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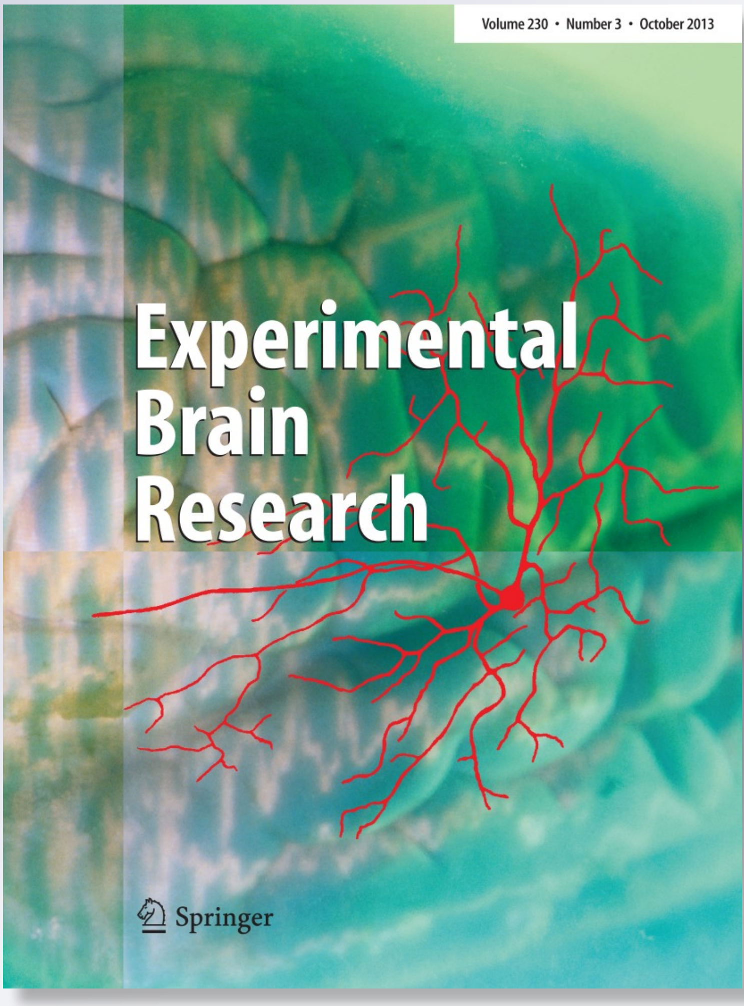
Experimental Brain Research

ISSN 0014-4819
Volume 230
Number 3

Exp Brain Res (2013) 230:333-343
DOI 10.1007/s00221-013-3658-2



Springer

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DOI 10.1007/s00221-013-3658-2

RESEARCH ARTICLE

Athletes and novices are differently capable to recognize feint and non-feint actions

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Received: 13 July 2012 / Accepted: 24 July 2013 / Published online: 18 August 2013

Abstract Fast motor reactions in sports often require the ability to predict the intended action of an opponent as early as possible. Therefore, the present paper investigates whether beach volleyball athletes are able to recognize different attack hits (i.e. smash vs. poke shot) at an earlier stage of the movement than novices. Beach volleyball athletes and novices took part in a response priming experiment (Experiment 1). Participants had to decide whether a presented target picture depicts a smash or a poke shot. Importantly, the preceding prime pictures were taken from different stages of the movements varying between the jump (beginning of the movements) and the hand-ball contact (end of the movements). Diverging response congruency effects was found for athletes and novices. Athletes were able to recognize at an earlier movement stage than novices which kind of attack hit was shown at the prime picture. It is suggested that athletes might implicitly read movement-related patterns in the depicted athlete's body posture (e.g. the angle of the elbow). In contrast, novices might use information which is easier to access (e.g. hand-ball relation). In a second experiment, novice participants received a visual training to test for a potential perceptual source of the priming effects. Notably, participants did not improve their ability to differentiate the volleyball techniques, indicating that a better recognition performance in athletes is based on motor and not on perceptual expertise.

Keywords Action representation · Motor expertise · Priming · Feint action

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Introduction

Human interaction in a social environment requires the ability to predict the intended actions of other people. This ability is necessary in order to attune one's own actions to an interacting partner (e.g. to grasp a transported object). Predicting others' intentions and initiating an appropriate motor response become much more complex if an acting person tries to hide his real intentions. This is a typical aspect of sport scenarios. For example, for an offensive move in volleyball, an attacking player pretends to smash the ball with maximum speed into the opponent field, but instead he smoothly lobs the ball above the blocking player. Evidently, a defending player is better able to react appropriately if he predicts the true action intention (i.e. recognition of feint and non-feint) of the attacker as early as possible.

Commonly, video sequences of feint and non-feint actions are used to investigate the detection performance of experts and novices (Canal-Bruland and Schmidt 2009; Canal-Bruland et al. 2010; Jackson et al. 2006; Morris and Lewis 2010; Sebanz and Shiffrar 2009). In a recent study by Sebanz and Shiffrar (2009), for example, expert basketball players and novices had to distinguish between a basketball player passing the ball or mimicking passing the ball (i.e. feint). The videos stopped either before the ball left the player's hands (passes) or just before the player withdrew the hands (feint). The main finding is that experts outperform novices, indicating that experts are better able to use movement cues to infer the true action intention of an actor.

