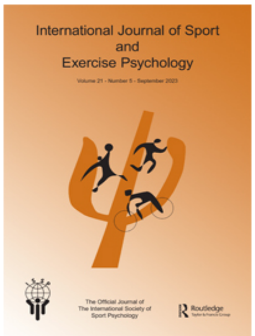

International Journal of Sport and Exercise Psychology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rijs20

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INTERNATIONAL JOURNAL OF SPORT AND EXERCISE PSYCHOLOGY
https://doi.org/10.1080/1612197X.2023.2204364

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RESEARCH ARTICLE

Individual attention capacity enhances in-field group performances in soccer

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ABSTRACT

Visual attention capacity impacts performance in different laboratory and real-world tasks positively. The present field-study extends for the first time performance gains from individuals to team performance. Our study examined the attention capacity of 88 soccer players to create low vs. high attention capacity teams (LACT vs. HACT) who competed in a controlled field-study. Positional data were gathered using player tracking systems (1 Hz) in a standardised 11 vs. 11 soccer game. Key performance indicators (KPIs), which have been established in match analysis research, were measured to reflect tactical performance of the teams. As predicted from attention frameworks, HACT outperformed LACT in five out of seven KPIs, suggesting that attention capacity might play a crucial role for/in searching and gathering important space on the pitch. These findings provide evidence for attention being a predictor of team success. Practice task designs with an emphasis on attention capacity therefore could be a useful tool to study the emergent behavioural dynamics in a real-world environment.

ARTICLE HISTORY
Received 12 August 2022
Accepted 13 April 2023

KEYWORDS
Attention; team performance; real-world performance

Introduction

Kevin De Bruyne, Messi, or Luka Modric succeed effortlessly in finding solutions in extremely complex situations. Successful soccer coaches, and often also players, speak of mental speed, “the head is important”, “very fast in the head”, or “intelligent players”. And indeed, research supports the expert’s appraisal that cognitive skills play a fundamental role in soccer and other sports games (for reviews, see Mann et al., 2007; Scharfen & Memmert, 2019; Voss et al., 2010; Memmert, 2021a). One of the biopsychological descriptors (Latinjak & Hatzigeorgiadis, 2021) which can be modulated by means of cognitive skills is attention. Next to other factors (e.g., perception, anticipation, working memory; see Furley and Memmert, 2012), high attention capacity has been suggested as one of the major determinants of extraordinary players (e.g., Verburgh et al., 2016; Vestberg et al., 2012). An important indicator of attention capacity is the size of the attention window (for a review, see Hüttermann & Memmert, 2017). This claim is supported by various experimental studies, showing that sports experts have a broader visual attention

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capacity than novices (Hüttermann et al., 2014) and that the width of visual attention is linked to creative decision making in a computer-based test (Hüttermann et al., 2019), penalty kicking performance (Memmert et al., 2020), and performance of soccer assistant referees in correctly detecting offside situations (Hüttermann et al., 2018). What is still unclear, though, is how attention processes and especially the attention window of players impact group performance in real-world settings.

Theoretical framework

In sport science, attention is regarded as a key factor for athletic performance (for a review, Moran, 2016; Memmert, 2009; Memmert et al., 2023). Team and racket sport players need adequate attention skills while simultaneously performing various activities in order to be able to act successfully in complex situations (Memmert, 2015a; 2021b). Further evidence for the significance of attention in sports performance stems from the finding that directing or redirecting attention is one of the mechanisms through which the positive effects of self-talk are mediated (Galanis et al., 2018). In soccer, for example, it is necessary to lead the ball and shield it from your opponent while at the same time "searching" for free players (Williams et al., 1999). Or the soccer referee has to observe both the position of the goalkeeper and the players in the other half of the pitch. In many soccer situations, it is necessary to process several pieces of information at different places in parallel.

In sport psychology, the concept of attention, as a subprocess of perception, can be understood as the selection of relevant stimuli and the selective structuring of the field of perception (Hüttermann & Memmert, 2017). It has been shown that visual attention is necessary for consciously perceiving pieces of information (Dehaene et al., 2006). Interestingly, for the case of team sports, it has been found that athletes receive much of their information through peripheral vision (e.g., Ryu et al., 2013), which makes the area of the visual field which a person can process a key determinant of visual capabilities in sport. This notion is based on Feature Integration Theory (Treisman & Gelade, 1980), which states that parallel detection of visual targets is possible without focal attention. This parallel detection is based on certain features of the targets, like colour, and can be as effective as serial detection if the environment presenting the targets is familiar. It is particularly important in situations where focused attention is prevented by brief exposure or overloading. In the context of team sports situations, the environment can be assumed to be familiar to players and for example jersey colour can be considered a feature enabling the detection of teammates and opponents. Given the limited time available to players for making decisions (Musculus, 2018; Petiot et al., 2021), parallel detection seems relevant to perception in team sports situations.

