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STUDYING COGNITIVE ADAPTATIONS IN THE FIELD OF SPORT: BROAD OR NARROW TRANSFER? A COMMENT ON ALLEN, FIORATOU, AND McGEORGE (2011)[1]

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Summary.—This commentary addresses Allen, Fioratou, and McGeorge (2011), drawing attention to the important topic of how humans cognitively adapt to activities they engage in on a daily basis. We elaborate on the critique and suggestions made by Allen, *et al.* by reviewing research on the relationship of sport and cognition and argue that publication bias may be an issue when studying cognitive adaptations as a function of sport engagement. Implications for future research on the sport-cognition relationship are discussed.

Athletes are required to adapt to specific constraints (Davids, Button, & Bennett, 2007) imposed by the sporting environment to perform successfully or circumvent potential performance decrements. According to Williams, Davids, and Williams (1999), these adaptations are essential because the speed of many sports may exceed the constraints imposed on the basic information-processing capacities of athletes. A topic of recent controversy concerns the possible cognitive adaptations that occur as a function of extensive confrontations with sports.

A large body of evidence supports the *specific processing hypothesis,* which has recently also been named *narrow transfer hypothesis* (Chabris & Simons, 2010). The narrow transfer hypothesis suggests that people with years of experience in an activity such as team sports, playing an instrument, or playing chess only differ in cognitive processing skills directly related to their field of experience and that those skills do not translate to different domains due to adaptations in "basic" cognitive abilities such as memory capacity, perceptual acuity, or intelligence (e.g., Eccles, 2006; Ericsson, Charness, Hoffmann, & Feltovich, 2006). For example, expert chess players do not have greater memory capacity, *per se,* but do have a greater memory capacity for meaningful chess configurations (Chase & Simon, 1973).

In contrast, the *broad transfer hypothesis* suggests adaptations in basic cognitive abilities as a result of prolonged experience in activities such as flying an airplane (Bellenkes, Wickens, & Kramer, 1997), action video-

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game playing (Green & Bavelier, 2003, 2006), or air traffic control (Allen, McGeorge, Pearson, & Milne, 2004). Specifically, the broad transfer hypothesis assumes that practice in a certain activity can potentially lead to adaptations in basic cognitive abilities which in turn transfer to various different skills in more remotely related domains.

Cognitive Adaptations Through Sports?

Studies in the field of sports provide equivocal evidence concerning the broad and narrow transfer hypotheses. These controversial findings have broadly been driven by two different perspectives on the relationship of sport and cognition (Voss, Kramer, Basak, Prakash, & Roberts, 2010): the *expert performance approach* (Starkes & Ericsson, 2003; Mann, Williams, Ward, & Janelle, 2007) which studies athletes in sport-specific contexts, and the *cognitive component skill approach*, which compares the performance of experienced athletes on basic cognitive ability measures with non-athletes or less experienced athletes (Nougier & Rossi, 1999; Starkes & Ericsson, 2003). The two approaches imply different predictions about how athletes adapt to the demands of tasks they engage in on a daily basis.

Two recent studies, by Furley and Memmert (2010) and Memmert, Simons, and Grimme (2009), investigated differences in visuospatial abilities as a function of prolonged experience in basketball and team handball. In these studies, general visuo-spatial ability tasks that might tap the domain of experience of basketball players—multiple object tracking (Alvarez & Franconeri, 2007), functional field of view (Green & Bavelier, 2003), Corsi Block-tapping (Corsi, 1972)—were administered to groups of experienced basketball and team handball players and a control group of participants with no such experience. The results did not indicate any performance differences between the two groups.

Furley and Memmert's interpretation (2010) of these results as being in line with the narrow transfer hypothesis was critiqued in a recent commentary by Allen, Fioratou, and McGeorge (2011), who argued that the results may not necessarily be in line with the narrow transfer hypothesis. The commentary by Allen, *et al.* (2011) was valuable as it drew attention to an important topic and made important suggestions for future research in this area. In this subsequent commentary, we elaborate on the critique and suggestions made by Allen, *et al.* (2011) for studying cognitive adaptations in the field of sport. Before doing so, we briefly highlight the previous findings in this research area.