There are two ways how experts' superiority can be explained (see for example, Canal-Bruland et al. 2010). First, it is argued that athletes' frequent visual exposure to members, opponents, or coaches makes athletes more efficient in picking-up relevant movement information (Huys et al. 2009; Mann et al. 2007; Williams et al. 2009). Alternatively, it is suggested that motor expertise likely has a significantly larger impact than visual expertise for action perception (Aglioti et al. 2008; Calvo-Merino et al. 2006; Casile and Giese 2006). More specifically, it is argued that both perception and production of action are commonly represented (common coding theory, Prinz 1997). That is, to perceive an action and to perform an action relies on the same cognitive representation. Thus, athletes who have motor representations available might have better capabilities to perceive (and to predict) movements of their movement repertoire. Novices, in contrast, have no or relatively simple motor representations that could improve perception via common representations.

Support for the common coding approach is, for example, gained from a study conducted by Calvo-Merino et al. (2006). In an fMRI study, male and female dancers watched videos of dancing movements performed by either gender. As all ballet dancers train together, they have equal visual experiences with both types of dancing moves, but only motor representations for gender-specific movements. The results show that the activation of motor representations (in parietal-premotor circuits) was stronger when participants watched movements from their own movement repertoire compared to movements where they had only visual experiences. Thus, activation of motor representations predominantly depends on specific motor knowledge and less on visual experiences. A further study dissociating the influence of motor and perceptual capabilities for perceptual recognition was conducted by Casile and Giese (2006). Participants learned to produce a gait pattern with unnatural arm movements. During the learning phase, participants were blindfolded and did not receive any visual stimulation. Before and after the blindfolded motor training, participants' visual recognition performance of gait patterns from point light displays was assessed. Casile and Giese (2006) found a selective improvement in the recognition performance for the learned gait pattern. The study of Casile and Giese (2006) points out that the acquisition of motor patterns directly influences visual recognition performance of the particular movement.

Besides, it is not clear whether or not athletes of a certain movement can only benefit from their experiences when judging *dynamic* movement information (i.e. videos) or if they are also superior in perceiving *static* movement information (i.e. pictures). In a second experiment by Sebanz and Shiffrar (2009), for example, only the last frames of the above-described basketball videos were used. Participants had to judge whether the static images depict a basketball player just before a pass or a fake. Even though both groups were still able to discriminate passes and fakes above chance, experts' superiority in detecting feints compared to novices disappeared. Therefore, Sebanz and Shiffrar (2009) argue that experts' prediction superiority is selective for dynamic displays.

The results of a recent study conducted by Güldenpenning et al. (2012) are contrary to the suggestion of Sebanz and Shiffrar's (2009) even though these two studies used different methodologies. Güldenpenning et al.'s study used photographical stimuli from a high-jump movement in a response priming experiment. Specifically, skilled high-jump athletes and novices had to classify a target picture as taken from the approach phase or from the flight phase of a high-jump movement. Before the target, a prime picture with a body posture from either the approach or the flight phase appeared. Importantly, the movement sequence shown in prime–target pairs could either depict a natural movement order or a reversed movement order. Such a movement order was true for both prime–target pairs of one movement phase and prime–target pairs from different movement phases. For example, the second picture of the approach phase as prime followed by the third picture of the approach phase as target reflects a *natural* movement order *within* a movement phase. In contrast, a flight prime followed by an approach target reflects a *reversed* movement order *between* movement phases. Processing of the temporal order within a movement phase (e.g. the second and the third picture of the approach) requires a detailed processing of the body postures. In contrast, for processing the temporal order between movement phases (e.g. an approach prime followed by a flight target), a rough processing of distinct features is sufficient, such as the orientation of the body (i.e. a running athlete is oriented vertically, whereas a flying athlete is more curved).

The main finding is that skilled athletes responded faster to prime–target pairs reflecting the natural movement order, which includes a natural movement order between movement phases (i.e. an approach prime followed by a flight target) and a natural movement order within a movement phase (e.g. the second picture of the approach followed by the third picture of the approach). In contrast, novices only processed the temporal order between movement phases, that is, the temporal order between the approach and the flight phase.

Güldenpenning et al. (2012) argue that perceiving the prime picture automatically activated future states of the action in the participants (Urgesi et al. 2010; Schütz-Bosbach and Prinz 2007). This activation facilitated encoding of a target picture if it depicted a forthcoming action. The availability of a fine-grained cognitive representation of the high-jump movement in athletes (Schack and Mechsner 2006) prompts a precise movement anticipation (i.e. within the approach and within the flight phase). In contrast, in novices who lack specific movement expertise, primes activate only coarse representations of future postures of the movement (i.e. the approach is followed by the flight). Thus, athletes with domain-specific motor expertise may be better in predicting a movement than non-athletes without domain-specific movement expertise.

