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**Perceptual-Cognitive Processes Underlying Creative**

**Expert Performance in Soccer**

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**Abstract**

Creativity is one of the key parts of expert performance in sport and other domains. The aim of this study was to determine the underlying perceptual and cognitive processes that underpin creative expert performance in the sport of soccer. Forty skilled adult soccer players participated. In the experimental task they interacted with representative video-based 11 vs. 11 attacking situations whilst in possession of a ball. Clips were occluded at a key moment and participants were required to play the ball in response to each presented scenario as they would in a real-game situation. Moreover, they were required to name other additional actions they could execute for each situation. Their solutions on the task were measured using the three observation criteria for creativity of originality, flexibility, and fluency of decisions. Using these criteria, players were categorized into either high- or low-creative groups. Visual search and cognitive thought processes were recorded during the task using a portable eye-movement registration system and retrospective verbal reports. The creativity-based between-group differences in decision making were underpinned by differences in visual search strategy. Compared to the low-creative group, the high-creative players made more fixations of shorter duration in a different sequential order and to more task-relevant locations of the display, indicating a broader attentional focus. They also generated a greater number of verbal reports of thoughts related to the assessment of the current task-situation and planning of future decisions when compared with the low-creative players. Our findings highlight the perceptual-cognitive processes that underlie creative expert performance in a sport-specific domain.

**Keywords:** *creativity; expertise; perception; gaze behaviors; cognition; verbal reports*

**Introduction**

The ability to generate creative decisions are important not only in sports like soccer and other team ball sports (Memmert & Roca, 2019), but also across other domains such as art, music or science (e.g., Gridley, 2006; Hass & Weisberg, 2009; Runco, 1990, 2014). In performance sport contexts, creativity is usually associated with an athlete’s ability to make decisions in specific situations that are surprising and unexpected and, therefore, less likely to be anticipated by opponents. Creativity is defined as the ability of the performer to produce a variety of solutions that are not only original (statistically rare and surprising), but also appropriate and useful (Runco, 2014; Sternberg & Lubart, 1999). Creative behaviors are always original, but without utility or effectiveness, original behaviors are not necessarily creative. The importance of creative expert performance is assumed to be increasing in team sports due to coaching staff being more able to gather key information about opponents’ tactical patterns and behaviors with the help of systematic observation (video) and statistical data analysis. Although domain-specific creativity is thought to play a key role in a range of high-performance sports, thus far, few researchers have investigated the perceptual and cognitive processes and mechanisms underpinning creative behavior in such performance contexts. In contrast, a number of extensive research studies exist in general and domain-unspecific creativity (for extended overviews, see Kaufman & Sternberg, 2010; Runco, 2014) and a few others in the domains of sciences, traditional arts, and business or marketing (for a recent overview, see Kaufman, Glăveanu, & Baer, 2017).

Over the last few years, researchers have begun to investigate some of the perceptual and attentional processes underlying domain-specific creativity in sport performance contexts (e.g., Furley, Memmert, & Heller, 2010; Roca, Ford, & Memmert, 2018). For example, Roca et al. (2018) used eye-movement recording to assess the visual search behaviors of skilled soccer players making decisions during a representative soccer-specific creativity task. Players who selected more original and appropriate decisions on the task were found to employ a broader attentional focus, characterized by more fixations towards important informative areas on the display when compared to their less-creative counterparts. They made more and earlier fixations on key attacking teammates in positions that could lead to goal scoring opportunities during the offensive play with no differences found for fixations made on other attackers in no threatening positions, defenders, or the player in possession of the ball. Although researchers have gained important insights into some of the underlying processes linked to superior creative performance in sports, they have only partly focused on attentional and perceptual sources of information that athletes use to guide their performance. So far, there have not been any attempts to provide an integrated and multidimensional analysis of the dynamic and complex perceptual and cognitive processes underpinning expert creative performance in sporting domains. The exploration of these issues is clearly warranted, perhaps by combining different types of process-tracing measures, including eye-movement recording and verbal report protocols to provide more information about the processes that mediate creative performance (Williams, Fawver, & Hodges, 2017). Verbal report protocols help measure how performers translate information from the visual system into appropriate creative cognitive processes and behaviors, therefore, offering a greater insight into processes that mediate and link perception and tactical creativity.

