The effect of expertise on encoding of movements and bodily indexes: a study on volleyball players

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Abstract

The use of a particular attentional paradigm, the paradigm of Sidedness (Ottoboni, Tessari, Cubelli & Umiltà, 2005) has highlighted as professional volleyball players differ from non-players in the ability to encode specific spatial indexes. The presentation of images of hands of potential adversaries incorporates meanings related to sport that make volleyball athletes sensitive to directional spatial characteristics previously unobserved. What appears to be crucial in the generation of such effect is the ability to predict the direction of an action.

Keywords: action prediction, action directionality, body, Sidedness, expertise, sport.

Introduction

The ability to anticipate events and actions is essential to interact with the environment in a profitable way. For example, anticipating the movement of the opponent is required to prepare the most appropriate response to counter it during many sport actions. Some behavioral studies have revealed significant differences between athletes and non-experts, in terms of processing capabilities for both visuol-perceptual and motor skills. In ball games, for example, experienced athletes are able to anticipate "where" and "when" the ball will be thrown by the ability to extract the essential information expressed by the movements of the opponent before the ball begins its trajectory (Williams & Grant, 1999; Aglioti, Cesari, Romani & Urgesi, 2008). It was also shown that expert athletes are better than non-experts or non-athletes in recognition and storage of complex patterns of actions (Abernethy, 1990; Allard et al., 1980; Starkes & Allard, 1983; Starkes, 1987). This increased ability seems to be based on reading the observed gesture's kinematics: experienced athletes are able to anticipate perceptual strategies because they have a wider and consolidated visuo-motor repertoire (Savelsbergh et al., 2002; Williams et al., 2002) acting as the basis for their visual perception, as well as for the resulting motor execution. These skills seem to be supported also by differences in the activation of premotor and parietal cortical areas (Calvo-Merino, Glaser, Grezes, Passingham & Haggard, 2005; Calvo-Merino, Ehrenberg, Leung & Haggard, 2010) and processes of mental simulation involving the activation of the motor areas (e.g. the shot at the basket in basketball players; Aglioti, Cesari, Romani & Urgesi, 2008).

In general, expert athletes do not possess different structural cognitive characteristics from those of non-experts: they are only more skilled in selecting the most effective signal for detecting a change in the position of the opponents among those available (e.g. the trajectory of the ball or an attack action). For example, it has been found that volleyball players orient attention along the horizontal and vertical axes in significantly different manners (Rizzolatti, Riggio, Dascola & Umiltà, 1987). In the present study we investigated whether professional volleyball players were able to extract relevant information from the vision of individual parts of the body. In particular, we tried to isolate what directional indices athletes were able to process automatically in response to the presentation of hands that imply motion. We wanted to investigate if volleyball players were able to process the intention to act transmitted by the posture of the presented hands, given that it is an essential information for the game (for example to predict the direction of a possible spike action). Such processing capabilities allow athletes to predict the actions of opponents and to anticipate the motor behavior in order to oppose them. The hypothesis is based on results from studies on the perception of photographs of the body or body-parts giving the impression of movement (eg. Kourtzi & Kanwisher, 2000; Urgesi, Moro, Candidi, & Aglioti, 2006) . This processing ability would anticipate what the final position is based on information we already have about "already seen and experienced" movements (Freyd, 1983).

Therefore, the posture of opponent's hand might allow volleyball athletes to predict the direction of the ball.

