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EXPERT–NOVICE DIFFERENCES IN BRAIN FUNCTION OF FIELD HOCKEY PLAYERS

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Abstract—The aims of this study were to use functional magnetic resonance imaging to examine the neural bases for perceptual-cognitive superiority in a hockey anticipation task. Thirty participants (15 hockey players, 15 non-hockey players) lay in an MRI scanner while performing a video-based task in which they predicted the direction of an oncoming shot in either a hockey or a badminton scenario. Video clips were temporally occluded either 160 ms before the shot was made or 60 ms after the ball/shuttle left the stick/racquet. Behavioral data showed a significant hockey expertise × video-type interaction in which hockey experts were superior to novices with hockey clips but there were no significant differences with badminton clips. The imaging data on the other hand showed a significant main effect of hockey expertise and of video type (hockey vs. badminton), but the expertise × video-type interaction did not survive either a whole-brain or a small-volume correction for multiple comparisons. Further analysis of the expertise main effect revealed that when watching hockey clips, experts showed greater activation in the rostral inferior parietal lobule, which has been associated with an action observation network, and greater activation than novices in Brodmann areas 17 and 18 and middle frontal gyrus when watching badminton videos. The results provide partial support both for domain-specific and domain-general expertise effects in an action anticipation task. © 2015 Published by Elsevier Ltd. on behalf of IBRO.

Key words: fMRI, sport, action observation network, action anticipation, hockey, badminton.

INTRODUCTION

Research has indicated that expert athletes have better visual and motor skills than novices (e.g. Kato and Fukida, 2002; Ward and Williams, 2003; Le Runigo et al., 2010; Cañal-Bruland et al., 2011; Piras et al., 2014). Further, advanced cue utilization research has found that a key component of elite sports performance involves the ability to predict and anticipate the behavior of other players. This has been shown in sports including football (Dicks et al., 2010), cricket (Müller et al., 2006), volleyball (Schorer et al., 2013), squash (Abernethy, 1990), tennis (Loffing and Hagemann, 2014) and badminton (Abernethy, 1988).

The neural underpinnings of perceptual-motor expertise have been studied in many domains including imitation of hand actions in guitarists (Vogt et al., 2007), motor imagery (Guillet et al., 2008), learning of action sequences in pianists (Landau and D'Esposito, 2006) and dance (Calvo-Merino et al., 2005). Recently, there have been several functional magnetic resonance imaging (fMRI) studies of the superior perceptual-motor abilities of expert sports players. Wright et al. (2010) found that expert badminton players, when predicting the part of the court to which a shot was aimed, exhibited greater activity than novices in a set of brain areas integral to action observation, imagery and execution, often referred to as the action observation network (AON). A further experiment using point-light stimuli showed essentially similar results (Wright et al., 2011). Likewise, AON activation and expertise effects have been reported for tennis (Balser et al. 2014a), basketball (Abreu et al., 2012) and football (Bishop et al., 2013; Wright et al., 2013). One crucial skill component common to such sports is the ability to anticipate what an opponent is going to do next and this is one skill which sets experts apart from novices (e.g. Abernethy, 1990; Abernethy et al., 2008). Often these studies employ temporal occlusion techniques and experts seem to be constantly superior at using the earliest information available from an opponent's body kinematics (e.g. Jones and Miles, 1978; Jackson, 1986; Houlston and Lowes, 1993). Thus, in the present work, a temporal occlusion paradigm will be used to explore expert–novice differences in the brain mechanisms underlying advance cue utilization as participants make judgements of shot direction in the sport of field hockey.

A second area for investigation in the present study is to see whether the 'expert brain' also functions differently from the 'novice brain' when performing a task in which neither group of participants has any experience. There

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Abbreviations: ANOVAs, analysis of variances; AON, action observation network; BC, badminton control; BL, badminton long; fMRI, functional magnetic resonance imaging; FWE, family-wise error; HC, hockey control; HL, hockey long; HS, hockey short; MEPs, motor-evoked potentials; MNI, Montreal Neurological Institute.

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has been very little work to explore this possibility. The only behavioral studies currently in this area focus on pattern recognition. Smeeton et al. (2004) found that the skilled footballers and hockey players were able to transfer perceptual information or strategies between their respective sports. In a similar paper (Abernethy et al., 2005), expert netball, basketball and hockey players and a control group performed a recall task for patterns of play derived from each of these sports. Experts consistently outperformed the non-expert controls in their recall of defensive player positions in their non-preferred sports, suggesting some selective transfer of pattern recall skills.