More recently, researchers have used verbal reports along with eye-movement recording to provide insight into the perceptual-cognitive processes in skilled performers in sports, such as cricket (Runswick, Roca, Williams, Bezodis, & North, 2018), soccer (Roca, Ford, McRobert, & Williams, 2013), and tennis (Murphy et al., 2016). They have shown that expert thought processes consist of more advanced planning, reasoning, and evaluation during anticipation of opponent actions in these sports. For example, in a multi-experimental study Murphy et al. (2016) examined the perceptual-cognitive processes underlying the use of contextual information during anticipation in skilled and less-skilled tennis players by collecting eye-movement data and retrospective verbal reports of thoughts. Participants were required to anticipate opponent intentions while viewing animated footage of tennis rallies where postural information from the players was removed, constraining participants to anticipate based on contextual information alone. They found that skilled players employed different gaze behaviors and more thoroughly evaluated the contextual information available to anticipate with greater accuracy than their less-skilled counterparts.

Researchers utilizing verbal report protocols in sports have interpreted findings as support for Long-Term Working Memory (LTWM) (Ericsson & Kintsch, 1995; for alternative conceptualizations of expert memory, see Gobet, 1998). LTWM holds that expert performers acquire a highly organized and complex memory system that allows them to easily encode, store, and retrieve domain-specific information. It enables experts to meet the processing demands of their domain through engaging in forward planning, anticipation, and evaluation of courses of action during performance (Ericsson, 2014; 2018). It is likely that LTWM is a key underlying mechanism of creative behavior. For example, by exploring and generating different task-relevant options or alternatives before selecting a final decision on actions to execute (e.g., Getzels & Csikszentmihalyi, 1976; Ward, Ericsson, & Williams 2013). This flexibility to generate and consider a diversity of tactical options that may be available during a course of action, which results from the capacity for divergent thinking, is a crucial component of creative behavior (Runco, 2014). Certainly, the production of creative performance and the acquisition of LTWM appear to depend on long-term immersion in a domain and the acquisition of expertise (Hayes, 1989). Although creative decision making appears to be an important component of expertise, relatively little is known about the underlying perceptual-cognitive processes of creative expert performance in the field of sports (Memmert & Roca, 2019). Therefore, further research is needed to provide a detailed description of the structure of the underlying perceptual-cognitive processes in this particular domain. Such knowledge is essential to the development of complete conceptual models of creative expertise, enabling researchers to move away from mere description, to explanation and prediction of creative expert performance.

In the present study, we investigate the perceptual and cognitive processes that underpin the creative performance of skilled soccer players. Eye-movement recording and verbal reports of thoughts were employed to identify the mediating processes underlying creative superior performance during a representative soccer-specific creativity task. It is possible that different process-tracing methods may identify somewhat unique strategies, thereby providing support for one another and enhancing our understanding of the important creative performance characteristics. Creativity scores obtained from the task were used to create two groups from a larger sample of skilled soccer players: high-creative and low-creative group. We expected that between-group differences in creative decision-making performance would be underpinned by differences in visual search strategy and cognitive thought processes. Specifically, we predicted that the high-creative players would employ a broader attentional focus including more fixations and to more task-relevant locations of the display compared to the low-creative players. Furthermore, the high-creative group would be able to detect key perceptual cues earlier in offensive plays, such as their attacking teammates in positions that could lead to a goal scoring opportunity (Furley et al., 2010; Roca et al., 2018). Finally, and in support of the LTWM theory (Ericsson & Kintsch, 1995), we predicted that high-creative players would engage in a greater number of evaluations and assessment of the current situation, as well as more planning of future tactical decisions to undertake, facilitating high levels of flexibility and creativity in their response in comparison with their low-creative counterparts.

