ing cues. In contrast, the worst overall driving proficiency occurred when search
patterns were more erratic and drifted to irrelevant cues. Apparently, a shift in
attentional resources away from the central location and to the periphery led to a lack of information acquisition from central locations.

In conclusion, without the capacity of attending to and processing relevant information in an efficient manner, human performance is greatly compromised in a variety of different environments. Furthermore, the ability to excel, especially in the sport context, is highly dependent on the continual refinement and appropriate application of these attentional skills. Previous evidence has suggested that when they are placed in stressful environments, a narrowing of the attentional field negatively affects the attentional ability of participants. Results presented here indicate that although this may be the case, the influence of anxiety on attention is also determined by distraction. Individuals in situations that require the continuous monitoring of both central and peripheral cues must be aware of the influence of anxiety on attention and take appropriate measures to reduce the potentially devastating consequences of ignoring alterations in attentional capabilities.

References


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