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# "I Spy With My Little Eye!": Breadth of Attention, Inattentional Blindness, and Tactical Decision Making in Team Sports

**Daniel Memmert and Philip Furley**
University of Heidelberg

Failures of awareness are common when attention is otherwise engaged. Such failures are prevalent in attention-demanding team sports, but surprisingly no studies have explored the inattentional blindness paradigm in complex sport game-related situations. The purpose of this paper is to explore the link between breadth of attention, inattentional blindness, and tactical decision-making in team ball sports. A series of studies revealed that inattentional blindness exists in the area of team ball sports (Experiment 1). More tactical instructions can lead to a narrower breadth of attention, which increases inattentional blindness, whereas fewer tactical instructions widen the breadth of attention in the area of team ball sports (Experiment 2). Further meaningful exogenous stimuli reduce inattentional blindness (Experiment 3). The results of all experiments are discussed in connection with consciousness and attention theories as well as creativity and training in team sports.

***Key Words:*** visual attention, decision making, instructions

While watching team sports, for example, soccer, one often cannot help wondering why the player with the ball did not pass to a much better positioned teammate, even though this player seemed to be right in his or her field of vision. When the coach or a teammate asks the player after the game why he or she did not pass the ball to the free player, the player typically responds that he or she had not seen the other player. Ostensibly, this sounds like an excuse, but recent research suggests that there could be a explanation for this phenomenon.

A possible explanation for this occurrence could be inattentional blindness, which has been a topic of discussion in recent years (Mack & Rock, 1998; Most, Scholl, Clifford & Simons, 2005; Most, Simons, Scholl & Chabris, 2001; Most et al., 2000). This concept suggests that conscious perception requires attentional processes. If attention is diverted to another object, observers sometimes fail to notice an unexpected object, even if it is right in front of them. Unexpected objects,

Memmert and Furley are with the Institute of Sport and Sports Science, University of Heidelberg, Heidelberg, Germany.

such as open teammates, occur very frequently in team sports. And precisely perceiving these unexpected players and passing the ball to them is in many cases the best solution in complex game situations, and is even considered to be creative performance. For this reason, the inattentional blindness paradigm appears helpful in studying differences in tactical decision making in team ball sports.

An initial step in applying the inattentional blindness phenomenon to sports involved developing a test in which participants had to make tactical decisions. While planning the test, we wondered whether it was conceivable that participants failed to include an open teammate in their decision-making process, if their attention had been deliberately focused on their direct opponent. By varying the instructions that participants received before taking part in a decision-making task, it was possible to manipulate the focus of attention systematically in order to avoid or induce inattentional blindness.

## The Inattentional Blindness Paradigm

In the course of their "selective looking" studies, Mack and Rock (1998) introduced the so-called inattentional blindness paradigm. This paradigm demonstrates that conscious perception seems to require attention. "When attention is diverted to another object or task, observers often fail to perceive an unexpected object, even if it appears at fixation—a phenomenon termed *inattentional blindness*" (Mack & Rock, 1998, p. 14). The authors applied this paradigm in a series of studies with over 5,000 participants. They used simple experiments with brief, static displays, which limited the number of eye movements possible during each display. In a typical version of their task, observers first had to fixate on a cross in the center of a screen for 1,500 ms. In the following trials, they were asked to judge which of the two arms of a briefly displayed (200 ms) larger cross, appearing in a similar location as the initial fixation cross, is longer. In the next trial of this task (critical trial), an unexpected object in the form of a geometric shape appeared at a nearby position and for the same duration. Observers were then asked to report whether they had seen anything else other than the cross, whose arm length was being judged. In the last trial (full-attention trial) observers repeated the critical trial, this time with the suggestion not to concentrate on the arms of the cross, but to view the entire scene. Surprisingly, between 60 and 80% of the observers failed to detect the unexpected stimulus in the critical trial, even though they detected it in the full-attention trial. Moreover, the unexpected stimulus was a completely familiar, high contrast, geometric shape subtending across a visual angle of at least 0.6° and had been presented at fixation for 200 ms.

Further selective looking experiments used dynamic stimuli in more complex settings (Most et al., 2000, 2005). For instance, observers in these experiments were faced with the task of counting the number of passes made between three basketball players (Simons & Chabris, 1999). What was impressive about this experiment was that some did not even notice that a gorilla or a woman with an umbrella was moving through the group as the game was played. These studies enabled the researchers to show that many observers did not perceive an unexpected object in a dynamic setting, even though the unexpected object was right in front of them. Regardless of the attentional set, the task set, and the properties of the unexpected object, in these more naturalistic tasks approximately 50% of observers failed to notice the unexpected object (Most et al., 2005; Simons & Chabris, 1999). An important characteristic of these early studies is that all participants were adults. However, first experiments with younger participants by Memmert (2006) revealed no significant differences between junior and adult observers (35% vs. 38%). As hypothesized from findings in developmental research (e.g., Rebok et al., 1997; Ruff & Lawson, 1990), it seems there are no differences between 13-year-old and 23-year-old participants. Inattentional blindness age effects are, however, apparent between 8-year-olds and 23-year-olds.