Feature Integration Theory predicts increased search times for larger display sizes (i.e., for detecting more targets). Since the available search time is limited in a team sports setting, detecting as many targets as possible within the available time frame can be considered the main challenge of team sports. The more targets (teammates or opponents) a player can detect, the more information is available to him or her in order to make decisions (for example choosing the right player to pass the ball to or the right location to run to). Making better decisions in team sport situations in terms of passing or movement will increase the chances for a team to score goals or win matches (Rein et al., 2017).

Therefore, in the context of sporting performance, one of the most important indicators of attention capacity is the maximum distance between two stimuli, both presented peripherally, which can still be perceived by the athlete (Hüttermann & Memmert, 2017). This visual attention capacity, further referred to as attention capacity, can be measured by the attention window task, which captures the scope of a participant's visual attention (Hüttermann & Memmert, 2017).

Hüttermann et al. (2013) developed a new paradigm with which the so-called "visual attention window" (VAW) of a person can be determined. This represents the maximum consciously perceptible field of attention in the horizontal, vertical, and diagonal directions. Athletes in team sports have up to 25% larger VAW than non-sports game players, at least in terms of horizontal and diagonal alignment (Hüttermann et al., 2014). In follow-up studies, the research group of Hüttermann established this attention window-paradigm and demonstrated the crucial role of the attention window in different kinds of contexts (for an overview, see Hüttermann & Memmert, 2017). Latest research scrutinised the relationship between attention capacity and performance in sport-specific computer lab tasks. Here, people with a high attention capacity (HAC) outperformed the low attention capacity (LAC) group in a soccer-specific divergent thinking task (Hüttermann & Memmert, 2017) and in an offside decision-making task (Hüttermann et al., 2018). Furthermore, it could be shown that the width of the attention window positively affected performance in a basketball-specific interference task (Güldenpenning et al., 2020). In summary, the relationship between attention capacity and performance in sport-specific lab tasks has been established. The question arises if individual attention window capacity translates to improved team performance in a real-world scenario, where multiple persons as well as their specific capabilities interact to produce solutions to domain-specific problems such as playing soccer.

To measure the complex behaviour and performance of teams and the players in an 11:11 soccer match set-up, we use established Key Performance Indicators (KPIs) of the match analysis literature (for reviews, see Memmert et al., 2017; Low et al., 2020). Although it might seem reasonable to utilise the match outcome as a measure of team performance, this is not advisable because the rareness of goals causes a large influence of chance on the score line, making goals an unstable indicator of performance (Lames & McGarry, 2007; Wunderlich et al., 2021). For these reasons, it has become common practice in match analysis research to rather examine performance indicators, which allow a more nuanced assessment of teams' performance (Rein et al., 2017).

The KPIs used in this study measure the performance of teams with respect to moving the ball into dangerous zones within the opponents' half of the pitch by means of passing (Rein et al., 2017). Although a pass is executed by a single player, the KPIs reflect the performance of the whole team, since the space controlled by a team is a consequence of the positioning of all players on the field, their distances to each other and to their opponents (Memmert et al., 2017). The space control gained by a successful pass is therefore not only affected by the player executing the pass, but also by the player receiving the pass as well as by every other player on the field, and can consequently be considered a team-level variable (Brinkjans et al., 2022). The same is true for the number of outplayed opponents per pass, since all players participate in opening up spaces for successful passes (Rein et al., 2017).

The present research

Thus, the rationale for the present research was twofold. First, we followed the call from Kingston et al. (2003; see also Fiedler, 2011; Simmons et al., 2011) who pointed out the necessity of replicating effects found with one set of stimuli with different stimuli that are more representative of the real world to ensure that the phenomenon of interest does not only apply to a certain, highly controlled stimulus sets but actually generalises toward the behaviour or phenomenon of interest.