**Methods**

*Participants*

Forty male outfield soccer players (*M* age = 21.0 years, *SD* = 2.0) took part in the study. These players were recruited from a range of different professional and semi-professional soccer clubs in South East England. They had an accumulated average playing experience of 15.5 years (*SD* = 2.7) and were engaged in an average of 8.5 hours (*SD* = 2.0) soccer practice a week at the time of the study. Ethical approval was obtained from the lead author’s University’s research ethics committee and research was conducted in accordance with the guidelines of this committee. All participants provided written informed consent.

*Experimental task*

Participants were presented with a representative task involving video sequences of dynamic 11 versus 11 attacking situations that offered a variety of options for the player in possession of the ball at the time of video occlusion (see Figure 1). The video-based test stimuli were created with the assistance of three qualified UEFA (Union of European Football Associations) soccer coaches from a large battery of videotaped matches in the highest professional soccer league in Germany. The 20 video sequences used in the study for the soccer-specific creativity test were those for which the expert coaches had agreed upon and offered a range of multiple decision options that may provoke creative tactical solutions (Roca et al., 2018). Each scene lasted approximately 10 sec and was occluded at a key moment in the action (i.e., the participant in possession of the ball with a variety of possible tactical options including different attacking passes, shot at goal, or dribbling forward).

*Procedure*

The soccer-specific creativity test video was projected (Epson EB-X31 3LCD Projector, Tokyo, Japan) onto a large white wall (image size 2.5 m high x 3.4 m wide). Participants started each trial in a standing position immediately behind a soccer ball (Mitre Cyclone indoor size 4 ball) placed on an “X” mark on the floor at a distance of 3 m from the video screen wall. They were required to imagine themselves as the attacking player with the ball. In order to increase the representativeness and fidelity of the decision-making behaviors and demands of the ‘real-world’ performance environment, participants were asked to physically play the ball in response to each situation as quickly as possible as the screen occluded (e.g., Roca, Williams, & Ford, 2014). Moreover, they were required to verbally confirm their response immediately after executing the action, which should be either to whom they were passing the ball or if they shot at goal or dribbled the ball forward. Additionally, they had to define how they intended to pass the ball to the player or shoot the ball at goal (i.e., how decision).

Immediately after the participant had completed their decision-making response, they were asked to provide a retrospective verbal report of the actual thoughts they recalled thinking whilst performing the task under time constraint. These retrospective verbal reports were taken on every second or third trial in a total of 8 randomly selected trials so that participants could not precisely determine when they were expected to give a verbal report on their thoughts (cf. McRobert, Ward, Eccles, & Williams, 2011). Following this, and for every trial, the last frame of the video clip was shown again for 45 sec. Participants were required to generate all other adequate tactical solutions they would or could execute for that situation (divergent thinking). Previous research (e.g., Johnson & Raab, 2003) revealed 45 sec to be a sufficient time period for participants to name the other additional actions they could or would perform.The real ambient crowd noise of the stadium was played through multimedia stereo speakers (Logitech Z200, [Lausanne](https://en.wikipedia.org/wiki/Lausanne), [Switzerland](https://en.wikipedia.org/wiki/Switzerland)) during the test to enhance realism and immersion on the task.

 A mobile eye-tracking system (Applied Science Laboratories, Bedford, MA, USA) including its mounted audio microphone was used to capture participants’ visual search and verbal report data, respectively. The head-mounted monocular eye-movement system computes point-of-gaze within a scene through calculation of the vector between pupil and cornea.

Insert Figure 1 about here

 Prior to testing, participants were given an overview of the experimental task and completed a biographical information sheet. Subsequently, participants underwent training on how to think aloud and provide retrospective verbal reports using Ericsson and Kirk’s (2001) adaptation of Ericsson and Simon’s (1993) original protocol. The training consisted of instructions on how to report thoughts retrospectively, description of how providing verbal reports differs to normal conversation, and practice providing retrospective verbal reports on generic and domain-specific tasks (for details on training participants to provide valid verbal reports of thoughts, see Eccles, 2012). These training instructions were read out for each participant from a pre-written script to ensure parity across participants. On average, the verbal report training protocol lasted approximately 30 min.