## Breadth of Attention, Inattentional Blindness, and Decision Making in Complex Situations in Team Sports

Team players need a wide breadth of attention in order to generate tactical response patterns and seek original solutions in their game plans. Therefore, they must be able to perceive unexpected stimuli so as to incorporate these into response patterns and modify those patterns, as necessary. *Breadth of attention* refers to the number and range of stimuli that a participant has to attend to simultaneously (for a review, see Kasof, 1997). Most people remember the incredible passing abilities of Earvin ("Magic") Johnson, who became famous for his "no-look passes." Magic Johnson seemed to be able to take in all relevant stimuli of the present situation and then use this information to fool his opponents by looking in the direction of the most obviously open teammate, but then passing the ball to another player instead without even looking at him. Theoretical models suggest that Magic Johnson had a very wide breadth of attention, making it possible to attend to stimuli that may initially appear to be irrelevant. For example, a player could suddenly perceive an unmarked team member who had been closely guarded a moment before. The more elements a person can focus on simultaneously, the more likely he is to make a greater variety of tactical decisions. Martindale (1981) explains this fact using the following example:

> The more elements that can be focused on, the more candidates there are for combination. Thus, with two elements—A and B—in the focus of attention, only one relationship—AB—can be discovered. With three elements—A, B, and C—there are three potential relationships—AB, AC, and BC—to be discovered. With four elements, there are six potential relationships, and so on. (p. 372)

Inattentional blindness is one factor of attention capacity that is related to failures of awareness. Within the inattentional blindness experiments, the unexpected object is noticed more often if the task does not demand too much attention, meaning there is more attention available for perceiving the situation in more detail (see Most et al., 2005; Simons & Chabris, 1999). This suggests that inattentional blindness is less likely to occur if the primary task is relatively simple (e.g., only counting the passes in the basketball situation, instead of the passes and the number of bounces). Furthermore, it gives the observers the chance to direct their attention toward other aspects of the current situation.

To our knowledge, none of the previous studies using dynamic stimuli have investigated complex situations in team ball sports. It is important to extend inattentional blindness findings in sports for several reasons. (a) In a dynamic, video-based sports inattentional blindness task (SIBT), there are more events requiring attention. This wider choice of events may mean that fixation does not stay on any one location for long. (b) A real-world video task may also be harder, leaving fewer attentional resources available for processing unexpected objects. (c) Participants must not only solve one simple task in a dynamic, video-based SIBT, such as counting passes, but also must make tactical decisions, which involve including as many alternatives as possible. This is a very important point because making a tactical decision always involves searching for as much useful information, including free players, as is available. (d) Finally, open teammates can transmit further stimuli, which may capture attention. Shouting or waving a hand are examples of such exogenous stimuli. In many perceptual training experiments, there was evidence that attention directed to the most informative cues leads to better perceptual performance (for an overview, see Hagemann, Strauss, & Cañal-Bruland, 2006).

A dynamic, video-based SIBT would be a more ecologically valid approach to understanding inattentional blindness in sport. It is not clear where participants look when complex stimuli are used, and unexpected objects are presented in dynamic scenes for several seconds. In this sense, the computer-based paradigm may not fully capture all aspects of natural situations in real-world sports. Hence, situations in ball games appear to be a good starting point for constructing decision-making tasks with a high complexity level (Raab, 2003). Participants play in dynamic situations where teammates and opponents interact and balls have to be received and passed quickly. For this reason, players will not be able to capture all available information in such a situation and a player who is suddenly free could turn out to be an unexpected object. Although it is obvious that every player has expectations of what is going to happen, it is not possible for a player to consider all possibilities in complex situations, which means he or she will probably consider only the most likely ones. That is why suddenly free players are often not perceived and therefore are not passed to.

Thus, sport seems a fruitful area for studying complex behavior in a real-world context (Williams, Davids, & Williams, 1999). The purpose of this article is to contribute to the debate by exploring the links among breadth of attention, inattentional blindness, and tactical decision making in team ball sports. Specifically, we investigate the effects of inattentional blindness on tactical performance in an experimental setting. This study tested three main hypotheses in three experiments. Experiment 1 examines the premise that inattentional blindness exists in the area of team ball sports. Considering the attention set of the participants (top-down processing) in the dynamic SIBT, it was expected that the participants would be more likely to detect the unexpected object, than has been reported in previous studies typical of the inattentional blindness paradigm. In addition, we looked at the influence that different screen sizes had during the presentation of the SIBT (Experiment 2); we hypothesized that more tactical instructions would cause a narrower breadth of attention and therefore increased inattentional blindness, whereas, conversely, fewer tactical instructions would cause a wider breadth of attention, reducing inattentional blindness. With Experiment 3, we hypothesized that further relevant exogenous stimuli would reduce inattentional blindness.