Second, the following research will try to provide the first direct evidence that individual attention capacity influences performance in a specific real-life group scenario (here: KPIs in a soccer match set-up). While there exists evidence for the importance of the breadth of attention for sporting performance (Nideffer, 1976, 1990; Hüttermann et al., 2018), previous work has either utilised self-report measures of attentional breadth and an observational approach to the study of attention and sporting performance (Nideffer, 1976) or laboratory-based assessments of sporting performance, which might not generalise to real-world sporting performance (e.g., Hüttermann et al., 2018). In the present study, we used an objective measure of attention capacity and adopted an experimental study design by assigning players to different teams based on attention capacity, while studying their sporting performance in a representative task design in the field. To this end, we used several of the most common and validated KPIs in soccer (e.g., Folgado et al., 2014; Fonseca et al., 2012; Memmert & Raabe, 2018; for a review see Low et al., 2020). Thus, we aimed to compare the in-field performance of two teams with differences in players' attention capacity adopting a real-world paradigm. A trial-based approach was used to study the performance effects of teams with different individual attention capacity (HAC vs. LAC team) on KPIs in 11 vs. 11 soccer (see Memmert et al., 2019). Especially in team sports, the orientation and direction of attention play an important role (Williams et al., 1999; Memmert, 2015a). The respective players need to rely on attention capacity during searching for different locations and spaces on the pitch, in order to act successfully in complex situations of any type of sport (Savelsbergh et al., 2005). In previous research (cf. Hüttermann et al., 2018, 2019) it was found that better attention capacity led to better decision making by soccer players and referees in a lab setting. Drawing from Feature Integration Theory, this is likely due to the players' ability to detect more relevant targets (teammates or opponents) in order to inform their decisions, for example by detecting an opponent who could possibly intercept a pass or by detecting a teammate in a promising position. If this effect translates to the real-world setting, the same should hold true for the KPIs in an 11 vs. 11 soccer match and players with better attention capacity should be able to detect more relevant targets and therefore to make better decisions, for example by moving the ball or themselves to a better position. In combination, the players from the HAC team should be able to collectively occupy more space and to overcome more opponents by means of their movement and passing behaviour. We consequently derive the following hypotheses:

(1) The HAC team (HACT) will show greater Space Control Gain per pass in the Attacking Third than the LAC team (LACT)
(2) The HACT will show greater Space Control Gain per pass in the Score Box than the LACT

(3) The HACT will show more Outplayed Defenders per pass than the LACT

In order to occupy space in the offensive third and in the score box, a spatial distribution toward the centre of the pitch is necessary, resulting in a longitudinal shape of the team. Therefore we further assume:

(4) The HACT will show a lower Effective Playing Space than the LACT
(5) The HACT will show a higher Team Length than the LACT
(6) The HACT will show a lower Team Width than the LACT
(7) The HACT will show a higher Length-per-Width ratio than the LACT

Materials and methods

Participants

A total of 88 male participants (age: $M = 19 \pm 5$ years), who had been playing for an average of 12 ± 5 years at a higher amateur level took part in the study, which consisted of four testing sessions. Therefore, 22 players took part in every testing session. The participants on average spent 4.9 ± 1.9 h per week practicing and 1.5 h per week in competition. For every testing session, the respective players competing together belonged to the same team and were therefore familiar with playing with each other. The participants received no monetary compensation. All participants gave their informed written consent prior to their inclusion in the study and were debriefed afterward. The present research fully complies with the highest standard of ethics and participant protection which followed the guidelines stated in the Declaration of Helsinki and was approved by the local ethic committee.

Procedure

For each of the four respective testing sessions, 22 players performed the attention window task (AWT) several days in advance of the in-field testing sessions. The AWT is extremely robust with regard to many influencing factors (Hüttermann & Memmert, 2017). In addition to reliability and objectivity measures, validation studies are also carried out, which consider the factors age, gender, expertise, motivation and physiological factors, among other factors (e.g., Hüttermann et al., 2014). All variables are theoretically compliant and indicate that the AWT is a reliable test instrument to determine the attention window of subjects.

After AWT scores had been obtained for each participant of one session, the players were split into two teams (HACT vs. LACT) based on their AWT scores, while balancing their skill level between teams and assigning them to appropriate positions based on their previous soccer experience. The assignment into teams was carried out by the head coach of the respective team, together with a UEFA-A-licensed coach (8 years of coaching experience at this level), who had observed the teams in training or competition before.

On the day of the in-field testing session, players arrived and were told their allocation to one of the teams. They were not told about how the teams had been formed. After team formation, each player was fitted with a sensor. Before each testing session, the participants performed a standardised 20-min warm-up consisting of running, stretching, and a small-sided game.

To assess the KPIs, a field-study was conducted on a standard-size natural turf pitch (105 m x 68 m) and was played – apart from an artificial segmentation into trials – in accordance with official soccer rules in an 11-vs.-11 soccer match setup. Each testing session lasted about 90 min and, in total, four testing sessions were carried out.