Following the verbal report training, participants were fitted with the gaze recording system, placing the eye-tracking glasses on their head and the digital transmission unit in a small backpack on their back. The system was calibrated as per manufacturer’s guidelines using six to nine non-linear calibration points on the visual display which encompassed the entire area of the display participants could potentially fixate on. The calibration function maps eye movement against scene data by relating the positions of eye features (the pupil and corneal reflection cluster) to known positions within the scene image. Calibration of the system was checked prior to starting the familiarization trials, between familiarization trials, and periodically during testing.

Participants were presented with three familiarization trials and were asked to practice giving retrospective verbal reports immediately after they had executed the action and verbally confirmed their decision-making response. If these reports were not satisfactory due to participants to summarizing or explaining their thought processes, the participant was reminded of their verbal report training and given further practice attempts. Participants completed 20 test trials and each individual test session was completed in approximately 90 min.

*Outcome data analysis*

Soccer-specific creative performance on the video-based tactical creativity task was assessed using the three criteria *originality*, *fluency*, and *flexibility*. This is a standard procedure in main general and domain-specific creativity research (Guilford, 1967; Memmert, 2015; Runco, 2014). *Originality* referred to the production of responses that are rare or less usual according to the norm. Three independent raters (qualified UEFA soccer coaches) judged the originality of the solutions given by participants for each scene using a scale ranged between 1 (not original at all) to 5 (very original). The inter-rater reliability for originality was above the critical limit of 0.80 (intraclass correlation coefficient). As an alternative to freezing the last frame of the clip as per past research in this field (e.g., Memmert, Hüttermann, & Orliczek, 2013; Hüttermann, Nerb, & Memmert, 2018), each scene was occluded at a key moment in action to obtain a prompt and more realistic action response similar to those required in a real-match situation. As a result, an additional originality criterion was used for the initial response (Roca et al., 2018). These ratings were used to calculate two mean originality scores for each participant, one for the initial response and another for the responses given when the last frame was shown afterwards for 45 sec (summed ratings for each response were divided by the total number of responses).

 *Fluency* was assessed by the number of appropriate tactical solutions produced by a participant per trial. *Flexibility* was measured via diversity of responses. All solution options given by the participants were sorted into different categories based on Roca et al. (2018: short pass, lofted pass, through ball, wall pass, back heel pass, outside of the foot pass, feinting, turn, crossing, dribbling, shot at goal). One point was given for each category selected by a participant and summed for the respective trial, before being divided by the total number of trials in order to determine a flexibility score for each participant. We used the standard procedure in creativity research (cf. Furley & Memmert, 2015; Hüttermann et al., 2018; Memmert et al., 2013) in which each of the four components (originality of initial response, originality, fluency, flexibility) were first analyzed separately followed by averaging the z-transformed values of each component into a single creative score for each participant.

 We used the creative performance scores (total, z-value) from the soccer-specific tactical creativity test as an objective method to differentiate the 40 skilled soccer players by using the score to create a rank order of participants (see Figure 2). Two groups were created from this rank order. The top 10 ranked players were classified as ‘high creative’, whereas the 10 players with the lowest creativity scores were classified as ‘low creative’. Players ranked in the middle 11-30 were excluded from further analysis. Response scores for originality of initial response, originality, fluency, flexibility, and the total creativity score were analyzed using independent *t*-tests between the high- and low-creative groups.

*Visual search data analysis*

The eye-movement data were recorded at 25 frames per second with the video footage being subjected to frame-by-frame analysis using Focus X2 video analysis software (Elite Sport Analysis, Fife, UK). The three most discriminating trials based on the greatest between-group differences in mean creativity scores were subjected to visual search analysis (cf. McRobert, Williams, Ward, & Eccles, 2009; Roca, Ford, McRobert, & Williams, 2011). The analyses of the eye-movements were conducted from the moment the play breaks forward and builds into a dangerous attacking scenario to the time of video occlusion for each situation as in Roca et al. (2018). Three main measures of visual search behavior were analyzed: search rate, percentage viewing time, and moment of first fixation on key attackers.