However, other studies suggest domain-specific rather than domain-general expertise. Calvo-Merino et al. (2005) investigated whether the action observation system is specifically tuned to an individual's motor repertoire by including two differing types of dancer, experts in classical ballet and experts in capoeira, as well as inexpert control subjects. Their results showed that there were greater bilateral activations in AON areas when an expert viewed movements that they had been trained to perform compared to movements they had not. Aglioti et al. (2008) asked athletes (basketball players), expert watchers (coaches and sports journalists involved with basketball) and novices to predict the outcome of free throws in basketball or kicks at goal in football. They found that basketball players could predict the outcome of free throws in basketball earlier and more accurately than either novices or expert watchers. Using single-pulse transcranial magnetic stimulation (TMS) they found an increase in motor-evoked potentials (MEPs) in athletes when they were observing the basketball free throw but not the football kick, suggesting that the brain sends out different messages when watching a clip of a sport in which an athlete actively competes. Balser et al. (2014b) compared expert tennis players and expert volleyball players using video clips of both sports, with each group acting as novice controls in the sports for which they were not expert. This meant that the 'novice' groups still had high levels of anticipation experience as well being used to making decisions under time pressure. Their results nevertheless maintained a difference between the two groups with domain-specific stimulus material; experts experiencing increased activation within the AON, particularly the pre-supplementary motor area, the superior parietal lobule, as well as broad sections of the cerebellum.

However, in a recent critique, Press and Cook (2015) argue that the case for domain-specific motor effects on action observation is weaker than is commonly supposed. They point out that many domain-general effects of motor processes on perception have been identified, and argue that the apparent domain-specific effects reported could be mediated by low-level properties of the stimuli and task such as spatiotemporal perception and attention.

Thus, the present study further explores whether expertise in one sporting domain confers an advantage in a different, non-expert, domain and whether experts show differences in brain activation patterns from novices in this non-expert sporting domain. Instead of using two groups of experts as in the above-mentioned Balser et al. (2014b) study, it was decided to have experts and novices, but to include a task in which both groups would be novices in order to see if differences in activation still occurred. From the little behavioral research carried out in this area it would seem that some transfer of perceptual skills is possible. However, if research on the importance of specific motor expertise in action observation (Calvo-Merino et al., 2005; Aglioti et al., 2008; Balser et al., 2014b) is taken into account it may be expected that brain function of expert hockey players may not differ from novice hockey players when watching badminton clips. This is because, as the study by Calvo-Merino and colleagues shows, the action observation system is very specific in its activation. Finally it should be noted that domain-specific and domain-general effects are not mutually exclusive, and that both may occur.

This study therefore set out to test four main hypotheses: (a) that there are domain-specific effects of hockey expertise on prediction accuracy in hockey and badminton video stimuli, (b) that there are domain-specific effects of hockey expertise on fMRI activations in the same task, (c) that there are domain-general effects of hockey expertise on prediction accuracy and (d) that there are domain-general effects on fMRI activations.

EXPERIMENTAL PROCEDURES

Participants

Fifteen hockey players, ranging in ability from club level to senior international (mean age 28.7, SD 7.3, 10 male and 5 female, average years' experience of competitive hockey = 8.86, SD 5.6), and 15 non-hockey players (mean age 22.1, SD 3.5, 9 male and 6 female) took part in the study. All participants had a minimum education level of having at least begun a university degree. The hockey players were recruited through the first author's contacts in various hockey teams and clubs. The non-hockey players were recruited through the university or were friends of the hockey players who also wanted to take part. No participants from either group had any experience playing badminton beyond school PE lessons. None of the participants reported regularly watching badminton and none of the non-hockey players reported regularly watching hockey. All had normal or corrected to normal vision. All participants were fully briefed on the experiment and the use of fMRI. All participants signed a consent form and were free to withdraw at any point.

Stimuli and design

Continuous fMRI data were acquired as participants viewed 2-s video clips of either an opposing badminton player or an opposing hockey player making a shot/pass either left or right. Participants pressed one of two buttons, during a 2-s luminance-matched screen after each clip, to predict to which side they believed the shuttlecock/ball to be traveling. The actors in the video clips were national- level players in each respective sport, and the hockey and badminton clips were approximately matched in terms of the filming distance,