The testing in each of the four sessions was segmented into eight blocks of six trials each, yielding 48 trials per session. For each block, one team was allocated the attacking team, playing in the formation 3-5-2, whereas the other team was the defending team, playing in the formation 4-4-2. Both teams (HACT and LACT) alternatingly acted as the attacking team for one block, respectively. Both teams were familiar with playing in both formations and the same coaching instructions were given to both teams in every testing session.

Each trial started with the goalkeeper of the attacking team initiating the trial through a short pass to a central defender. A trial was terminated when one of three events occurred. Either a goal was scored, the game was interrupted (i.e., a foul was committed, or the ball left the pitch), or the defending team gained possession. Possession was defined as playing one controlled pass in which the pass receiver was able to maintain ball control. Each trial, therefore, started from the same initial conditions. Once a trial was terminated both teams were given time to go back into their respective starting positions at their own speed. Prior to each block, the attacking team received instructions about its formation and the intention to score a goal. The defending team was instructed to try to clear the ball while maintaining its formation and playing a midfield pressing. Thus, no pressure was put on the goalkeeper when starting a trial.

The reasoning behind adopting a trial-based approach to assess tactical performance in soccer was based on previous work suggesting that such an approach could ensure a certain degree of standardisation while examining sport performance, ruling out confounding variables (Mackenzie & Cushion, 2013; Memmert et al., 2019).

Attention-window task (AWT)

According to Hüttermann et al. (2018, 2019), the AWT required participants to perceive two conjunct peripheral stimuli simultaneously. Players were tested individually in a quiet room near the pitch and sat approximately 49.5 cm in front of a 43.5 × 27.3 cm screen. A keyboard was used for the participants to respond and instructions were delivered on the screen prior to the task. They were also encouraged to ask questions before starting. Participants performed 16 practice trials, before commencing the attention-demanding conjunction task. This main task included 288 trials divided into six blocks à 48 trials with a break of 30 s after each block. At the beginning of each trial, a black fixation cross was shown for 1000 ms in the centre of the presentation area in the first display sequence. Subsequently, two indicating pre cues were blended in the second display sequence for 200 ms at the exact same places at which the target stimuli appeared later for 300 ms. The time interval between the presentation of the peripheral indicating cues and the target stimuli was 200 ms. By systematically varying the stimuli positions and the distances between the stimuli, the task enabled the measurement of participants' attention capabilities. In the AWT, different stimuli pairs were displayed along eight meridional directions (0°, 45°, 90°, 135°, 180°, 225°, 270°, or 315°; in total one horizontal, one vertical, and two diagonal meridians), symmetrically around the screen centre with eight standardised stimuli distances along each meridian. Stimuli positions varied randomly between all trials of each block. Each stimulus was composed of four elements that were either circles or triangles filled with light or dark grey. The form (circle, triangle) and shading (light grey, dark grey) of all elements varied randomly from trial to trial, meaning that there were four possible elements. Participants had to identify the number of light grey triangles in each stimulus. The probability of presenting zero, one, two, three, or four light grey triangles in a stimulus was 20% each. In this way, the task required participants to not just detect the form or the shading of elements but rather the conjunction of both, that is, triangle and light grey, which was attention-demanding (Treisman & Gelade, 1980). The AWT was programmed and run in E-Prime Version 2.0.8.74 (Psychology Software Tools, Pittsburgh, PA) and reliability and validity of the measures have been checked in previous research (e.g., Hüttermann & Memmert, 2017; Kreitz et al., 2016).

In-field key performance indicators (KPIs)

The playing field was equipped with a portable Kinexon© tracking system using 16 transponders. One standard-size soccer was used during data collection. The ball was equipped with a transponder which allowed tracking its position as well whilst not changing the physical properties of the ball. X-Y position data from all players and the ball was collected at 25 Hz. After carrying out the field-study, the raw position data was exported from the tracking system into csv-files and pre-processed for analysis (for the validity of the Kinexon© system, see Hoppe et al., 2018).

The data was subsampled to 1 Hz. To ensure data quality, each trial of the study was screened individually, and a completeness rating was calculated based on the fraction of time-points that contained data for all players and the ball. Subsequently, data with a low completeness score were omitted. Missing values in the remaining trials were then imputed by linear interpolation. The final sample consisted of 87 trials played in the LAC condition and 90 trials in the HAC condition.

Subsequently, several approaches for tactical data analysis were implemented (for an overview, see Memmert, 2021b): Game dynamics linked to passing behaviour were analysed using the SOCCER© software package (Grunz et al., 2012). Passes were automatically recognised, resulting in a total of 829 passes. Space control was modelled by utilising Voronoi diagrams of the pitch at each point in time (Fonseca et al., 2012) and differentiated following a division of the pitch into three areas of interest: defensive zone, midfield zone, and attacking zone (Lago, 2009). A given space on the field is, per definition, controlled by the player whose position is closest to that space. Space control was calculated for the attacking zone and the score box (Tenga et al., 2010). Based on Rein et al. (2017), the gain in space control and the number of outplayed defenders through passing were selected as important factors for analysing attacking play. The number of outplayed defenders per pass is calculated as the difference of opponent players that are located between the ball and the opponent's goal before and after the pass was made.