To date, it is undisputed that athletes of a certain sport are better able to predict a perceived movement than novices. However, it is not clear whether athletes only outperform novices when dynamic movement information is available (i.e. video scenes) or even when only static information is present (i.e. a body posture shown at a picture). Moreover, it is still under debate whether athletes' superiority is based on their motor representations or on their frequent visual exposure to those movements. To address these issues, a response priming experiment with photographic (i.e. static) stimulus material of two attack hits typically performed in beach volleyball was conducted (Experiment 1). Additionally, a visual training study was performed (Experiment 2) to investigate whether or not a better recognition performance in athletes is based on motor expertise or on visual experience (Experiment 2).

Experiment 1

To evaluate recognition performance between athletes and novices, a response priming experiment with photographic stimulus material of an attack hit (i.e. smash) and a feint (i.e. poke shot) typically performed in beach volleyball was conducted. In a feint scenario, an attacking player pretends to smash the ball with maximum speed into the opponent field (i.e. smash), but instead he smoothly lobs the ball above the blocking player (i.e. poke shot). Notably, an attacking player intending to play a poke shot tries to pretend as long as possible that he will play a smash. Therefore, both movements have a similar run-up and take-off, but differ more as they come to their end (see Fig. 1).

In the present study, beach volleyball athletes and novices had to classify a target picture as a smash or as a poke shot. There was a particular target picture for each response category, which depicted the hand-ball contact at the end of each action. Before the target appeared, a prime picture was presented, which could depict a body posture either from the smash or from the poke shot. Thus, a prime picture could either demand the same response as the target (i.e. same action) or the alternative response (different actions). It was expected that a prime picture would activate the movement category (i.e. smash or poke shot) appropriate to

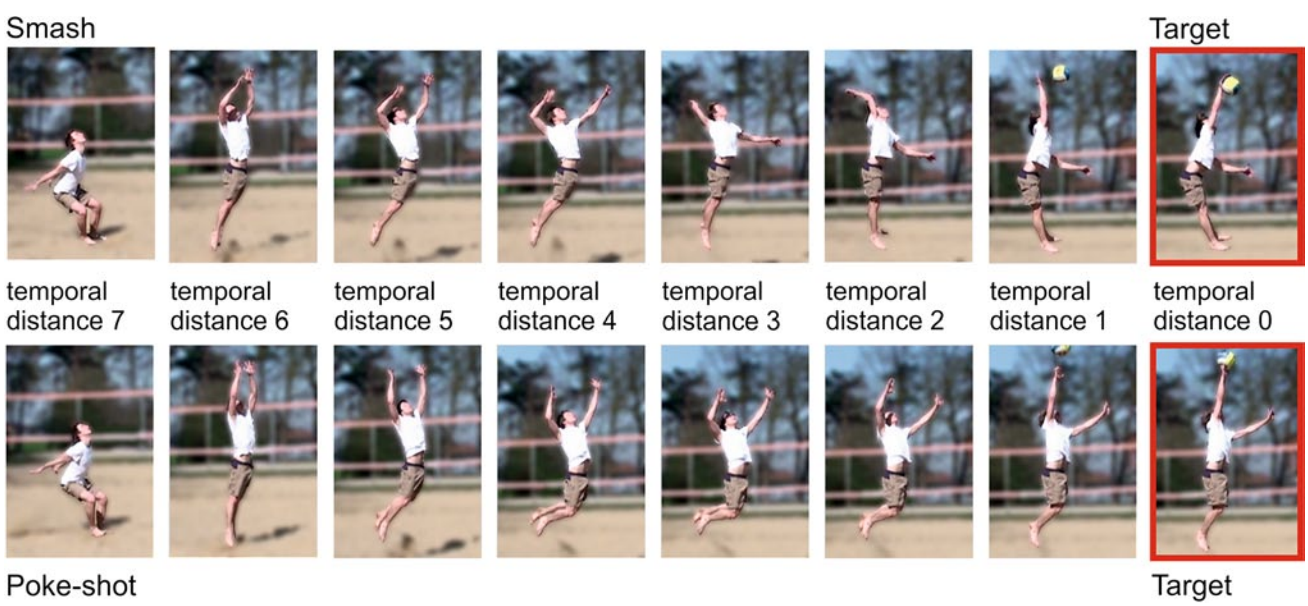

Fig. 1 Stimulus material used in the present study. The *upper* pictures depict the smash, whereas the pictures below depict the poke shot. Only the two pictures on the far right were used as targets (temporal distance 0; framed), whereas all pictures were used as primes. The original pictures used in the experiments were coloured, and the background was *blurred* to reduce distraction from irrelevant background information

the prime, and thus influence responses to the target stimulus. This should produce a response congruency effect (e.g. Neumann and Klotz 1994; Dehaene et al. 1998; Kunde et al. 2003); that is, a faster response when prime and target are from the same response category (e.g. prime and target depict a smash) than when they are from different response categories (e.g. prime depicts a smash and target depicts a poke shot). Here, this effect is called the action congruency effect.

Importantly, the prime pictures were taken from eight different points in time. A prime picture from the beginning of the movement has a large temporal distance from the body posture shown in the target picture, whereas a prime picture from the end of the movement has a small temporal distance to the target picture (factor *temporal distance*). Thus, a prime with a large temporal distance does not unambiguously signal the movement to be performed (i.e. smash or poke shot), whereas a prime with a small temporal distance clearly indicates the movement to be performed. Accordingly, primes with a large temporal distance to the target might be less sufficient to activate the associated action category (i.e. smash or poke shot) than primes with a small temporal distance to the target. Specifically, it was predicted that the action congruency effect would be modulated by the factor temporal distance. No action congruency effect was expected for primes taken from the beginning of the movement (e.g. with a large temporal distance to the target), whereas a larger congruency effect was expected for primes taken from the end of the movement (e.g. with a small temporal distance to the target).