*Search rate.* Three measures of search rate were examined, namely, the mean fixation duration (in milliseconds), the mean number of fixations per second, and the mean number of fixation locations per second. A fixation was recorded when gaze remained within a 1.5º of movement tolerance upon a location for a minimum of 120 ms (Ward, Williams, & Bennett, 2002). Between-group differences across each of these three measures of search rate were analyzed separately using independent *t*-tests.

*Percentage viewing time.* The portion of time spent fixating various key performance-specific locations in the display was analyzed including: *player in possession of the ball*; *ball* (i.e., ball flight); *space* (i.e., areas of free space on the pitch in which no player is located); *attacker*; *attacker in threatening position* (i.e., teammate in a dangerous position which could lead to a goal scoring opportunity if he received a pass); *defender*; and *other* category for visual saccades and fixations that did not match with the aforementioned areas (e.g., fixation on spectators or stand). A factorial two-way ANOVA with Group (high-creative, low-creative) as the between-participant factor and Fixation Location (player in possession of the ball, ball, space, attacker, attacker in a threatening position, defender, other) as within-participant factors was conducted to analyze percentage viewing time.

*Attacker in threatening position fixation.* The moment of first fixation on different attacking teammates in or moving into a threatening position during the attacking play was recorded. This visual search measure is thought to be particularly relevant in characterizing some of the key perceptual processes underpinning creative performance in soccer (Roca et al., 2018). Between-group differences for moment of first fixation on the different attacking teammates in threatening positions were analyzed separately using independent *t*-tests.

*Verbal report data analysis*

The verbal report data were analyzed using the three most discriminating trials between groups, which were chosen based on the mean scores from the creative decision-making performance measure (see visual search data analysis). Participants’ retrospective verbal reports were transcribed verbatim and coded into three categories according to a structure originally outlined by Ericsson and Simon (1993) and further developed by Ward, Williams, and Ericsson (2003). The three types of cognitive thought statement categories were: (i) *monitoring* *statements*, recalling descriptions of current events and current actions (e.g., “left midfielder making a forward run”); (ii) *evaluation statements* were thosemaking some form of comparison, assessment, or appraisal of events that are situation, task, or context relevant (e.g., “right winger in lots of space”); and (iii) *planning statements* were about the participant’s own future tactical decisions/actions and action effects in a future situation (e.g., “ thinking to play a long through ball to the striker”).

Intra- and inter-observer reliability checks conducted on the verbal reports data provided an intraclass correlation coefficient of 0.91 and 0.82, respectively. These figures were created from a re-analysis of 20% of the data. Verbal report data were analysed using a factorial two-way ANOVA with Group (high-creative, low-creative) as the between-participant factor and Type of Verbal Statement (monitoring, evaluation, and planning) as within-participant factors. Finally, pairwise comparisons were conducted to investigate differences between groups in the type of statement made.

The Greenhouse-Geisser correction was employed in the case of violations of Mauchly’s test of sphericity. Effect sizes are reported using partial eta squared (*ηp2*) in all instances and Cohen’s *d* for comparisons between two means. In the case of significant main effects or interactions, Bonferroni-corrected pairwise comparisons were used as post-hoc tests. The alpha level was set at .05, but in the case of multiple *t*-tests, the Bonferroni correction was applied to control for familywise error (McLaughlin & Sainani, 2014).

**Results**

*Outcome data*

 The ranked creativity scores (total, z-value) from the soccer-specific tactical creativity test for the 40 skilled soccer players are presented in Figure 2. The mean response scores for originality of initial response, originality, fluency, flexibility, and overall creativity performance on the test across groups are presented in Table 1. The high-creative group obtained a significantly higher overall creative score on the test compared with the low-creative peers, *t*(18) = 13.53, *p* < .001, *d* = 6.02. Similarly, the high-creative players produced more original decisions for the initial response, *t*(18) = 4.39, *p* < .001, *d* = 1.99, and for the responses given when the last frame was shown, *t*(18) = 4.43, *p* = .001, *d* = 1.94, as well as more appropriate, *t*(18) = 7.87, *p* < .001, *d* = 3.51, and flexible, *t*(18) = 8.23, *p* < .001, *d* = 3.73, tactical solutions during the attacking situations.