Finally, seven indicators of tactical performance were analysed as dependent variables: Space Control Gain in the Attacking Third per pass, Space Control gain in the Score Box per pass, Outplayed Defenders per pass in the direction of play, Effective Playing Space, Team Length, Team Width and Length-per-Width ratio. The variables related to space control gain reflect percentage values (the change in space control between initiation and completion of every pass) and were averaged over the respective passes per trial. Outplayed Defenders is expressed as the average number of opponent players that are outplayed per pass in the respective trial. Effective Playing Space represents the space occupied by a team, and uses the convex hull computation to calculate the polygonal area formed by players on the periphery of play (Frencken et al., 2011); Team Length and Width represent the teams' spread on the field (maximum distances between two outfield players longitudinally and laterally, respectively) and the Length-per-Width ratio is calculated by dividing the Team Length by the Team Width, reflecting the team's shape as flat (Team Width is greater than Team Length) or elongated (Team Length is greater than Team Width) (Folgado et al., 2014). Trial averages of these measures were calculated for further analyses.

Statistical analysis

For the AWT, final scores were calculated for horizontal, vertical, and diagonal trials. The final score for each meridian is composed of the largest distance between the stimuli at which at least 75% of responses were correct. For the seven variables of tactical performance, trial-based analyses were performed, resulting in a sample size of $N = 177$ (87 with LACT attacking and 90 with HACT attacking). The trials originated from four different testing sessions with different teams participating in the respective sessions, which led to a hierarchical study design. Therefore, all dependent variables were modelled using linear mixed effects models, modelling the effect of attention capacity as fixed effect and the effect of the testing session as random effect (Faraway, 2016). The effect of the fixed effect on the dependent variables was determined using t-tests. The magnitude of the effects was calculated following Brysbaert and Stevens (2018), adopting a calculation of Cohen's d fit for mixed models. All statistical analyses were performed using the R statistical software (R Core Team., 2017). Linear mixed models were calculated using the *lme4* package (Bates et al., 2007). Because of the difficulty of determining degrees of freedom in a mixed model, the Satterthwaite approximation was used, resulting in decimal numbers for the degrees of freedom. The level of significance for all tests was set at $\alpha = 0.05$.

Results

Descriptive statistics of all dependent variables and the variance in each parameter that could be attributed to the random effect of test session can be seen in Table 1.

As intended by assigning players to teams based on their performance in the AWT, players in the HACT showed higher attention capacities than the players in the LACT in all four test sessions tested separately [$t(10.33) = 3.96$, $p \leq .05$; $t(20) = 5.66$, $p < .001$; $t(20) = 4.5$, $p < .001$; $t(19) = 7.28$, $p < .001$] as well as for overall testing [$t(72.19) = 6.22$, $p < .001$]. Therefore, we collapsed all tests group together in HACT and LACT for testing the main assumptions.

Table 1. Means and standard deviations for all variables for LACT and LACT and random effect of test session in the linear mixed models.

	Team		
	LACT	HACT	Random effect of session
	M ± *SD*	*M* ± *SD*	*Variance*
Space Control Gain in Attacking Third [%]	0.45 ± 2.21	1.51 ± 3.45	0.09
Space Control Gain in Score Box [%]	0.03 ± 1.11	0.44 ± 1.42	0
Outplayed Defenders [#]	0.57 ± 1.00	0.62 ± 1.26	0.04
Effective Playing Space [m^2]	1370.41 ± 155.79	1313.19 ± 257.76	22947.72
Team Length [m]	34.77 ± 3.42	35.42 ± 5.52	8.13
Team Width [m]	55.19 ± 5.27	53.88 ± 4.66	13.97
Length-per-Width [ratio]	0.65 ± 0.11	0.68 ± 0.14	0.01

As predicted, statistical analyses revealed a significant difference between HACT and LACT with respect to Space Control Gain in the Aattacking Third [$t(167.38) = 2.39$; $p \leq .05$; $d = .12$] and Space Control Gain in the Score Box [$t(170) = 2.13$; $p \leq .05$; $d = .25$]. In contrast to our main assumption, no significant differences were found for Outplayed Defenders [$t(166.97) = .28$; $p = .779$; $d = .04$].