Concerning expertise, it is suggested that the mental representation of the beach volleyball movements relates to performance (Schack 2012; Bläsing et al. 2009). Thus, athletes being able to perform the smash and the poke shot have differentiated knowledge about the volleyball techniques available. Novices in contrast not being able to perform the movements might only have coarse knowledge about the volleyball techniques. According to the common coding approach mentioned above (Prinz 1997), this qualitative difference concerning the movement representation might influence perceptual recognition performance. Therefore, it was predicted that perceiving a prime picture more strongly activates the corresponding movement representation in beach volleyball players than in novices. This should result in larger action congruency effects in athletes than in novices. Within the same line of reasoning, we expect athletes being able to recognize at an earlier stage of a movement than novices, which movement is to be performed. Therefore, an action congruency effect in athletes for a larger temporal distance compared to the (largest) temporal distance for potential action congruency effects in novices was predicted.

Method

Participants

Thirty-two participants took part voluntarily or in exchange for course credit. Sixteen participants (four females, all right handed, mean age 24.9; range 19–31; $SD = 4.18$) were considered novices. They reported having no practical experiences with beach volleyball or volleyball. All novice participants were physically active students, performing at least one form of sport (7 participants performed individual sports, 6 performed team sports, 2 performed competitive sports, and 1 performed racket sport). Sixteen participants (four females, all right handed, mean age 23.7; range 18–39; $SD = 5.79$) were considered skilled beach volleyball athletes due to their practical experiences with this particular sport (an average of 9.4 years of training, range 4–21; $SD = 4.47$). All beach volleyball athletes were still active players. Nine participants took part in A-Cup competitions, and seven participants took part in B-Cup competitions. Athletes playing A-Cups are first or second division league players in indoor volleyball. B-Cup player compete at an intermediate level. All participants had normal or corrected-to-normal vision, they were all naive with regard to the purpose of the experiment, and all provided written informed consent before testing started. The experiment was performed in accordance with the ethical standards of the sixth revision (Seoul, 2008) of the 1964 Declaration of Helsinki.

Apparatus and stimuli

For stimulus presentation, a notebook with a 17-inch VGA display (vertical retraces 85 Hz) and the software Presentation® (version 14.3) was used. Responses were given by pressing the right and the left control buttons of a standard computer keyboard with the index fingers.

The stimuli consisted of eight pictures of a smash and eight pictures of a poke shot, both performed by a male athlete, taken from high-definition video records (SONY Camcorder HDR-SR11E). The recording rate for the stimuli was 25 frames per second. The picture of each action that displayed the end of the movement (i.e. the hand-ball contact) was used as the target. All sixteen pictures were used as prime pictures (see Fig. 1). The temporal distance between subsequent prime pictures was 5 frames (=200 ms), except between the target picture from the end of the movement and the prime right before hand-ball contact (2 frames = 80 ms). The stimuli had a size of 7.4 × 10.7 cm (280 × 404 pixels). The pictures used in the experiment were coloured, and the background of the stimulus pictures was blurred to reduce potential distraction from irrelevant background information. All stimuli were presented centrally on a black background and subtended a visual angle of 7.1° in horizontal and of 10.2° in vertical from the viewing distance of 60 cm.

Design and procedure

The present study used a 2 × 8 × 2 mixed factorial design with the within-subjects factors *action congruency* (congruent vs. incongruent) and *temporal distance* (0, 1, 2, 3, 4, 5, 6, 7). The level of participants' *expertise* was a between-subjects factor (beach volleyball athlete vs. novice). The dependent variables were reaction time (RT) and error rate (ER). Participants sat in front of a computer screen (60 cm) and were instructed in written form to classify the presented target as fast and as accurately as possible as showing a smash or a poke shot by pressing one of the two response buttons with the index finger. The response button assignment was counterbalanced across participants for each group.

The procedure of the experiment is illustrated in Fig. 2. Each trial started with the presentation of a fixation cross (400 ms), followed by a blank screen (100 ms), the prime (100 ms), a second blank screen (100 ms), and the target, which remained on the screen until the response was given. Incorrect responses elicited the word "Fehler" (German word for "error"). An inter-trial interval of 1500 ms elapsed before the next trial started.

Before starting the main experiment, 16 representative trials were used as a practice block. Data from this block were not analysed. The combination of 16 primes with 2 targets result in 32 prime–target pairs. These prime–target pairs were randomly presented on block, and blocks were shown nine times to avoid immediate repetitions of particular prime–target pairs. Thus, each participant performed 288 trials. All trials were presented continuously with one short break in the middle of the experiment. After the reaction time experiment, participants filled in a questionnaire with open question. Here, participants were asked to describe what kind of cue they used for classifying the target picture. The session took about 30 min.

Results

Data analyses

Response times (RTs) were screened for outliers using a total cut-off. RTs below 200 ms and above 1,000 ms were excluded (1.0 %). Trials with wrong answers (2.4 %) were not used in the analysis of the RTs.