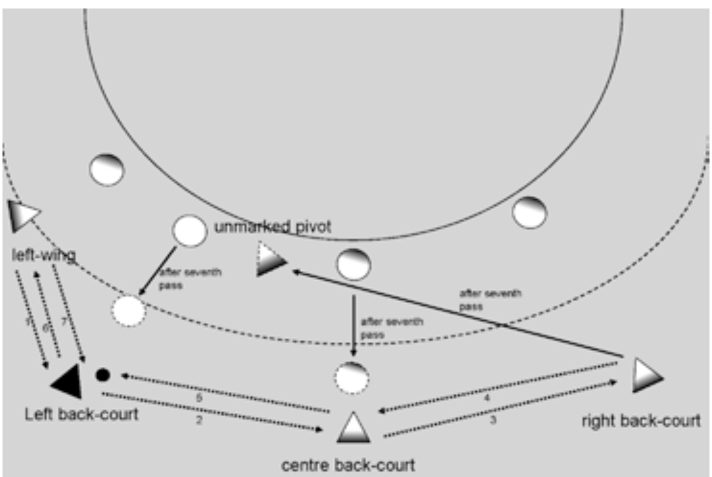
# Experiment 1

## Method

***Participants.*** Thirty-four young male team handball players ($M$ = 13.8; $SD$ = .85) participated in Experiment 1. They had been playing handball for an average of 4 years. Each participant volunteered and did not receive any kind of compensation for participation. Informed consent was obtained before commencing the experiment.

***Stimuli.*** For the video-based SIBT, 40 video sequences were filmed, in which four attacking players played against four defending players (and a goalkeeper) in a standard handball training game (Figure 1a). The camera was positioned at the

*a*




*b*

**Figure 1—** (a) Single frame from the video-based sports inattentional blindness task (SIBT). These tapes were in color. In view are four attacking and four defending players as well as the unexpected object—the unmarked player is in the circle. The figure shows the “frozen” display, which lasted for 3 s of the 15-s video. (b) Shows the script of the crucial third trial: Direction of passes is indicated by dotted lines, players’ movements by solid lines.

same level as the players and followed the movement of the ball so that a realistic and close picture was captured for the observer. All players were instructed to act as authentically as possible and to avoid looking into the camera. The crucial players in the SIBT are the attacking left backcourt player, who wore a yellow shirt, and his opposite number, the right half defender, who wore a white shirt. The other attackers wore blue shirts, whereas the other defenders had different colored shirts, as this is common in handball training situations. The attackers' task was to pass the ball from one player to another, beginning at the left side, and back again. This was the same procedure in all the videos. When the left backcourt player received the ball for the second time from the left-wing player, the defending and attacking players had received instructions on how to behave so that one attacker was totally free. For example, after the left-wing player passed the ball back to the left backcourt player, the right-wing player ran into the center of the field and became a completely free pivot player (Figure 1b).

The other important instruction the players received concerned the direct opponent of the left backcourt attacker. He was told either to stay in a defensive position at the 6-m line or to clearly step out toward the attacker. The video sequence came to an end when the left backcourt player wearing yellow had the ball in front of the defender in white. The video clips were selected through expert ratings and item analysis. From the 40 sequences filmed, test clips were chosen that were the most authentic and involved the unmarked player constituting the best tactical solution. Three handball experts were asked to rate every sequence according to the degree of obviousness of the best possible tactical solution, on a scale from 1 (*totally obvious*) to 4 (*not at all obvious*). The best rated clips involved sequences in which the free player was closest to the white defender, on whom the participants had to focus their attention, and which had been unanimously rated as (1) totally obvious. In addition, similar videos were filmed, in which there was no obviously free unmarked player (Trials 1 and 2).

All videos were filmed with a Panasonic mini-DV video camera (AG-DVC15) and were digitized and edited using a nonlinear digital video-editing system (Premiere Pro 1.5). The video sequences were exported using the MPEG-1 codec with a frame size of 640 × 480. The average bit rate was 2,000 kbits/s (two-pass VBR).