Previous Findings on the Relationship of Sport and Cognition

Besides the studies above that found no differences between experienced team sport athletes and nonathletes in basic attention tasks, other studies have provided evidence along this line showing that athletes were no better at basic visual perceptual tasks (e.g., Abernethy, Neal, & Koning, 1994; West & Bressan, 1996; Wood & Abernethy, 1997). Moreover, Mann, Ho, De Souza, Watson, and Taylor (2007) demonstrated that good vision was not a limiting factor of sport performance in interceptive sports and athletes had to be made "legally blind" (by wearing special contact lenses) before any significant performance decrease occurred.

On the other hand, there is evidence suggesting enhanced attentional orienting abilities—measured by spatial cuing tasks—which have been interpreted as expert athletes possessing enhanced "attentional flexibility" due to the demands of their sports (Nougier, Ripoll, & Stein, 1989; Nougier, Stein, & Bonnel, 1991; Enns & Richards, 1997; Nougier & Rossi, 1999; Pesce, Tessitore, Casella, Pirritano, & Capranica, 2007). Further, a recent meta-analysis (Voss, *et al.,* 2010) found a small-to-medium effect size indicating that athletes performed better on measures of processing speed and several attentional paradigms. Many studies on the relationship of sport and cognition only find very small or nonsignificant effects in favor of athletes. Therefore, Voss, *et al.* (2010) argued that aggregating the effects in a meta-analysis increased statistical power and thus provided evidence for the broad transfer hypothesis—a point we will elaborate on in the next section.

Methodological Issues

Allen, *et al*. (2011) suggested three alternative explanations why the results of Furley and Memmert (2010) might not be supportive of the narrow transfer hypothesis (Ericsson, *et al*., 2006): (i) experienced athletes might not have enhanced spatial capacity detectable by the measures used, (ii) cognitive adaptations of athletes might be minimal, and (iii) the nonathlete control group might have enhanced visuospatial abilities caused by other activities such as action video-game playing. Considering the results and argumentation of Voss, *et al*. (2010), it might be conceivable that the explanations (i) and (ii) are responsible for the nonsignificant results. On the other hand, one can argue that a publication bias (Riniolo, 1997) is responsible for the small-to-medium effect size obtained in the meta-analysis. According to Riniolo (1997), publication bias is defined as the increased likelihood of publication of a manuscript reporting statistically significant rather than nonsignificant results. Publication bias is caused by both a submission bias which occurs before the review process and a selection bias that occurs during the review process (Cooper, DeNeve, & Charlton, 1997). Evidence for this phenomenon has not only been found in psychology but also in medicine and biology (Sterling, Rosenbaum, & Weinkam, 1995; Cumming, Fidler, Leonard, Kalinowski, Christiansen, Kleinig, *et al*., 2007). As a result, publication bias can be responsible for an effect in the literature which actually does not exist, or for distorting the effect size in the literature (Rosenthal, 1979). Therefore, the small-to-medium effect of Voss, *et al.* (2010) may actually resemble a much smaller effect which is distorted due to a publication bias.

Although Voss, *et al.*'s trim-and-fill analysis (2010) did not show any statistical evidence for publication bias, this result may have been caused by the low test power due to the fact that the meta-analysis only included 20 studies. Fig. 1 displays a funnel plot of the studies included in Voss, *et al.* (2010) which is a common visual method to explore a potential publication bias. The asymmetrical distribution of studies, especially the tendency of small studies missing from the funnel plot's lower left, may be an indication of some nonsignificant results missing from the literature (Sterne & Egger, 2001). Further, Fig. 1 indicates that one study (Carmoney, 1993) is skewing the data. Therefore, it seems necessary to publish statistically nonsignificant results (e.g., Memmert, *et al.*, 2009; Furley & Memmert, 2010) and include these studies in meta-analysis in order to get an unbiased idea of an effect found in the literature.