As predicted, HACT showed a significantly lower Effective Playing Space compared to LACT [$t(172.01) = -2.45$; $p \leq .05$; $d = -.001$], a significantly lower Team Width [$t(172.02) = -2.48$; $p \leq .05$; $d = -.05$] and a significantly higher Length-per-Width ratio [$t(172.03) = 2.1$; $p \leq .05$; $d = 2.03$], while no significant difference was found for Team Length [$t(172.02) = 0.99$; $p = .321$; $d = .03$].

In practical terms, the HACT could, on average per pass, improve their space control in the attacking third as well as in the score box at a larger scale than the LACT. For this, all outfield players together covered a smaller area of the pitch while adopting a smaller lateral expansion than the LACT.

Consequently, HACT outperformed LACT in both indicators related to space control gain. HACT were on average less spread out on the field and rather adopted longitudinal distributions by positioning themselves less widely than LACT.

Discussion

As athletes are continuously confronted with a multitude of visual and auditory stimuli in the specific situations of their sports, the question arises of which role individual attention capacity plays in order to make decisions on the pitch. Previous attention research demonstrated that visual attention capacity impacts performance in different laboratory and real-world tasks positively (see Hüttermann & Memmert, 2017; Hüttermann et al., 2014). Based on this assumption, we were able to test for the first time the effect of players' attention capacity on their in-field team performance by measuring tactical indices in a field-setting (11 vs. 11 soccer match set-up) and therefore extend attention performance gains from individuals to team performance.

We used the AWT which is a reliable, objective and valid measurement to determine the attention window of subjects. Variables like age, gender, expertise, motivation and other physiological factors were theoretically compliant and indicated that the AWT is a reliable test instrument (e.g., Hüttermann & Memmert, 2017; Hüttermann et al., 2014).

The results support the main prediction that teams with higher attention capacity generally outperform teams with lower attention capacity in five of seven performance variables in an in-field soccer scenario. The observed differences had small effect sizes but were statistically significant. This might be due to the high complexity of the interactions between 22 players which make up the KPIs. Many players have to move in a certain way to elicit large changes in the dependent variables, while on the other hand, even small changes in these variables can be meaningful for the outcome of a game. This is corroborated by the findings of Rein and colleagues (2017), who observed small effect sizes of these KPIs that could significantly explain match success. In summary, teams with higher attention capacity had higher Space Control Gain from passing, whereas team dispersion was less, due to a narrower team width, which led to a more elongated playing shape. As soccer is a game about space and time, understanding how teams occupy pitch spaces is an important part of tactical analysis. Previous research has shown that teams in attack occupy larger areas than teams in defence (Castellano et al., 2013; Fonseca et al., 2012; Moura et al., 2012); this is similar to the results of this study (SCMF + SCA > 50%) and is aligned with soccer principles of play, as making the playing area bigger helps attacking teams create more goalscoring chances while defending teams reduce their playing area to prevent opponents from doing just that. A previous study has shown that in GK + 7 vs. 7 + GK, using different formations can result in different space control values, while some formations showed no clear differences (Baptista et al., 2020). The present results further contribute to research by showing that using the same formation, differences in competing teams' space control can also be linked to innate differences in teams' attention capacity.

The present study examined the creation of space control by means of players' passes, in so doing, providing more context to the analysis (Wright et al., 2013). A study by Filetti and colleagues (2017) linked space control with passing as part of a technical index, which subsequently related to a higher likelihood of winning. Similarly, another study showed that in the attacking third, the gain in space control from passes successfully predicted goals scored and win probability (Rein et al., 2017). Since the same measures were used in this study, we can infer better performance in the high attention capacity teams. In sum, these findings on space control add to the currently scarce literature and indicate better attacking performance in teams with broad attention capacity. This extends findings from earlier laboratory research, indicating a positive effect of attention capacity on performance in a soccer-specific computer lab task (Hüttermann & Memmert, 2017) and shows that a high attention capacity actually improves the ability to make decisions in a soccer match set-up. More importantly, Hüttermann and Memmert (2018) have shown that attention capacity can actually be improved by implementing specific laboratory-based and field-based training means. Based on the present results, it can be assumed that these improvements translate to the match and team setting.

Players from the HACT showed higher quality of their passes, meaning that they could better perceive opportunities to increase the team's space control by moving the ball to another location. Perceiving those opportunities requires the ball carrier to process visual information of as many teammates and opponents simultaneously as possible. Possessing a higher attention capacity seems to positively affect this perception and processing of visual stimuli.