ANOVAs with the within-subjects factors *action congruency* and *temporal distance* and the between-subjects factor *expertise* were performed with reaction time (RT) and error rate (ER) as dependent variables. Mean RTs and ERs for each participant and each condition were computed. A violation of the sphericity assumption resulted in a correction of the *p* values and degrees of freedom according to Greenhouse–Geisser. Multiple comparisons were corrected according to Holm–Bonferroni. The effect size of t tests was calculated according to Cohens' *d*. Before performing the ANOVA on error rates, the proportions were converted to arcsine values.

Reaction times

The reaction time as a function of the factors *action congruency* and *temporal distance* is illustrated separately for athletes and novices in Fig. 3. The main effect of *action congruency* was significant ($F(1, 30) = 107.46$, $p < .001$, $\eta_p^2 = .78$) as well as the within-subjects factor *temporal distance* ($F(5.10, 152.92) = 15.23$, $p < .001$, $\varepsilon = .73$, $\eta_p^2 = .34$). The interaction between *action congruency* and *temporal distance* was significant ($F(5.37, 161.08) = 43.45$, $p < .001$, $\varepsilon = .77$, $\eta_p^2 = .59$), as was the interaction between *action congruency* and *expertise* ($F(1, 30) = 7.98$, $p < .01$, $\eta_p^2 = .21$). There was neither a main effect for expertise nor any other significant interaction (all p's > .50).

To illuminate whether the *action congruency* effect is generally larger for beach volleyball athletes compared to novices, the different values for athletes (mean = 28 ms, *SD* = 13.82 ms) and novices (mean = 16 ms, *SD* = 11.03 ms)

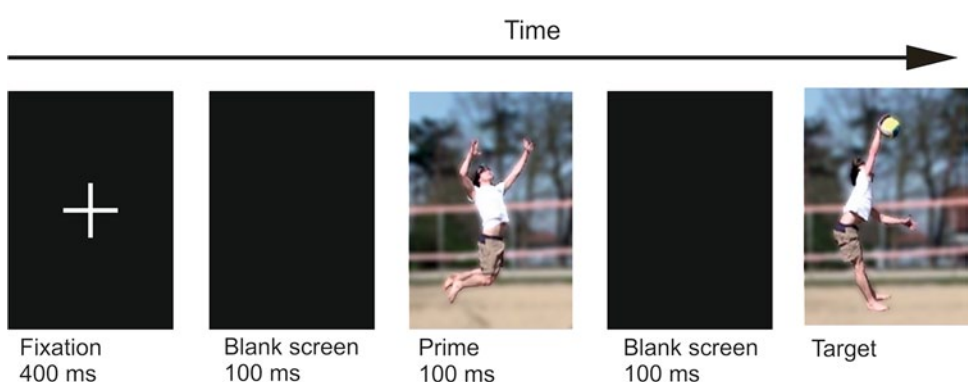

Fig. 2 Procedure of the experiment. The displayed example illustrates an incongruent trial with a temporal distance of 3. The prime is the fifth picture of the poke shot sequence, whereas the target reflects an attack hit

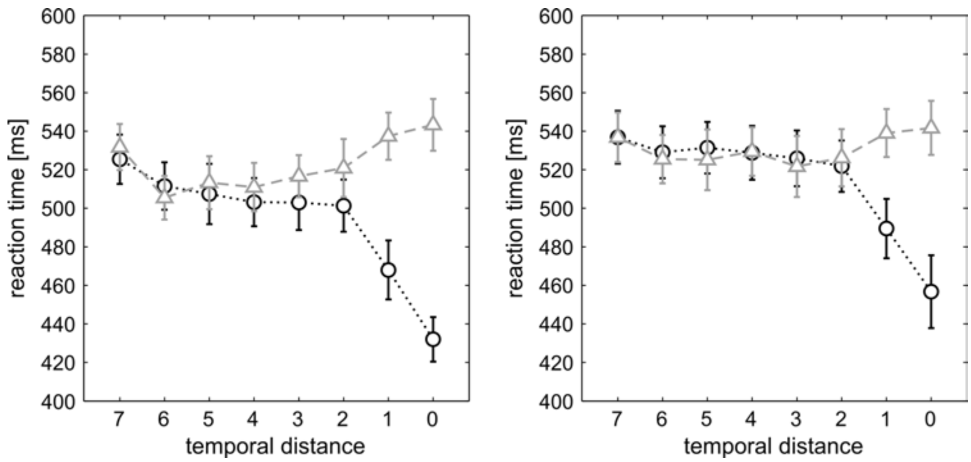

Fig. 3 Reaction times in milliseconds (±SEM) as a function of prime–target distance and action congruency for beach volleyball athletes (*left panel*) and novices (*right panel*). The *dotted black line* (*circles*) displays RTs to congruent prime–target pairs, and the *dashed grey line* (*triangles*) displays RTs to incongruent prime–target pairs

were tested for mean difference. The *t* test confirmed that the action congruency effect was significantly greater for athletes (about twice as great) compared to novices ($t(30) = 2.83$, $p < .01$, $d = 1.00$).