In the present work we used the paradigm of Sidedness, commonly used to define precisely the spatial coding based on the side of the body which the hand or foot is "connected to" (Ottoboni et al., 2005; Tessari et al., 2012a). For example, a left hand presented from the palm view with the fingers oriented upward activates a right spatial code because it is perceived and represented as the right hand of a human body facing the observer. The same hand, but seen from the back (Figure 1A left panel), actives instead a left spatial code because it is represented to the left of a body that turns its back to the observer (Figure 1B right panel).
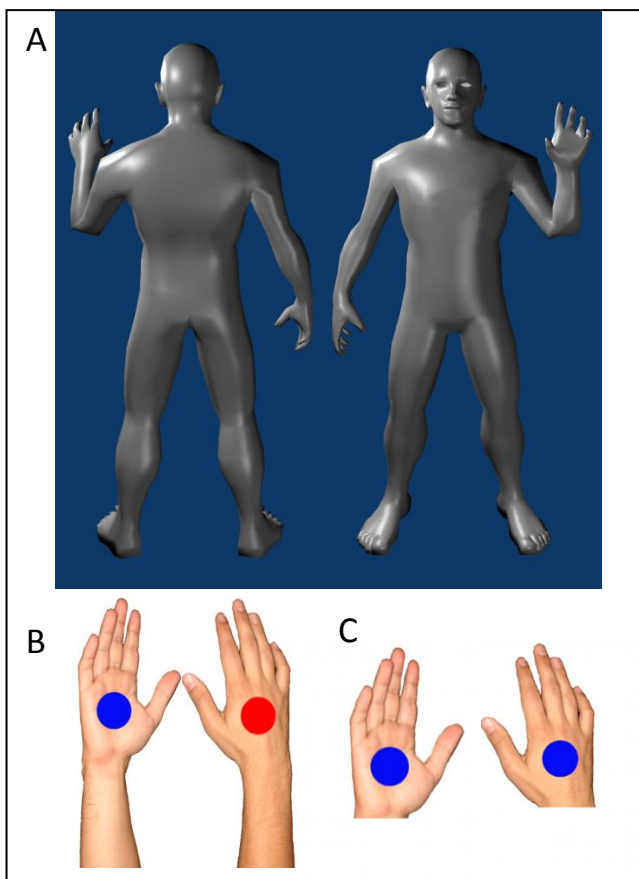

Figure 1: Figure 1A illustrates the concept of Sidedness, that is, the mode in which each hand is spatially coded in relation to a body as a function of the posture. Figure 1B shows the stimuli used in Experiment 1 and Figure 1C those of Experiment 2.

Experiment 1

Using photographs of oriented hands, we aimed at testing if volleyball players were able to process information on a potential attack action by encoding the direction imprinted to the ball. As anticipated, we suggested that every hand presentation generates different spatial codes: one linked to the Sidedness and one related to the direction of the action. For example, a right palm hand, since it appears to act from left to right (i.e. the ball would be crushed to the right), should direct the attention of the observer to the right, thus the spatial code of Sidedness would be the opposite one, activating a left Sidedness code, in turn. In this way, if players were able to process both codes, we could observe a mutual cancellation. However, our prediction takes into account also the posture of the hand (i.e. palm vs. back). Back hands, that are not salient in the context of the game, are not expected to induce processing of action direction, but only an encoding of Sidedness. On the contrary, the palm hands are assumed to be coded according to both Sidedness and direction, with a consequent annulment of the two opposite spatial codes.

Method

Participants Sixteen right-handed volleyball players belonging to elite teams were tested (mean age= 22 years).

Apparatus and procedures The stimuli were photographs of right and left hands in back and palm views with the forearm (23° X 9° visible angle), rotated of 30° along their ulnar axis as in Tessari et al. (2010a; 2012b). See Figure 1b. A red or blue circle was superimposed in the middle of the hand. The experiment was run using a Pentium III, 512 Mb, connected to a 15" screen. The experiment was controlled by E-Prime 1.1 (SP3) software (Psychology Software Tools Inc.). The stimuli were 120 for both the back and palm conditions and lasted on the screen for 100 ms, each. The next stimulus appeared after participant's response and no longer than 1000 ms after. Participants were required to respond according to the colour of the circle by pressing one of two keyboard keys ("X" and "."), respectively on the left and the right side. Feedbacks about reaction times (RT), errors and omissions were given after each response (it lasts for 1500 ms). The response conditions were counterbalanced between subjects.