However, no significant differences could be found for the number of outplayed defenders per pass. This might be due to the similarity in playing formations of both teams. Descriptive statistics indicate that the number of outplayed defenders per pass is similar for both teams. Since both teams defended in a 4-4-2 formation, it is likely for a pass to outplay one of the three lines which contained the same number of players for both teams. Presumably, better passes were rather characterised by opening up more space than by outplaying defenders.

The present study also analysed spaces through the examination of teams' effective playing space. Its basis differs from the aforementioned variable of space control. The latter sums up portions of the pitch controlled by individual teammates (Kim, 2004), and is hence a simple addition of individual areas; the Effective Playing Space, however, is based on the concept of the team as a complex collective entity, possessing inherent characteristics not otherwise observable from the simple aggregate of constituent elements (Duarte et al., 2012). The present results show that teams with broad attention capacity attacked with smaller dispersion than teams with narrow attention capacity. This seemingly contradicts the earlier finding (broad attention capacity teams attack with higher space control but a lower Effective Playing Space) but can be explained methodologically – as peripheral players move inwards, a team's convex hull decreases but space control increases (attacking team), insofar as they remain peripheral players. Also, the lower dispersion can be attributed laterally rather than longitudinally, since broad attention capacity teams had reduced Team Width but similar Team Length, further explaining the larger Length-per-Width ratio.

Since the current participants are already experienced adult players, the results on team dispersion show support that beyond a certain tactical ability, expert teams do not increase their dispersion more than needed, suggesting a principle of *as wide as necessary*, rather than *as wide as possible*. Since teams generally try to defend their goal and, therefore, defensive pressure is higher in the centre of the pitch, a narrow spatial distribution closer to the goal places higher demands on the players with respect to perception of their surroundings. If players are generally covered more closely by opponents, they have to process visual stimuli more efficiently in order to make good decisions under pressure. Following from this, a higher attention capacity seems to enable players to position themselves more closely to the centre of the pitch. Concomitantly, the findings could also suggest that peripheral players in teams with narrow attention capacity, increase their team width as a compensatory mechanism; an interesting finding which future research could explore. Previous research has shown that in youth soccer, larger and wider dispersion reflect better tactical ability in teams. This was demonstrated by: increasing trends of Effective Playing Space with age (Barnabe et al., 2016; Vieira et al., 2019); increasing trends of lateral dispersion with age (Barnabe et al., 2016; Olthof et al., 2018); decreasing trends of Length-per-Width ratio with age (Folgado et al., 2014; Olthof et al., 2018); and a higher dispersion in national-level players compared to regional-level players of the same age (Silva et al., 2014). However, this increasing trend between dispersion and tactical maturity does seem to plateau. Vieira and colleagues (2019) investigated Effective Playing Space in under-11 (U11), U13, U15, U17, U20, and professional players and only observed this increasing trend in the first three age groups; furthermore, U15, U17, and U20 players had similar or larger dispersions than professionals. Gonçalves and colleagues (2016) also showed larger dispersions in amateur players compared to professional players. Taken together, these findings on dispersion show differences in intrinsic team behaviour between broad and narrow attention capacity soccerers, and, in the context of wider literature, suggests an explanation for dispersion in adult teams.

A benefit of the present study design is that our approach – in contrast to other studies was performed in a real-world setting. The ecological psychologist Egon Brunswik (1956) advocated for scientists to pursue representativeness in the design of tasks they required participants to perform. This means that the field-settings represent, as much as possible, participants' natural sporting environment to which the generalisation of results is intended. This is important because artificially contrived laboratory experiments alone may not distinguish expert and novice athletes (Farrow & Abernethy, 2003). Although the present study examines soccerers in their playing environment, it constrains the field investigation to organised attacks commencing from goal-kicks. However, this trade-off ensures standardisation of initial conditions, limits confounding variables, and contextualises behaviours in attacking and defending moments of play. Since published studies have shown that 58% of attacks are organised attacks (Tenga et al., 2010), the present study design, though constrained, still represents a substantial proportion of match playing situations. Therefore, one main benefit of the present study design is showing that players' attention capacity can be translated from laboratory settings to real-world field settings.

