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DIFFERENCES IN SPATIAL WORKING MEMORY AS A FUNCTION OF TEAM SPORTS EXPERTISE: THE CORSI BLOCK-TAPPING TASK IN SPORT PSYCHOLOGICAL ASSESSMENT[1]

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Summary.—Individual differences in visuospatial abilities were investigated in experienced basketball players compared with nonathletes. Most research shows that experts and novices do not differ on basic cognitive ability tests. Nevertheless, there are some equivocal findings indicating there are differences in basic cognitive abilities such as attention. The goal of the present research was to investigate team-ball athletes in regard to their visuospatial abilities. 112 male college students (54 basketball players, 58 nonathlete college students) were tested in their spatial capacity with the Corsi Block-tapping Task. No differences in spatial capacity were evident between basketball players and nonathlete college students. The results are discussed in the context of the expert performance approach and individual difference research.

Until fairly recently, great athletes were considered an "assemblage of physical prowess" so researchers did not pay much attention to cognitive factors involved in expert sport performance (Starkes, Helsen, & Jack, 2001). Today most sport psychologists acknowledge the important role of cognitive processes in sporting performance, which has led to a substantial accumulation of literature (Starkes & Ericsson, 2003; Sternberg & Grigorenko, 2003; Williams & Hodges, 2004; Ericsson, Charness, Feltovich, & Hoffman, 2006).

One finding within research on expertise in sports is that experts in a particular sport are not only better than novices at physical skills but also on numerous underlying perceptual cognitive and strategic components of the sport in question (for a review, see Williams & Ford, 2008). This line of research further indicated that within a specific domain, about 10 years of experience or 10,000 hours of practice are necessary to achieve expert performance (see Ericsson, *et al.*, 2006, for a recent review). Williams and Ford (2008) argued that every cell of the human body adapts to compensate for the increased demands of the performance environment. Along this line, Ericsson (2007) stated that physiologically, muscle adaptation is triggered by regular intensive training activities that push athletes' bodies beyond their normal homeostasis. He further proposed that the only validated exceptions concern body size and height and also that the brain

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exhibits functional adaptations and anatomical changes as a function of extended training. The super-compensation of the physiological system with sport participation is well known, but only recently have these adaptations been demonstrated within the structure and function of the brain (Hill & Schneider, 2006). Therefore, expertise researchers today favor studying basic cognitive processes, such as memory and categorization, instead of the highest achievement (Ericsson & Ward, 2007).

Individual differences in "basic" cognitive processes (e.g., intelligence, memory capacity, and perceptual functioning) have not been predictive of attained skilled performance in most domains (see Ericsson, Roring, & Nandagopal, 2007). Most findings indicate that experts and novices should only differ in processing directly tied to their domain of expertise (e.g., Hammond & Stewart, 2001; Eccles, 2006; Ericsson, *et al.*, 2006). Following this line of argumentation one would not expect differences between expert and novices on general ability tests. Although a lot of research points in this direction, there seem to be some cases in which this expectation does not hold up. For example, in attention there is evidence that experts and novices differ in their selective focus of attention across various domains of expertise. Bellenkes, Wickens, and Kramer (1997) found expert–novice differences on basic attention tasks in the field of flying. Further, Allen, McGeorge, Pearson, and Milne (2004) reported similar findings on a multiple-object tracking task in the case of radar-operator expertise. In a frequently cited paper, Green and Bavelier (2003) reported evidence for enhanced attentional abilities among video-game experts. What is significant about these findings is that seemingly the mere confrontation with their activities led to adaptations in basic cognitive abilities—in this case, attention—that were measurable with basic attention tasks but are not directly linked to their field of expertise. Thus, the human body seems to have adapted to the increased demands of the performance environment of expert pilots, expert video-game players, and expert radar operators. These superior attentional abilities in turn enable them to perform efficiently in their daily environments. This surprising finding is not in line with the predictions of Ericsson and colleagues (e.g., Ericsson, *et al.*, 2006) who stated that experts and novices should only differ in processing directly related to the domain of expertise.