Results Participants whose error threshold was above 10% and RTS 2 standard deviations higher or lower than the overall participants' mean for corresponding and non-corresponding pairings in each block were excluded from the analyses. Data were submitted to a 2 x 2 ANOVA for repeated measures with View (Back vs. Palm) and Correspondence (Corresponding pairings vs. Non-corresponding pairings between hand laterality and response hand) as the within-subjects factors. The two factors (View: $F(1,16)=60.03$, $p<.001$, and Correspondence: $F(1,16)=42.65$, $p<.001$) and their interaction $(F(1,16)=33.48, p<.001)$ were significant. RTs for the palm hands were faster than those for back hands (M=312 ms, SE=4.22 vs. M=340 ms, SE=6.07), and corresponding pairings were responded faster than the non-corresponding ones (M=318ms, SE=4.61 ms vs. M=333 ms, SE=6.51). When stimuli were presented from the back view, RTs were faster for corresponding (M=325, SE=6.40) than for non-

corresponding pairings (M=355, SE=9.01): two-tailed t(15)= -8.34, p<.001. For the palm view no difference emerged (t(15)=0.04, p>.05; non-corresponding pairings M=312, SE=5.69, and corresponding pairings M=312, SE=6.43). See figure 2a.
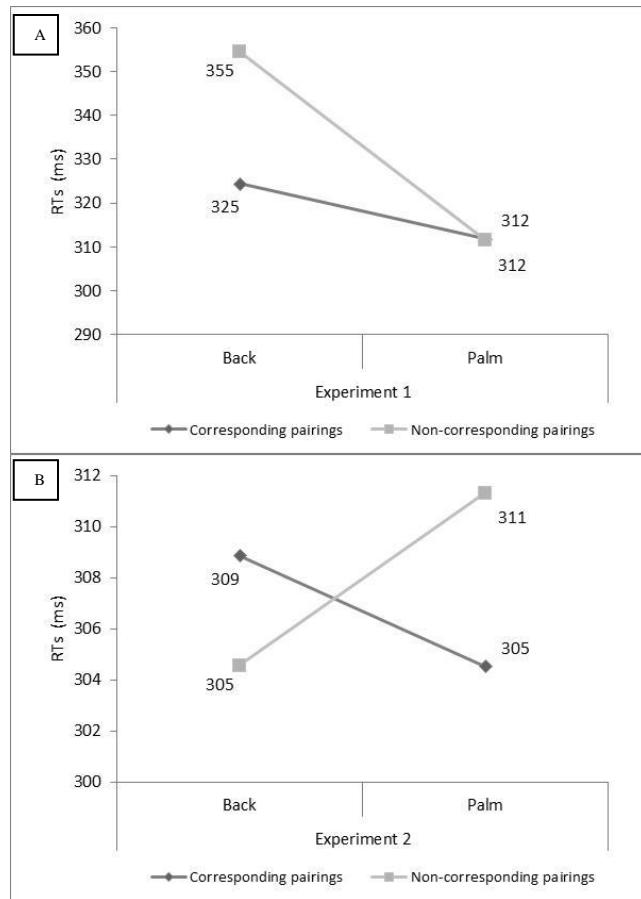

Figure 2: The graph shows the values of the reaction times in Experiment 1 (upper part) and Experiment 2 (lower part).

Discussion

Compared to a previous study on non-athletes, where an Sidedness effect emerged for both back and palm hands (Tessari et al. 2010a; Tessari et al., 2012b), the effect emerged only for the back hands in volleyball players. As hypothesized, the palm hands were more informative and relevant as confirmed by the significant effect of Posture (faster responses to the palm), but also by the absence of effect for the palm hands which seem to have been encoded for both Sidedness and the direction of the potential action. This way, the spatial codes were opposites and Summing themselves resulted in a null effect. To confirm this interpretation we conducted a second experiment where we tried to rule out the Sidedness effect by hiding the forearm in the stimuli.