Insert Figure 2 and Table 1 about here

*Visual search data*

*Search rate.* High-creative players visual search strategy involved more fixations (*M* = 2.73 fixations/sec, *SD* = 0.55), *t*(18) = 3.19, *p* = .005, *d* = 1.42, of shorter duration (*M* = 336 ms, *SD* = 74), *t*(18) = -3.10, *p* = .006, *d* = 1.39, when compared with the low-creative players (*M* = 2.04 fixations/sec, *SD* = 0.41 and *M* = 465 ms, *SD* = 108, respectively). Furthermore, high-creative players fixated gaze on more locations in the visual display compared to their low-creative counterparts (*M* = 1.11 fixation locations/sec, *SD* = 0.15 vs. *M* = 0.94 fixation locations/sec, *SE* = 0.16), *t*(18) = 2.42, *p* = .026, *d* = 1.03.

*Percentage viewing time*. Percentage viewing time data showed a significant main effect for fixation location, *F*(1.91, 34.37) = 53.72, *p* < .001, ηp2 = .75. Pairwise comparisons demonstrated more time was spent fixating the player in possession of the ball (*M* = 37.5%, *SD* = 14.1) compared to all other fixation locations. Players also spent more time fixating on attackers in a threatening position (*M* = 14.3%, *SD* = 6.1), followed by areas of free space (*M* = 13.1%, *SD* = 6.1), and other unclassified locations/visual saccades (*M* = 13.7%, *SD* = 3.2), when compared to other locations. There were no significant differences between fixations on the ball (*M* = 9.1%, *SD* = 4.4), defenders (*M* = 6.6%, *SD* = 4.2), and other attacking team players (*M* = 5.8%, *SD* = 3.8); all *p* = 1.00. ANOVA showed a significant Group x Fixation Location interaction, *F*(1.91, 34.37) = 6.58, *p* = .004, ηp2 = .27. These data are illustrated in Figure 3. *Post-hoc* tests revealed that high-creative participants spent more time viewing attacking teammates in or moving into a threatening position compared with the low-creative participants (*M* = 18.7%, *SD* = 4.2 vs. *M* = 9.9%, *SD* = 4.2, *p* < .001, *d* = 2.10).

*Attacker in threatening position fixation.* The mean data for attacker in threatening position fixations are presented in Figure 4. There were significant group-based differences for the moment of first fixation on attackers in threatening position. The high-creative participants identified a first (*M* = 2,149 ms, *SD* = 637 vs. *M* = 3,977 ms, *SD* = 1,252), *t*(18) = -4.12, *p* = .001, *d* = 1.84, and a second attacking teammate in or moving into a threatening position (*M* = 3,906 ms, *SD* = 827 vs. *M* = 4,899 ms, *SD* = 742), *t*(18) = -2.83, *p* = .011, *d* = 1.26, earlier on in the attacking play in comparison with their low-creative counterparts. Additionally, the high-creative participants identified on average four attacking teammates in threatening positions per trial as compared to only three attackers for the low-creative group.

Insert Figures 3 and 4 about here

*Verbal report data*

A main effect of group was found, *F*(1, 18) = 13.99, *p* = .001, ηp2 = .44. High-creative participants (*M* = 4.47 statements, *SD* = 1.18) generated significantly more verbal statements of cognitive processes in comparison with the low-creative group (*M* = 2.80 statements, *SD* = 0.77). A significant main effect for verbal statement type was observed, *F*(1.48, 26.66) = 19.24, *p* < .001, ηp2 = .52. Pairwise comparisons for statement type revealed that participants made significantly more evaluations (*M* = 1.70 statements, *SD* = 0.71) than all other statement types. A higher number of planning statements (*M* = 1.18 statements, *SD* = 0.54) were verbalized in comparison with monitoring statements (*M* = 0.75 statements, *SD* = 0.51) (*p* = .011, *d* = 0.82). There was no significant Group x Statement Type interaction, *F*(1.48, 26.66) = 1.66, *p* = .21, ηp2 = .09.