To investigate whether the action congruency effect in athletes is significant at a larger temporal distance to the target compared to the temporal distance of the congruency effects seen in novices, planned comparisons (one-tailed) between each congruent and incongruent temporal distance were made, separately for beach volleyball players and novices.

For athletes, responses to congruent prime–target pairs compared to incongruent prime–target pairs were faster with the distances 0 [$t(15) = 11.51$, $p = .001$, $d = 2.88$], 1 [$t(15) = 7.05$, $p = .000$, $d = 1.76$], and 2 [$t(15) = 2.81$, $p = .007$, $d = .70$]. Even though an action congruency effect was marked for the temporal distance 3 [$t(15) = 1.86$, $p = .04$, $d = .46$], the pair-wise comparison failed to reach the corrected *p*-value ($p_{crit} = .01$). There was no congruency effect for prime–target pairs with the distances 4, 5, 6, and 7 [all $t(15) < 1.3$ all *p*'s > .20].

For novices, pair-wise comparisons indicated a congruency effect for prime–target pairs with the distances 0 [$t(15) = 8.07$, $p = .000$, $d = 2.02$] and 1 [$t(15) = 5.12$, $p = .000$, $d = 1.28$], but no significant effect for the distances 2, 3, 4, 5, 6, and 7 [all $t(15) < 1.0$, all *p*'s > .50].

Response errors

An ANOVA with the factors *action congruency, temporal distance*, and *expertise* was performed. The factor *action congruency* reached significance [$F(1,30) = 25.41$, $p < .001$, $\eta_p^2 = .46$]. Both the interaction between *temporal distance* and *expertise* [$F(1,30) = 2.65$, $p < .05$, $\eta_p^2 = .08$] and the interaction between *action congruency* and *expertise* [$F(1,30) = 4.18$, $p < .05$, $\eta_p^2 = .12$] reached significance. No other main factor and no other interaction revealed a significant effect (all *p*'s > .15). Subsequently, performed paired t tests confirmed that athletes made significantly more mistakes in incongruent trials (2.5 %, *SD* = 2.32 %) compared to congruent trials (1.4 %, *SD* = 1.21 %). Also, novices made significantly more mistakes in incongruent trials (mean = 4.0 %, *SD* = 4.12 %) compared to congruent trials (mean = 1.8 %, *SD* = 2.19 %). Concerning the interaction between temporal distance and expertise, none of the independent t tests reached significance.

Questionnaire

On the basis of participants written answers, it was counted how often participants used body-related cues (shoulder angle, body tension, elbow) or superficial features (position of the ball, position of the hand) to discriminate between the smash and the poke shot target. The questionnaire revealed that 31 % of the athletes and 25 % of the novices mentioned a body-related cue. Conversely, 69 % of the athletes and 75 % of the novices indicated relying on superficial features when classifying the target picture. As indicated by a non-significant chi-square test ($\chi^2(1) = 0.16$, $p > .60$), the questionnaire did not provide evidence that novices and athletes focused on different cues.

Discussion experiment 1

In Experiment 1, it was asked whether pictures of attack hits typically performed in beach volleyball more strongly activate the corresponding movement representation in beach volleyball players compared to novices. Moreover, it was asked whether or not athletes recognize the attack hits at an earlier stage than novices. In accordance with our hypothesis, the action congruency effect was more pronounced and set in for larger temporal distances for athletes compared to novices. For novices, only primes depicting a beach volleyball player right before the hand-ball contact (i.e. temporal distance 1) and the hand-ball contact itself (i.e. temporal distance 0) were sufficient to evoke an action congruency effect. This result indicates that novices recognized the prime pictures with the temporal distances 0, and 1 as a smash or as a poke shot and prepared a motor action appropriate to the prime. This prime-induced motor activation mismatched with the required response if prime and target were taken from different attack hits (action incongruent condition). Action incongruent prime–target pairs resulted in response competition, and hence slowed response times relative to action congruent trials (Dehaene et al. 1998). In contrast, athletes showed an action congruency effect for prime pictures taken from earlier stages of the movements, that is, for the temporal distances 0, 1, and 2. The prime from an earlier stage of the strike phase (temporal distance 3) was sufficient to produce a markedly action congruency effect (14 ms), however, shortly failed to reach significance. Thus, even prime pictures from the strike phase were sufficient to activate the associated action category (e.g. smash vs. poke shot) in long-term memory (Schack 2012; Schack and Mechsner 2006).

The analyses of the error rates were in accordance with the reaction times, that is, an action congruency effect was also evident for the error rates in both groups. The written questionnaire participants completed after the reaction time experiment did not indicate that athletes and novices used different cues (body-related cues or superficial features) to classify the target picture.

To control whether athletes' superiority in recognizing the smash and the poke shot is rather based on their motor expertise than on their visual experience, a second experiment was conducted (Experiment 2).

Experiment 2

In Experiment 2, additionally recruited novice participants took part in an intervention study. The intervention program was conducted according to Hagemann et al. (2006), showing that a 45-min visual training with occluded videos is sufficient to improve prediction performance in novices. Participants watched videos (50 min, divided into 2 sessions) of smash and poke shot scenarios which were occluded at hand-ball contact. After the end of the videos, participants had to decide which of the technique was shown by pressing a response button. As soon as the response was given, the same video was started again, showing the same scenario until the smash/poke shot was performed completely. To assess potential effects of visual experiences, participants took part twice (pre-test and post-test) in the identical priming study as described in Experiment 1. The pre-test performance was assessed in the first intervention session *before* the videos were shown. The post-test performance was measured in the second intervention session *after* the videos were shown. Thus, between pre- and post-test, participants received 50-min video training.