Explanation (iii) is derived from the Green and Bavelier (2003, 2006) findings: the null result might have been caused by other confounding variables causing enhanced visuospatial abilities such as playing action-video games in the control group. Although, we did not control for this possible confounding variable—and future research should control for

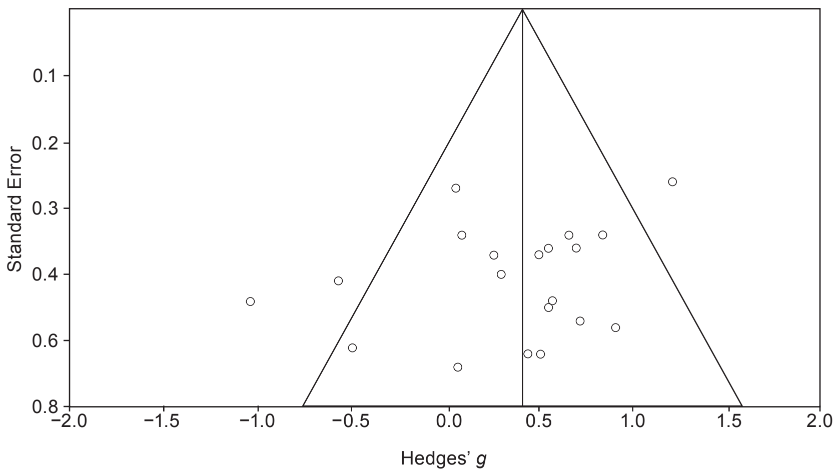

Fig. 1. Funnel plot of the studies included in the meta-analysis of Voss, *et al.* (2010). Dots represent the individual studies with the individual effect sizes observed (x axis) plotted against the standard error (y axis). The vertical line represents the mean effect of the included studies and the diagonal lines define a region in which 95% of studies may lie in the absence of publication bias.

this—it does not seem likely that the control group spent more time playing action-video games than the athlete group. Nor is the effect of action-video games on developing and enhancing of visuospatial abilities as clear cut as Allen, *et al*. (2011, p. 244) stated: "even very brief exposures to action video games result in significant improvements in attentional abilities."

Boot, Kramer, Simons, Fabiani, and Gratton (2008) did not find any causal relationship although they prolonged the video training duration and increased the number of participants in both the experimental and the control group, which should have actually increased the effect. This point was emphasized by Chabris and Simons (2010) who provocatively asked, "How can 10 hours of training in a video game improve basic attentional abilities if every person spends hours of their life in activities such as driving in which one also is required to spread one's attention across a wide visual field?"

Future Research Avenues

A general problem with the common between-groups paradigm (e.g., athletes vs nonathletes) when studying the sport-cognition relationship is that it does not allow inference of a causal relationship. Therefore, this approach does not answer the question whether engagement in team sports leads to improvements on cognitive ability tests, or whether enhanced cognitive abilities lead people to engage in team sports in the first place and decreased the likelihood of dropping out. Thus, the only method of studying the broad transfer hypothesis is an experimental or longitudinal design as Green and Bavelier (2003, Study 5; 2006) used for studying the cognitive adaptations as a result of playing the action-video game *Medal of Honor*. This point was also highlighted as a fruitful future research avenue by Allen, *et al.* (2011) for addressing the sport–cognition relationship.

Moreover, it seems necessary that future research should control for several potential confounding variables: (i) that the different groups do not differ in the time spent in other activities (e.g., action-video game playing) that might potentially cause cognitive adaptations, and (ii) that the different groups do not differ in any other state or trait variables that might account for superior performance in test situations (e.g., competitiveness). A further confounding variable that requires careful attention when studying the relationship of sport and cognition is physical fitness. Recent research (Kramer, Hahn, Cohen, Banich, McAuley, Harrison, *et al*., 1999; Hertzog, Kramer, Wilson, & Lindenberger, 2008) has demonstrated enhanced cognitive functioning as a consequence of increased physical fitness. Thus, differences between nonathletes and athletes on cognitive tests may not have been caused by the fact that athletes cognitively adapted to the demands of the sport, but instead by increased fitness of athletes compared to nonathletes.

A last point that should be taken seriously in this field of research is how the different groups are classified. Often the term 'expert' is used fairly loosely and care should be taken who can be classified as an expert or is simply experienced in an activity. Studies in the field of sport (Memmert & Roth, 2007; Memmert & Harvey, 2010) show that expertise might be an important factor as these studies are indicative for a broad cognitive transfer (e.g., tactical creativity, or tactical intelligence in sport) during the acquisition of expertise in early learning phases.

In conclusion, both the present commentary and the commentary by Allen, *et al*. (2011) highlight that much work is needed to advance current theoretical and empirical understanding of potential cognitive adaptations that occur as a result of extensive engagement in sports. The mentioned future research avenues may help to advance understanding of the relationship of sport and cognition.

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