***Procedure.*** For 15 participants, the SIBT was projected onto a large screen (3.2 m [horizontal] × 2.4 m [vertical]). The observers sat in front of the screen at a distance of 6 m. The size of the stimulus field was 21.8° of the visual angle in the vertical dimension and 28.1° of the visual angle in the horizontal dimension. In order to be able to work more ecologically in the future, the SIBT was also shown to 19 participants on a PC monitor (15 inches, diagonal). The observers sat on a chair in front of the screen at a distance of 45 cm. The size of the stimulus field was 27.1° of the visual angle in the vertical dimension and 33.7° of the visual angle in the horizontal dimension.

An experimenter tested each of the observers individually. Instructions were displayed on the screen and were read by the experimenter from a test protocol. The experimenter asked the observers to read the instructions displayed on the screen and to proceed by pressing the space bar if they had finished reading and understood the instructions. Participants were instructed to assume the role of the yellow backcourt player. They were told they had to make a tactical decision that would most likely lead to a goal. Two tasks were assigned to all participants for each of four trials of Experiment 1. For each trial, participants viewed a short video of a handball game in which four attacking players opposed four defending players (cf. Figure 1a). The first frame of the video appears frozen for 3 s so that the observers have some time to orient themselves. After about 15 s, the final frame freezes for 3 s and fades away into black.

**Task 1:** Participants had to fixate on the white defender and keep a silent record of his position in each 15-s trial (Primary Task). The task required identifying the white defender as being in either the offensive or defensive position. This is a common task that handball players are confronted with by their coach during training. The purpose of this task is to teach the players to make a tactical decision based on the position of the defender. The position of the defender has a major impact on the tactical decision. The task was demonstrated for each participant using two sample pictures, which showed both of the possible positions the white defender could adopt, either an offensive position almost right in front of the attacker or a defensive position at the 6-m line. Furthermore, participants were told that this was a fairly difficult task and that it would be quite hard to recognize whether the white defender occupies a defensive or an offensive position. Previous studies have revealed that this instruction improves the performance of the participants in the primary task, which is a necessary requirement for this paradigm.

**Task 2:** The participants are asked to make a tactical decision based on the situation and position of the white defensive player identified in Task 1. All participants were told that they had to make a tactical decision that would most likely lead to a goal and that identifying the position of the white defensive player might help them make this decision.

**The noncritical trial:** The first two trials were noncritical trials in which the video did not include an obviously unmarked player. In the first of these trials, the white defensive player is in the offensive positions in the final frozen frame. In the second trial, the white defensive player appears in the defensive position at the final frozen frame.

**Critical trial:** In Trial 3, the critical trial, in contrast to Trials 1 and 2, there was an obviously unmarked player who should receive a pass from the yellow backcourt player (the participant) if the participant had perceived him. If the participant correctly identified the position of the white defensive player, which in this trial is "offensive," and made the tactical decision to pass to the unmarked player, the experiment came to an end. If, however, the participants failed to see the free player in the final frame, they were asked to continue with Trial 4. Any participant who did not correctly identify the position of the white defensive player in this critical trial was excluded from the final data analyses, as it could be expected that he did not focus his attention on this player and therefore the paradigm could not be tested.

**Full-attention trial:** In Trial 4, the observers were instructed that the first task, reporting the position of the white defender, was not required for this trial (full-attention task). This meant that the participants had only to decide on a tactical solution (Task 2). What they did not know is that they were watching the same sequence as in Trial 3, with the slight difference that they were not instructed to focus their attention on the white defender. The purpose of this trial was to show that all participants were able to perceive the open player in the full-attention trial, suggesting that all participants were able to perceive the open player and include him in their tactical decision-making process without specific instruction.

After completing the trials, the participants answered follow-up questions designed to gather demographic information and to determine whether they had been familiar with this or other related experiments prior to participation.

## Results and Discussion

None of the participants claimed to know of the phenomenon and/or experimental paradigm of inattentional blindness. Of the 34 observers, 5 were excluded from the final data analysis for the following reasons. Firstly, one of the participants did not name the position of the white defender correctly in the crucial third trial. This indicates that he had not focused his attention on the white defender, which is crucial in the inattentional blindness paradigm. Secondly, two participants failed to see the unmarked player in the full-attention trial. Thirdly, two participants made ambiguous responses. Of the 29 valid observers, 16 participants perceived the open player (55%) and 13 failed to notice him (45%). Therefore, no differences from the normal distribution occur, $\chi^2(1, N = 29) = .310, p = .58$. According to the screen size, no differences were found between the participants who had made their decisions in the SIBT on the large screen (54% vs. 46%) and on a computer monitor (56% vs. 44%), $\chi^2(1, N = 29) = .033, p = .86$.