Method

Participants

Sixteen novice participants (six females, all right handed, mean age 26.3; range 23–30; $SD = 2.10$) were recruited for the control study. They reported having no practical experiences with beach volleyball or volleyball. All novice participants were physically active students, performing at least one form of sport (11 participants performed individual sports and 5 performed team sports). All participants had normal or corrected-to-normal vision, they were all naive with regard to the purpose of the experiment, and all provided written informed consent before testing started. The experiment was performed in accordance with the ethical standards of the sixth revision (Seoul, 2008) of the 1964 Declaration of Helsinki.

Apparatus and stimuli

For the presentation of the videos and for the presentation of the static pictures, a computer with a 17-inch VGA display (vertical retraces 85 Hz) and the software Presentation® (version 14.3) was used. Responses both to the static pictures and to the occluded videos were given by pressing the right and the left control buttons of a standard computer keyboard with the index fingers.

The stimuli for the priming study were identical to Experiment 1. For the video intervention, 120 video sequences were used. The video sequences consisted of videos frontally depicting a player demonstrating the smash technique (12 videos) and the poke shot (12 videos). Moreover, two players were filmed from a side view performing smash shots (12 videos) and poke shots (12 videos) from the right side of the field and performing smash shots (12 videos) and poke shots (12 videos) from the left side of the field. Moreover, video sequences from the Olympic quarterfinals in London 2012 were used, showing both the attacking and the defending team. The Olympic videos showed smash shots (12 videos) and poke shots (12 videos) from a front perspective and smash shots (12 videos) and poke shots (12 videos) from a back perspective.

Design and procedure

The present study used a $2 \times 8 \times 2$ within-subjects design with the factors *action congruency* (congruent vs. incongruent), *temporal distance* (0, 1, 2, 3, 4, 5, 6, 7), and *time* *of measurement* (pre-test vs. post-test). The dependent variables were reaction time (RT) and error rate (ER).

The general procedure of the experiment is identical to Experiment 1; however, participants were repeatedly tested in two subsequent sessions. In the first part of the first session, participants took part in the priming study as described in Experiment 1 (pre-test). In the second part of the first session, participants received a video intervention, taking about 25 min. The video intervention consisted of 120 videos being presented twice. The first presentation of a video stopped at the hand-ball contact, and participants were asked to predict whether a smash or a poke shot is to be performed. After the response was given, the same video was shown until the attacking scene was finished and the performed attack hit was played. The 120 trials (each including an occluded and a non-occluded video) were randomly presented.

In the second session, which took part 24–48 h after the first session, participants first received the 25-min video intervention and afterwards took part in the priming experiment. The experimental session took about 55 min.

Results

Data analyses

Response times (RTs) were screened for outliers using a total cut-off. RTs below 200 ms and above 1,000 ms were excluded (pre-test 1.2 %; post-test 0.8 %). Trials with wrong answers were not used in the analysis of the RTs (pre-test 1.6 %; post-test 1.2 %).

ANOVAs with the within-subjects factors *action congruency*, *temporal distance,* and *time of measurement* were performed with reaction time (RT) and error rate (ER) as dependent variables. Mean RTs and ERs for each participant and each condition were computed. Multiple comparisons were corrected according to Holm–Bonferroni. The effect size of t tests was calculated according to Cohens' d. Before performing the ANOVA on error rates, the proportions were converted to arcsine values.

Reaction times

The reaction time as a function of the factors *action congruency* and *temporal distance* is illustrated separately for the pre-test and for the post-test in Fig. 4. The main effect of *action congruency* was significant [$F(1, 15) = 44.29$, $p < .001$, $\eta_p^2 = .75$] as well as the within-subjects factor *temporal distance* [$F(7, 105) = 14.89$, $p < .001$, $\eta_p^2 = .50$]. Even the factor *time of measurement* [$F(1, 15) = 5.01$, $p < .05$, $\eta_p^2 = .25$] reached significance, indicating that participants responded faster in the post-test experiment (mean = 507 ms, SD = 11.05 ms) than in the pre-test experiment (mean = 534 ms, SD = 14.5 ms). The interaction between *action congruency* and *temporal distance* was significant [$F(7, 105) = 44.09$, $p < .001$, $\eta_p^2 = .75$]. There was no other significant interaction (all p's > .50).

To rule out that the action congruency effect found in the novice group of the control study is present for the identical prime–target distance compared to the novice group of Experiment 1 (i.e. temporal distances 0 and 1), planned comparisons (one-tailed) between each congruent and incongruent temporal distance were made. The paired comparisons indicated that responses to congruent prime–target pairs compared to incongruent prime–target pairs were faster with the distances 0 [$t(15) = 11.90$, $p = .000$, $d = 2.98$] and 1 [$t(15) = 6.21$, $p = .000$, $d = 1.55$]. There was no congruency effect for prime–target pairs with the distances 2, 3, 4, 5, 6, and 7 [all $t(15) < .10$ all p's > .30].