To test our a-priori prediction that the high-creative group would use more evaluation and planning statements than the low-creative group, we conducted two planned contrasts. These comparisons revealed the highly-creative group generated a significantly greater number of evaluation (*M* = 2.07 statements, *SD* = 0.58 vs. *M* = 1.33 statements, *SD* = 0.65, *p* = .016, *d* = 1.20) and planning verbal statements (*M* = 1.53 statements, *SD* = 0.45 vs. *M* = 0.83 statements, *SD* = 0.36, *p* = .001, *d* = 1.72) when compared to the low-creative group. These data are presented in Figure 5.

Insert Figure 5 about here

**Discussion**

We examined creative performance of skilled soccer players who were required to interact with a representative soccer video-based simulation of 11 vs. 11 attacking situations offering a range of decisional options for the player in possession of the ball. Players were categorized into high- and low-creative groups based on their performance on the soccer-specific creativity test, thereby allowing an intra-group comparison of perceptual-cognitive processes on the task. In order to identify the mediating perceptual-cognitive processes underlying creative expert performance on the task, we applied a combination of process-tracing measures that included eye-movement recordings and verbal protocol analysis. This has been the first attempt in the creativity literature within the sport domain to investigate how more creative athletes translate the information obtained from perceptual cues into appropriate creative tactical decisions. As per previous work on attentional and visual search in creativity in sports (Furley et al., 2010; Roca et al., 2018), we expected high-creative players to use a broader search strategy involving more fixations of shorter duration and an earlier detection of key informative cues in the performance setting (e.g., attacking teammates moving into goal-threatening positions) when compared with low-creative players. Moreover, we predicted that high-creative players’ broader attentional focus would be linked with engagement in a greater number of high-order cognitive processes involving evaluations and advanced planning of potential decisional options available on a course of action.

As predicted, the results revealed that between-group differences in creative decision-making performance were underpinned by differences in visual search strategy and cognitive thought processes. The search behaviors of high-creative players involved more fixations of shorter duration towards more informative locations in the visual display. These findings are in line with previous research on perceptual and attentional processes underlying creative decision making across different sports (e.g., Furley et al., 2010; Roca et al., 2018), providing support for the notion that the use of a broader breadth of attention, by taking in a large range of key task-relevant information, is critical to enable the production of creative expert behavior. The use of a wider attentional focus enables athletes to associate different visual stimuli that may, at first, appear irrelevant, thus preventing them from missing key game situation-specific information (Friedman, Fishbach, Förster, & Werth, 2003). Moreover, the analysis of the initial moment of gaze fixation on attacking teammates in or moving into goal-threatening positions showed that high-creative players not only recognized a greater number of teammates in these positions, but they fixated their gaze earlier in comparison with the low-creative players, supporting previous findings (Roca et al. 2018). It is expected that the ability of players to quickly recognize key advance information in the environment, which enables them to predict future scenarios, likely enables them to select decisions that are unexpected and less easily predicted by their opponent(s), thereby facilitating tactical creativity.

High-creative players not only employed a different visual search strategy when compared with their low-creative counterparts, but they also processed the information picked up by the visual system in a different manner. The high-creative players verbalized more thought processes that were related to the evaluation of the current situation and to the planning of potential tactical decisions to undertake in response to the attacking situations. These higher creative players appeared to engage in greater retrospective assessment of different options when compared to less-creative counterparts. Finding demonstrates high-creative players have a broader choice of original options stored within LTWM (Ericsson & Kintsch, 1995) as compared to less-creative players. In addition, the greater number of evaluation and planning statements made by high-creative players when reporting their thoughts are consistent with findings in the expertise literature and can be interpreted as evidence supporting the LTWM theory (Ericsson & Kintsch, 1995; for alternative conceptualizations of expert memory, see Gobet, 1998). It is likely that some key features picked up from the display by the high-creative players, have acted as retrieval cues, activating the retrieval of task-relevant information from LTM, resulting in their more advanced and superior planning and evaluation of current performance situation. According to Weisberg (2018), as individuals work through trying to apply their expertise to novel and unique situations, failures result in new information becoming available, which leads to the development and acquisition of innovative and new directions of thoughts and creative behaviors. The production of creative behavior appears to depend largely on long-term immersion in the specific domain, which provides the opportunity to engage in this process and for the acquisition of expertise.