The interesting finding is that we were able to transfer the inattentional blindness effects seen in previous studies to complex situations in team ball sport. One may compare the percentage of participants who noticed the open player with results found by others using the inattentional blindness paradigm (Memmert, 2006; Most et al., 2005; Simons & Chabris, 1999). The "50% noticing rate" from other inattentional blindness studies recorded in dynamic settings involving adults and juniors were approximately corroborated (55%).

Of the 13 participants who failed to notice the unmarked player in the third trial, 8 noticed that they had been watching exactly the same video in Trial 4 and were absolutely astonished that they had not passed to the free pivot player in Trial 3 but did so in the fourth trial. There was no mistaking the surprise of some of the participants, as "they could not help smiling" in consideration of the fact that they had not chosen to pass the ball to the obviously free team member in the third trial, although they had chosen to pass to him in Trial 4. The remaining players who had not noticed the unmarked pivot player in the third trial did not explicitly realize that they had been watching the same video in Trials 3 and 4. That they decided differently in the full-attention trial compared with Task 3 is notable.

These findings replicate the results of a number of recent studies (Mack & Rock, 1998; Most et al., 2005) and demonstrate that inattentional blindness is a robust phenomenon. Although the unmarked player was running in the middle of the video scene, then stood right next to the defender and was completely visible for 3 s at the end of the dynamic scene, 50% of the observers failed to notice him as a potential tactical opportunity in the critical trial.

In Experiment 2, we studied the influence of various kinds of instructions on the inattentional blindness paradigm during sport-related decision-making situations. Because there were no differences according to the size of the screens, we chose to present the SIBT on the PC monitor in the following experiments.

# Experiment 2

The pattern of results achieved by Experiment 1 showed that inattentional blindness effects found in previous studies using dynamic stimuli can be applied to complex situations in team sports. In further experiments, the instructions within the inattentional blindness paradigm could be targeted more strongly toward common training situations in handball. Up to now the focusing of attention while training sport tactical competence has not been considered systematically in experimental work. By means of certain instructions, it should be possible to control the focus of attention during sport games. Children and adolescents have to take in and process a great amount of information within a very short time in all sports games. They have to pay attention to sensory impressions that are at first totally new to them and, because of that, are also often unexpected. This raises the question of how children can become more proficient at perceiving constant minor and major changes in situations caused by the interaction of their opponents and team members if their attention has been directed only at a few specific aspects of the situation by the coach beforehand. Coaches are challenged to find ways of increasing their players' proficiency at identifying tactical solutions parallel to those they receive from the coaches, as it is not possible for the coach to mention all possible solutions for any situation or for the child to remember all of them (see also Kidman, Hadfield, & Chu, 2000).

For a training program, this means that it would appear to be beneficial not to practice, but rather to play in game situations, in which the trainer gives less tactical instruction but asks the right questions to direct the attention to specific information-rich areas (\bb\Mitchell, Oslin, & Griffin, 2006). In this way, discovery learning (Bakker, Whiting, & Van der Burg, 1990), implicit learning (Farrow & Abernethy, 2002), self-controlled learning (Wulf & Toole, 1999), and engaged learning (Renzulli, 1994) are possible.

A first step in studying instruction strategies involved carrying out an experiment in which players were confronted with different kinds of instruction before they had to make tactical decisions in complex situations in team ball sports. The breadth-of-attention hypothesis proposes that participants who were given team sport-specific instructions would be less likely to see the open player than those without a specific attentional focus. \bb\For example, in handball, team sport-specific instructions mean that if the defender stays defensive, then try to score a goal with a jump shot.

## Method

***Participants.*** Participants were 29 young male team handball players ($M = 15.3$; $SD = 1.07$) who had practiced the sport for an average of 4.5 years. Each participant volunteered to participate and did not receive any kind of compensation. Informed consent was obtained before commencing the experiment.

***Stimuli and Procedures.*** All observers were tested individually with the SIBT. The stimuli (this time presented only on a PC monitor) and the task (position of the opposite player; tactical decision) were identical to those in Experiment 1; the only difference concerned the instructions the players received, which were randomly allocated. Two kinds of instruction conditions were chosen. The attention-narrowing group (ANG) received two handball-specific "if-then" rules to be applied if considered appropriate: (a) If your defender goes on the offensive and steps out toward you, then try to deceive him with a feint (one-on-one action) and (b) if your defender stays defensive, then try to score a goal with a jump shot. These are typical instructions for children's handball training (Clanton & Dwight, 1996). The second, attention-broadening group (ABG) did not receive these rules. Again both groups were told at the beginning and at the end—just as in Experiment 1—that all options are open to them. For example, they could perform a one-on-one action, shoot at goal, or pass to any player. Otherwise, the procedure of Experiment 2 was the same as Experiment 1.