The rationale for the present study was derived from these ambiguous findings. Considering that team-ball players such as basketball players are constantly confronted with visuospatial stimuli in their domain of expertise, it seems plausible that they might also be affected by perceptual-cognitive adaptations, specifically in their visuospatial working memory. Cognitive psychologists generally use the concept of working memory to describe the ability to maintain and process simultaneously goal-relevant information. Baddeley and Hitch (1974) put forth a model of a multicomponent working memory system consisting of domain-specific storage buffers, which they referred to as slave systems, and a domain-general central executive. The proposed system comprises an attentional control system, the central executive, and two subsidiary slave systems: the phonological loop, which was assumed to be responsible for holding speech-based or acoustic information, and the visuospatial sketchpad, holding visual and spatial information. Within the visuospatial sketchpad there appears to be further division in a component operating on sensory information—visual appearance—and one operating on spatial location—environmental coordinates (see Zimmer, 2008, for a recent review).

Returning to the cognitive adaptation argument (e.g., Green & Bavelier, 2003), basketball players would have an advantage of having a greater spatial capacity (not visual capacity), for example when recalling offensive strategies presented on the tactic board and recognizing these during the game or recalling pass sequences and movement patterns from specific offensive plays. The finding that short-term memory capacity can be improved by training is well-established (see Ericsson, *et al.*, 2006, for a recent review). Chase and Ericsson (1981) found that, with repeated testing (practice) on the Digit Span task, their participants were able to improve their performance dramatically. The possibility of acquiring a greater spatial capacity through the mere confrontation with activities that frequently require visuospatial working memory has not been investigated so far, although Memmert, Simons, and Grimme (2009) conducted a similar study investigating attentional differences as a function of team-sport expertise using a multiple-object tracking task (Alvarez & Franconeri, 2007) which has been linked to the central executive part of working memory (Allen, McGeorge, Pearson, & Milne, 2006). Memmert, *et al.* (2009) found no differences in the central executive component of working memory as measured by a multiple-object tracking task (Allen, *et al.*, 2006) between team-sport experts and nonathletes. Considering the cognitive adaptation argument (Green & Bavelier, 2003) it seems feasible that expert athletes might only differ in the spatial storage component of Baddeley and Hitch's model (1974) even if they do not differ in the central executive component.

The present goal was to examine individual differences in visuospatial capacity as a function of team-sport expertise. More specifically, a comparison of the hypothesis derived from Ericsson and colleagues, that expertise-related differences are only evident on processing measures directly tied to their field of expertise and should not be evident on basic cognitive ability measures, and the cognitive adaptation hypothesis (e.g., Green & Bavelier, 2003), that individuals can acquire superior fundamental cognitive abilities by adapting to the demands of their daily activities and that these adaptations as measured by basic cognitive ability tests, was undertaken. To investigate whether experienced basketball players have a greater spatial capacity than regular college students who are nonathletes, both groups were given the Corsi Block-tapping Task (Corsi, 1972), a commonly utilized index of the spatial component of Baddeley's model (Berch, Krikorian, & Huha, 1998), and a frequently utilized sport psychological assessment tool within the Vienna Test System (Schuhfried, 2009). If Ericsson's specific processing hypothesis is valid, then no differences in spatial capacity between the two groups should be evident. However, if the cognitive adaptation hypothesis is valid, then experienced basketball players should perform better on the Corsi task than participants who were never involved in a team sport.

Method

Participants

Male college students ($N=112$; $M=24.8$, $SD=2.7$) took part in the study, of whom 58 never had participated in any kind of team-ball sport and 54 of whom were currently playing basketball for a minimum of 10 yr. not below the fourth highest league in Germany. No age-related differences were evident between groups. Informed consent was obtained from every participant before commencing the experiment.

Measure

As a measure of spatial span the Corsi Block-tapping Task (Corsi, 1972) was utilized. The test materials were nine wooden blocks (3-cm cubes) arranged and fixed on a flat wooden board (23 × 28 cm) in accordance to Milner (1971). The wooden blocks were approximately arranged as shown in Corsi's original dissertation (Corsi, 1972). The cubes were numbered on the experimenter's side of the board for easy identification and recording.

Procedure

Before commencing the test, participants filled out a questionnaire collecting demographic data. Each participant was tested individually. The experimenter tapped out randomly generated sequences of blocks at a speed of one block per second. After the experimenter had completed the entire sequence, participants were asked to repeat the sequence of blocks tapped by the experimenter. The difficulty was increased progressively by increasing the length of the sequences. Every difficulty level consisted of three trials, starting with a sequence of three blocks (Level 1) until maximally eight blocks (Level 6). The participant's spatial span was the level at which at least two of the three sequences were correctly reproduced (Berch, *et al.*, 1998).