The knowledge gathered from this study on the exploration of key perceptual-cognitive processes that mediate creative expert performance in the sport of soccer (e.g., information on the effective use of vision during creative decision making) can be used as initial research-based guidelines when designing or developing training interventions to facilitate the acquisition of domain-specific creativity. Moreover, such research findings may be used to test and refine existing models of creative expertise, potentially making significant contributions to skill-based theories of expert performance and creativity. Finally, domain-specific creativity tests such as that employed here can offer the potential to be utilized as talent screening tools. Future developments in the field of domain-specific creativity should shed further light on how creative performance is developed and can be facilitated through practice (e.g., Memmert, Baker, & Bertsch, 2010).

The viewing perspective of the video footage employed in this experiment may be considered a limitation in the study because it did not replicate a player’s first-person viewing perspective. However, we are mindful of the current challenges and difficulty of recreating such highly complex and dynamic 11 vs. 11 open-play scenarios from an attacker’s perspective (i.e., filmed from the perspective of the player in possession of the ball) given the game surrounds the player in possession of the ball. Furthermore, participants verbalizing the options they could execute following their initial physical response to each game situation is different to being able to perform those options in match play, which is a limitation of this type of methodological approach in sport creativity research. In future, scientists should attempt to develop even more representative and ecological approaches to the one employed in this research design (e.g., using immersive video or virtual reality technology, see Panchuk, Klusemann, & Hadlow, 2018) that could offer a more holistic method to study such complex behaviors and dynamic environments.

In conclusion, we have demonstrated that creativity-based between-group differences in decision making are underpinned by differences in visual search strategy and cognitive thought processes. High-creative performers employed a broader attentional focus that involved more fixations and picked up key informative cues earlier in the visual display (i.e., teammates getting into dangerous positions which could lead to a goal scoring opportunity if they received a pass) when compared with their low-creative counterparts. Furthermore, the more effective scanning strategies of high-creative players were supported by a greater engagement in high-level cognitive processes related with the planning and evaluation of task-relevant decisional options made available during the attacking situations. Findings reveal the perceptual-cognitive processes that mediate creative expert performance in the sport of soccer and may contribute to further develop theoretical accounts in the field.

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**Compliance with Ethical Standards:**
Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Figure 1. A final frame extracted from a typical trial of the soccer-specific tactical creativity test (camera’s viewing angle maintained across trials).

Figure 2. The creativity scores (total, z-value) from the soccer-specific creativity test for all participants presented in a ranked order.

Table 1. Mean (SD) response scores for the soccer-specific creativity test across groups

|  |  |
| --- | --- |
|  | **Group** |
| **Measure** | **High creative** | **Low creative** |
| Originality (initial response) |  3.28 (0.35) | 2.64 (0.29) |
| Originality |  2.80 (0.18) | 2.45 (0.18) |
| Fluency |  3.08 (0.21) | 2.23 (0.27) |
| Flexibility |  2.96 (0.32) | 1.91 (0.25) |
| **Creativity score** (total, z-value) |  **1.01 (0.30)** | **-0.89 (0.33)** |

Figure 3. Mean (SE) percentage time spent viewing each fixation location across groups (*PiP*, player in possession of the ball; *Attacker TP*,attacker in a threatening position).

Figure 4. Mean (SE) moment of first fixation during the attacking play on key attackers in or moving into a threatening position across groups.

Figure 5. Mean (SE) number of different types of verbal report statements made across groups.