## Results and Discussion

Data from five observers was discounted. They failed to see the unmarked player in the full-attention trial. No participants made incorrect tactical decisions in the crucial third trial. In this respect, the participants in the ABG ($n$ = 12) were no more accurate as to the correct position of the defender than the participants of the ANG ($n$ = 12).

About 83% of the ANG and 17% of the ABG failed to notice the unmarked player (Figure 2), even though the player remained in what was presumably the focus of attention and was clearly visible for 3 s. Both results differed from the normal distribution, each $\chi^2$ (1, $N$ = 24) = 5.333, $p < .05$. These results confirm the breadth of attention hypothesis and indicate significant differences between the two groups, $\chi^2(1, N = 24) = 38.400$; $p < .001$, $\Delta = 1.79$. Moreover, 83% of the participants who received specific instructions failed to consciously perceive the obviously unmarked player within their tactical decision-making process.

In sum, although no differences existed in completing the primary task, the ABG was more likely to see the free player than the ANG. This result indicates that

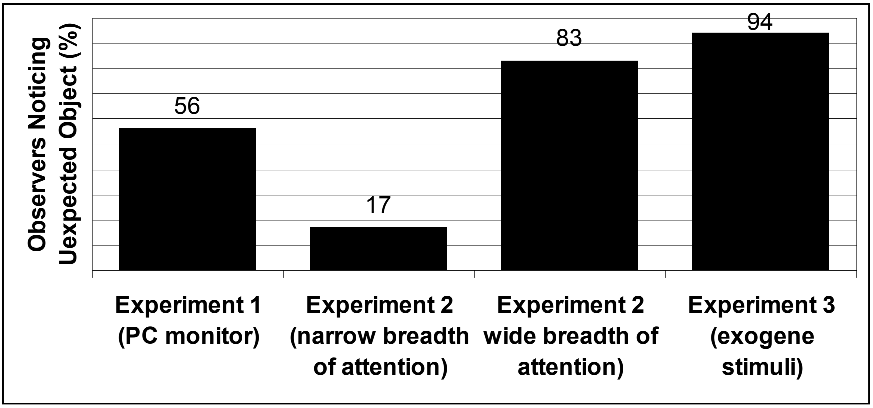



**Figure 2 —** An overview of the percentage of participants noticing the open player (unexpected object) in the video-based sports inattentional blindness task (SIBT) from Experiments 1 (computer screen), 2, and 3.

instructions can lead to a narrower breadth of attention, which results in the players not passing the ball to an obviously unmarked player, even if this player is in their focus of attention. Further studies are needed to corroborate these initial findings and several interesting questions remain. For instance, which instruction strategies should be chosen in order to focus attention to assist perception of solutions to new and unexpected situations? Are there external influences that might assist in the perception of an unmarked player? Recent findings in the field of neuropsychology (see Ellis, 2001) suggest that important cues could come from the unmarked player himself in order to attract attention—for example, waving his arms. The following experiment was designed to examine precisely this consideration.

# Experiment 3

The pattern of results achieved by Experiment 2 shows that participants with a wide attentive focus made better tactical decisions than participants with a narrow breadth of attention. Current theories in the field of neuropsychology indicate that while perceiving one's environment, the nervous system performs an evaluation of signals in order to preselect those that are important according to motivational usefulness categories (Ellis, 2001). Unconscious processes serve as an early selection mechanism that favors useful or emotionally interesting information for further processing. Currently, evolutionarily meaningful stimuli—for example, emotionally significant ones, such as loud noise—are being discussed as motivational usefulness categories. This suggests that motivational factors control the focusing of attention and, hence, influence information processing before we are consciously aware of an object. The results of Mack and Rock (1998) can be interpreted in this manner. The authors revealed a significant reduction in inattentional blindness in static settings if an emotional stimulus was given (e.g., a smiley face vs. a circle; 85% vs. 15%). Another example for emotional stimuli are significant words, such as the first name of participants, which were detected significantly more often than the two most frequently used words in America, *house* or *time* (88% vs. 50%).

Which "preinformation" cues could help team sports players pick up relevant information in an unexpected and new situation? A new situation can, for example, occur if a previously marked player releases himself from his opponent with a feint. The motivational usefulness categories mentioned above could help players detect meaningful stimuli that deserve their attention. According to the usefulness hypothesis, we investigated whether an unmarked player who waves his arms while running into position is perceived consciously, thereby reducing inattentional blindness.

## Method

***Participants.*** The participants were 16 young male team handball players ($M$ = 13.4, $SD$ = 1.36) who had practiced the sport for an average of 3.5 years. Each participant volunteered to participate and did not receive any kind of compensation. Informed consent was obtained before commencing the experiment.