Results

Overall Performance on the Corsi Block-tapping Task did not differ between experienced basketball players ($M = 4.30$, $SD = 0.76$) and college students ($M = 4.19$; $SD = 0.74$) not involved in any kind of team-ball sports ($t_{110} = -.49$, $p = .62$).

In order to make the dependent measure more sensitive, a percentage correct score (Berch, *et al.*, 1998) was computed. This score resulted from the correct number of sequences reproduced divided by the total number of sequences to be learned, although this is problematic in the present study since participants terminated the test when they could not reproduce a sequence twice at a level. Thus it was reasonably assumed that these participants would also not be able to reproduce sequences of higher difficulty. Since none of the participants did better than Level 6, the last trial of Level 6 was defined as 100% correct and percentages were computed for every participant. Again, basketball players descriptively ($M = 59.2\%$, $SD = 10$) scored minimally higher than regular college students with no team-ball sport experience ($M = 57.8\%$, $SD = 12$), but this marginal difference was not statistically significant ($t_{110} = -.63$, $p = .53$).

Discussion

Present results indicate that experienced team-ball players did not differ in their spatial capacity, as measured on the Corsi Block-tapping Task, than regular college students. This finding supports the prediction of Ericsson and colleagues who stated that expert performers only differ in processing abilities directly tied to their domain of expertise, since the Corsi task is a general measure of spatial capacity. The result gives further evidence for Ericsson's specific processing hypothesis among expert performers. Thus, no evidence was provided for expert novice differences in spatial capacity along the line of Bellenkes, *et al.* (1997), Allen, *et al.* (2004), and Green and Bavelier (2003) who found differences between experts and novices on basic attention tasks across various domains requiring superior attentional abilities. One explanation for this might be that the sequential nature of the Corsi Block-tapping Task did not tap the domain of expertise of basketball players, as this is not a common requirement of the game of basketball. The simultaneous presentation of the spatial stimuli is probably more suited for investigating differences between experts and novices in team-ball games on spatial abilities, since this type of processing is closer to the domain of expertise of basketball players. This assumption is tentatively supported by findings of superior pattern-recognition abilities among expert team-ball players (Allard, Graham, & Paarsalu, 1980; Williams, Hodges, North, & Barton, 2006).

Another issue with the Corsi Block-tapping Task as a measure for spatial ability in the present study is the sensitivity of the dependent measure, which might not be sensitive enough for investigating fine individual differences among healthy adults. It has been utilized in establishing developmental differences among children and adolescents (Farrell-Pap-gulayan, Busch, Medina, Bartok, & Krikorian, 2007) with relatively large differences in their spatial abilities given the ongoing developmental processes. Further, it has been utilized as a clinical assessment tool for neurological disorders (e.g., Kaplan, Fein, Morris, & Delis, 1991). However, it is not clear whether the Corsi Block-tapping Task is suited for conducting individual difference research among healthy adults, so this must be taken into consideration when interpreting the present results. Thus, it is not completely clear whether the pattern of results is in line with the argument of Ericsson and colleagues, although this seems plausible considering the large body of previous evidence, or whether the measurement tool utilized in the present study does not have sufficient discriminant validity, since the results showed only slightly higher scores for experienced basketball players. Nevertheless, this finding needs to be taken seriously in the field of sport psychology, since the Corsi is a frequently utilized measure of spatial capacity in sport psychological assessment tools, such as the Vienna Test System (Schuhfried, 2009), although it lacks sufficient discriminant validity. Given the described limitations of the measure, future research should address these limitations, as it seems feasible that spatial abilities are an important factor in team-ball sports.

Beyond the visuospatial subsystem derived from Baddeley and Hitch's original model of working memory (1974), the concept of working memory seems a highly fruitful research field in sports because topics such as attention or decision-making are well-studied within sport science and are shown to rely heavily on working memory (e.g., Knudsen, 2007). It seems essential to investigate systematically the working memory system in the field of sports. This task, according to Williams and Ericsson (2005), offers a fruitful domain for exploration of the validity of models developed in other fields, because most sports require numerous higher-order cognitive abilities and are performed under extreme stress where human limits are being continually challenged and extended.

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