Concerning practical relevance, this study shows that a broader attention window is more beneficial concerning the investigated KPIs in comparison to a narrow one. Therefore, coaches should pay attention to the fact that fewer instructions lead to a broader focus of attention whereas too many instructions lead to the opposite. Memmert and Furley (2007; see Furley et al., 2010 for basketball) showed in three experiments that participants with more instructions lost sight of free teammates more easily and thus they made worse decisions than the participants receiving no instructions. Especially coaches for children and teenagers should confront the players with a certain problem (implicit learning) in, for example, the area of small-sided games without communicating further advice about their tactical behaviour (explicit learning). Another study indicated that fewer instructions during the training sessions enhance creativity (Memmert, 2007) and creativity might be one factor of success to win a match. Having more space control in the midfield third for the team with a higher attention capacity (like in this study) is, on the one hand, excellent, but on the other hand, the team needs intelligent or rather creative players who are able to take advantage of the free space by scanning the pitch immediately with the help of a broad attention focus or rather an enhanced attention window. Practicing the attention window means for the coaches to play different games from a methodological perspective (pitch size, equal number, short-handed or superior number of players, goal size, number of goals, etc.) with variable provocation rules (Memmert, 2015b, p. 21).

As every research endeavour, the presented study bears some limitations that have to be considered in the interpretation of results. First and most importantly, we used performance indicators instead of measuring the teams' performance in goals. It can be questioned whether those indicators actually reflect the teams' performance and success. However, because chance plays an important role in the number of goals scored in a soccer match (Lames & McGarry, 2007), using performance indicators are a validated possibility to measure in-field soccer performance and the KPIs used in this study have been tested for their relationship with long-term success before (Rein et al., 2017).

Furthermore, since this study was conducted in the field, observations might have been affected by factors that could not be controlled as much as in a laboratory setting. However, by using a trial-based approach to the match analysis, each observation started from the same position and with the same action. All test sessions were conducted on the same soccer pitch and using the same setup. The soccer-specific skill of the players was ensured to be balanced between the teams competing against each other. To our knowledge, this represents the highest possible level of standardisation together with external validity for match analysis investigations in the field. Only physiological aspects such as cardiovascular fitness could not be assessed and therefore not be considered our analysis.

Lastly, it has to be stated that although assessing the attention capacity of participants beforehand and assigning teams accordingly, the actual state of attention on the respective days of data collection could have been affected by situational factors. For example, mental health, personality or intelligence as well as contextual motivation or task-specific skills could potentially affect attention in the field setting. Because personality and intelligence could be assumed to be stable over the comparatively short time period between AWT testing and on-field data collection, we believe that these factors can be excluded as potential confounders. The same is hypothesised for mental health, while in addition the participants stated in signing the informed consent that they did not suffer from any medical conditions, including mental health issues, on the day of the measurement. The potential confounding effect of motivation or task-specific skill has to be considered, although it was aimed at balancing skill when assigning the teams as well as providing a standardised state of motivation by means of standardised instructions.

Future research should continue to investigate the impact of biopsychological descriptors like attention or perception in field-studies in soccer and maybe add the level of expertise as an additional factor. What is the influence on player's performance regarding group performance in 11 vs. 11 soccer games of these psychological factors? Another methodological approach that could be taken to further examine this topic is the Action Research framework (Coghlan, 2019). Under this framework, the idea is to simultaneously generate value both for research and the applied field. Important characteristics of Action Research are that it (1) represents research in action, which means that it follows a cyclical process which is described below, (2) is participative, which means that the members of the system under investigation participate in the cyclical process, (3) is research concurrent with action, which means that it aims at making action more effective while simultaneously building up a body of scientific knowledge, and (4) is both a sequence of events and an approach to problem solving (Coughlan & Coghlan, 2002). Important implications for the present study are that future research could follow the Action Research Cycle, incorporating (1) the diagnosis of current evidence from lab studies as well as the newly generated insights from our study, (2) the planning of future action research, building upon these results, e.g., narrowing down the study design to the group or individual level, (3) taking these actions, and (4) the evaluation of the findings, which will lead to entering the next cycle of planning. In this way, the field could move from a macro to a micro level of analysis while ensuring the best possible ecological validity. Furthermore, utilising the participative aspect of Action Research, valuable knowledge from the participants could be interrogated in order to find out more about the mechanisms involved. Lastly, the concurrency of action and research could be employed in this field of research by applying findings from research for example in training in order to improve the effectiveness of its action, while observing the consequences of these applications in order to carry out further research.

In conclusion, this study has shown that teams with higher individual attention capacity players outperform peers in field settings and, therefore, attention capacity provides some generalisability to more specific tasks and collective performance. Although effects are small, statistically significant differences include higher Space Control Gain from passing (final third and penalty area) and a reduced dispersion due to a shorter Team Width, concomitantly resulting in a more elongated team shape.

Acknowledgement

The authors thank Philip Furley and Saumya Mehta for valuable comments on an earlier draft of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by a grant from the German Research Council (DFG, Deutsche Forschungsgemeinschaft) to the first author, [Grant Number ME 2678/3-3].

Data availability statement

The anonymised data is available from the authors upon request.

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