***Stimuli and Procedures.*** All observers were tested individually with the SIBT. The instructions and the task were exactly the same as in Experiment 1. The videos also showed almost exactly the same situation as the sequences in Experiments 1 and 2. The only difference concerned the stimuli in the critical third trial. This time the unmarked player waved both his arms while running into position right next to the white defender. Otherwise, the whole procedure of the third experiment was identical to that of the first experiment.

### Results and Discussion

No data were discounted. The usefulness hypothesis proposes that the participants can use hand waving as a bottom-up motivational stimulus to draw attention to the unexpected object. This time, only one participant (6%) failed to notice the free player, $\chi^2(1, N = 16) = 12.250$, $p < .001$. To evaluate the success rate of participants who noticed the unexpected object, these results can be compared with results obtained in Experiments 1 and 2 (Figure 2). The results indicated significant differences between this group and the attention-narrowing group (ANG), $\chi^2(1, N = 28) = 86.450$, $p < .001$, $\Delta = 2.07$, but not between this group and the attention-broadening group (ABG), $\chi^2(1, N = 28) = 1.250$; $p = .26$.

Our findings demonstrated that team members in sports are able to attract the attention of other team members by some kind of salient action. This is hardly surprising, but to our knowledge this is the first attempt, embedded within a theoretical framework, to support this experimentally. The organism seems to have to activate the frontal and parietal areas of the brain deliberately in order to search for emotionally meaningful object categories that the thalamus, in connection with the limbic system, has already classified as important. This "searching" has already started to form the visual image scheme before the occipital area has any kind of effect on the perceptive consciousness (Ellis, 2001).

It is important to mention that the salient action, of course, not only captures the attention of the player's fellow teammates, but may also capture the attention of the defending players and, therefore, may no longer have the desired effect of surprising the opposing team. This means that one should be cautious about drawing a hasty conclusion from these findings.

## General Discussion

The organism is literally bombarded by sensory stimuli, especially visually, which are too numerous to process completely. However, the human brain has been optimized in the course of evolution to select salient information by directing the focus of attention, which permits the filtering of information relevant for everyday life or for participating in a sports game. But for detecting important changes in the world around one ("change blindness"; e.g., Simons & Levin, 1997) or with regard to the failure to detect surprising and potentially relevant information (inattentional blindness), this mechanism can be considered an unwanted side effect or even a disadvantage for people in everyday situations (e.g., people telephoning while driving a car; Strayer, Drews, & Johnston, 2003), in their jobs (e.g., air traffic controller; Cummings & Tsonis, 2005), or people participating in a sports contest.

The purpose of the present series of experiments was to analyze the inattentional blindness effect in complex situations found in team ball sports. Considered together, the findings highlight the fact that the inattentional blindness paradigm also appears to play a considerable role in competitive sports. Our findings from Experiment 1 replicated the results of a number of recent studies (Most et al., 2000, 2005; Simons & Chabris, 1999) and demonstrated that inattentional blindness is a robust phenomenon that also occurs in the field of team ball sports.

Experiment 2 impressively revealed the influence of specific instructions on the tactical decision making of team sport players. The results showed that the players did not pass the ball to an obviously unmarked player, to whom they would have passed the ball without the specific instruction. In other words, team players often fail to find the optimal tactical solution to a situation because the coach narrows their focus of attention by giving restrictive instructions. Together, the findings corroborate the theoretical conjectures. A wide breadth of attention facilitates noticing unmarked players in dynamic situations in team ball games. A wide focus of attention is important for enabling junior players to see many opportunities in a sports environment. As children seem to perceive unexpected objects significantly less than adolescents and adults (Memmert, 2006), it is important to promote a wide focus of attention, especially in beginners' training. Another interesting point is that advanced players may have the ability to shift their attention as a special perceptual skill. Experiments by Memmert (2006) with experts in ball sports studied this effect more closely. His results confirmed the expertise hypothesis in a dynamic basketball task set by Simons and Chabris (1999). Significant differences were revealed between basketball experts and novices of a similar average age (61% vs. 36.5%). These findings indicate that it is possible to learn to perceive unexpected objects. Furthermore, this result indicates that sport experts have special perceptual skills that enable them to direct their attention toward other stimuli that initially appear to be irrelevant. In addition to advanced visual cues, pattern recognition or knowledge of situational probabilities (Abernethy & Russell, 1987), it seems that the reduction of inattentional blindness is a further perceptual skill of expert performers.

The reduction of inattentional blindness may be one factor in improving creative thinking in the area of team ball sports. Results of studies on creativity and eminent athletes' reports also suggest that deliberate play, including no specific instructions (attention-broadening condition), has a positive effect on the creativity and positioning skills of sports game athletes (Baker, Côté, & Abernethy, 2003; Raab, Hamsen, Roth, & Greco, 2001). In addition to other perceptual skills (cf. Williams & Grant, 1999), skilled performers have swifter access to relevant knowledge owing to a faster automation of individual thought processes. This frees attention capacity for other tasks. For instance, Abernethy and Russell (1987) demonstrated that experts show extremely high scores in selective attention tasks. By using suitable training scenarios, narrow and wide breadths of attention can be trained in a targeted manner.