Experiment 2

It is known that a hand or a foot can be referred to an appropriate body of reference only in the presence of physiological link such as the forearm or the ankle, that comply with the biomechanics laws of the human body (Ottoboni et al., 2005; Tessari et al., 2010b). In the absence of such links the Sidedness effect does not emerge. Following this logic, we presented the same hands of Experiment 1 without forearm to clarify whether the null effect obtained with palm hands was given by the sum of two opposite spatial codes (that generated by action direction and the one of Sidedness). In this condition the Sidedness effect should be deleted while the direction effect should remain.

Participants Eight right-handed volleyball players belonging to new elite team were tested (mean age = 25 years).

Apparatus and procedures Apparatus and procedure were those of Experiment 1 but hands were presented without the forearm (see Figure 1c).

Results The two factors (View: F (1,7)=0.06, p > .5, and Correspondence: F (1,7) = 0.11, p > .5) were not significant but their interaction was (F (1,7) = 13.04, p < 0.01). When stimuli were presented from the back view, RTs did not differ for corresponding (M=309 ms) and non-corresponding pairings (M=305 ms): t(7) = 1.24, p = .25. For the palm view corresponding pairings were in trend faster than the non-corresponding ones (M=304 ms vs. M=311 ms): t(7) = -1.55, p = .08. See Figure 2.

Discussion

Using as stimuli photographs of hands without forearm we got a pure effect of compatibility based on the direction of the attack action for the palm hands. For example, a right palm hand that directs attack action to the right induced a faster response with the right hand. Any effect emerged for the back hands without the forearm neither for Sidedness (as in non-athletes; Ottoboni et al., 2005) nor for direction. Therefore it seems that professional volleyball players are able to encode the palm hands as hands potentially performing a directed action while the back hands does not allow (even to experienced athletes) to extract any relevant information for the game.

Conclusion

The purpose of this research was to investigate the type of information that the high-level volleyball players extrapolate at the presentation of hands. These athletes were chosen because the volleyball game requires an excellent visual analysis of the spatial information transmitted from the hands of the opponents: they must be able to recognize in the shortest time potential attack actions, so as to implement the best response behavior. We hypothesized that hands slightly rotated were coded as hands in the process of acting and that they would have activated at least two spatial codes: one generated by the Sidedness (the spatial code

referred to a body) and the other conveyed by the direction of a potential spike action. Hands presented by palm and with the forearm allowed a complete activation of the opposite spatial codes (e.g. a right palm hand was coded as on the left of a body following the Sidedness, but the attack action drove attention to the right). However, back hands have only activated a spatial code based on Sidedness. To ensure that what was encoded was the direction of the potential attack action, we decided to rule out the Sidedness effect by presenting the same hands without the forearm. Indeed, the forearm is necessary to link the hand to a reference body and to generate the Sidedness effect (Ottoboni et al., 2005). In this condition, we only found an effect of directionality for the palm hands. Considering the results that emerge from studies of athletes (eg Kourtessis, Michalapoulou and Derrida, 1998; Nicoletti and Borghi, 2007, for a review) it seems that the athletics tasks requiring motor anticipation and quick response are highly dependent on the level of expertise. The extensive motor experience seems to develop a resonance system specific for the actions of a specific sport discipline, which allows to enhance both the predictive and the anticipatory abilities on the basis of a shared representation between the perceived actions and the actions performed in the sensorimotor repertoire (Aglioti et al., 2008). We can therefore assume that also the highly experienced volleyball players are able not only to effectively process bodily indexes but also the direction of a potential expressed action in contrast with non-athletes that are mainly focused on the normal relations between hand and body (Tessari et al. 2010a). It will be interesting to determine whether the described behavior was developed by the athletes during their career or if, alternatively, this capacity is a precondition that led the professional volleyball players to success.

Acknowledgments

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