Experiment 3 revealed that team members could capture the attention of other teammates by waving their hands. This led to a major reduction in inattentional blindness. What are the implications of this finding for theories of consciousness and attention? Attention theories need to make stronger use of preconscious self-organizing processes, which precede every state of awareness in the cortex and attempt to optimize the resulting state of awareness for the purpose of the organism. According to Ellis (2001), self-organized processes act here as an early "gating" mechanism, which influences the direction of attention through potentially useful or emotionally interesting information before conscious knowledge of the observed object is available. This is possible because cognitive functions are connected with emotional areas of the brain at a very early stage of processing. This means that after the information passes from the optic nerve to the thalamus, the thalamus and the limbic system act together before V1 to V4 are integrated (e.g., Watt, 2000). Motivational factors therefore control the direction of attention and influence the information process before the organism consciously perceives the specific input. The central question concerning which motivational meaningfulness categories exist remains to be answered. In an initial step, Ellis (2001) named three types of stimuli, all of which have a sound evolutionary basis: a) emotionally salient, b) meaningful, and c) those that are preset as part of the human hardware (e.g., loud noises).

Ellis (2001) summed up the neuropsychological discoveries (Ellis & Newton, 2000) and the findings from the inattentional blindness studies (Mack & Rock, 1998) and extrapolated a three-tier model. The first stage of this model is a preselective evaluation of stimuli determined by motivational usefulness categories. Ellis (2001) considered self-organizing processes as a kind of early "penstock" (conduit) mechanism, which favors potentially important or emotionally interesting information for further processing. If stimuli pass this preselection, they are "amplified," further processed, and encoded in the second stage. It is only in the third stage that consciousness is generated through resonance between anterior and posterior attention mechanisms. This means that these cognitive processes can function both as an early selection mechanism for incoming stimuli, as well as being able to determine whether information later reaches consciousness. Nevertheless, whether information reaches consciousness or not is considered to be determined to a great extent by an early processing stage. Enactive theories (Clark, 1997; Ellis & Newton, 2000; Varela, Thompson, & Rosch, 1993) state that both early and late selection mechanisms are at work and that these are both controlled by the same subcortical and limbic processes.

The results of all three experiments appear to be closely connected to findings from creativity research. In a general and more scientific context, Sternberg and Lubart (1999) define creativity as "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful)" (p. 3). A number of recent studies have shown that breadth of attention is positively related to creative performance (e.g., Martindale, 1999; Mendelsohn, 1976; for a review, see Kasof, 1997). Mendelsohn (1976) and later Kasof (1997) argued that as a result of a narrow breadth of attention, not all stimuli and information that could lead to original and possibly creative solutions in certain situations can be taken in and assimilated. A wide breadth of attention makes it possible to assimilate a variety of stimuli that may initially appear to be irrelevant. In addition to a large amount of anecdotal evidence, there is now also a series of important empirical findings that support the hypothesis that a wide breadth of attention facilitates creative performance (Carson, Peterson, & Higgins, 2003; Friedman, Fishbach, Förster, & Werth, 2003; Healey & Rucklidge, 2005). There are only a few studies that attempted to investigate the deliberate training of breadth of attention. To date, no longitudinal studies have yet been conducted. Longitudinal studies would make it possible to show whether wide breadth of attention can be trained in order to improve creative performance. In turn, implications for practice structures for various disciplines could be derived (i.e., all branches of artistic, theoretical, and practical creativity).

Further research in the area of decision making in team ball sports could help in answering a range of open questions: If one created a more demanding tactical decision-making test by making the primary task more complex, would adult handball players also fail to perceive an obviously unmarked player as their optimal solution in this situation? A limitation of the present study is that the existence of inattentional blindness in complex sport situations was examined only in adolescents. In order to replicate the current findings in ecologically valid circumstances (Davids, Button, Araújo, Renshaw, & Hristovski, 2006), one would have to consider whether tactical decision making alters if participants actually carry out their decisions physically (i.e., not only, say, mentally play the pass to player X, but really play it). Furthermore, whether it is possible to replicate these experimental results in real-life situations, such as a real sports competition, remains unknown. In order to do this, one would either have to create explicit scripts for the players or analyze real recordings of sport games. The last point could be realized by analyzing authentic sequences from the first person perspective with relatively rigid guidelines from the coach. Resolution of these issues could provide a more comprehensive model of sport decision making.

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