Response errors

Also, the error rates were calculated with the factors *action congruency*, *temporal distance*, and *time of measurement*.

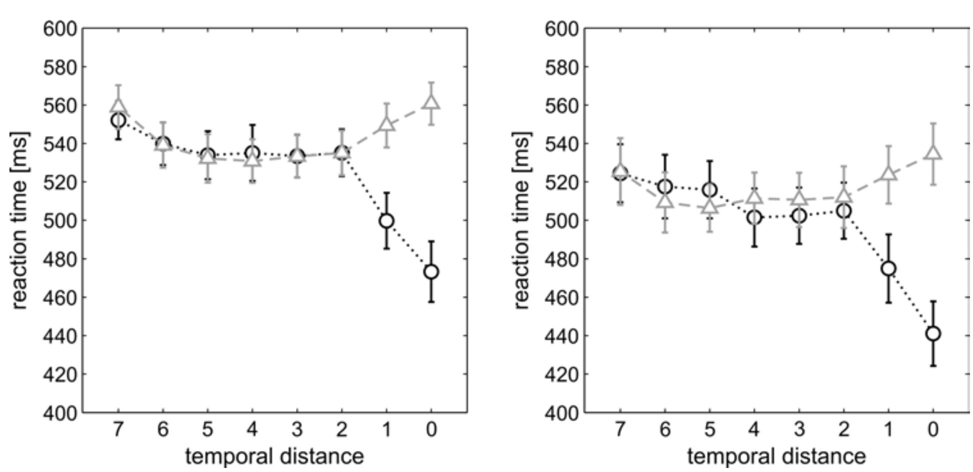

Fig. 4 Reaction times in milliseconds (±SEM) as a function of prime–target distance and action congruency before (*left panel*) and after (*right panel*) participants took part in the video intervention program. The *dotted black line* (*circles*) displays RTs to congruent prime–target pairs, and the *dashed grey line* (*triangles*) displays RTs to incongruent prime–target pairs

Only the interaction between *action congruency* and *temporal distance* reached significance [$F(7,105) = 3.44$, $p < .01$, $\eta_p^2 = .19$]. The interaction between *action congruency* and *time of measurement* failed to reach statistical significance [$F(1,15) = 3.28$, $p < .10$, $\eta_p^2 = .18$]. Subsequently, performed paired comparisons indicated that participants performed significantly more errors for incongruent prime–target pairs (2.6 %, $SD = 2.6$ %) with the temporal distance 1 compared to congruent prime–target pairs (1.1 %, $SD = 2.3$ %) with the temporal distance 1 [$t(15) = 2.75$, $p < .05$, $d = .69$]. For the temporal distance 5, participants performed significantly more error rates for congruent (mean = 2.3 %, $SD = 2.1$ %) compared to incongruent (mean = 0.5 %, $SD = 1.1$ %) prime–target pairs [$t(15) = 3.33$, $p < .01$, $d = .83$]. Also, for the temporal distances 6, participants made significantly more errors for congruent (mean = 2.7 %, $SD = 2.8$ %) compared to incongruent (mean = 1.4 %, $SD = 2.5$ %) prime–target pairs [$t(15) = 2.14$, $p < .05$, $d = .54$].

Questionnaire

The questionnaire revealed that 46 % of the participants mentioned a body-related cue (shoulder angle, body tension, elbow) and 54 % mentioned a superficial feature (position of the ball, position of the hand) when classifying the target picture in the pre-test. In the post-test, 42 % of the participants relied on a body-related cue and 58 % relied on a superficial feature. As indicated by a non-significant chi-square test [$\chi^2(1) = 0.05$, $p > .80$], the questionnaire did not provide evidence that participants changed their classifying strategy between the pre-test and the post-test.

Discussion experiment 2

Experiment 2 revealed that a video training did not improve the ability to recognize at an earlier stage whether the attack hit shown in the prime picture either is a poke shot or a smash. Moreover, the results found in Experiment 2, that is, a significant action congruency effect for the distances 0 and 1 replicate the results found in the novices group in Experiment 1. However, participants in Experiment 2 improved their ability to classify the target picture as indicated by overall faster response times in the post-test compared to the pre-test. This effect might either be based on the video intervention or on general familiarity effects with the stimulus material. Also similar to Experiment 1, the questionnaire indicated that participants relied on superficial cues (e.g. position of the ball) for classifying the target picture, and they did not change cue usage between the pre-test and the post-test.

General discussion

The present study addressed two questions. First, it was investigated whether athletes are better able than novices in recognizing static pictures of similar but distinct movements (i.e. feint vs. non-feint). Therefore, beach volleyball athletes and novices took part in a priming study with primes taken from eight different points in time from a smash shot and from a poke shot (Experiment 1). It was predicted that the activation of movement categories might be stronger in athletes compared to novices. Moreover, even ambiguous primes (from earlier stages of the movements) would activate the associated movement category for athletes but not for novices. This should result in a generally larger action congruency effect, which sets in for larger prime–target distances in athletes compared to novices. Second, it was asked whether a potential superiority in athletes is rather based on motor than on visual expertise. To control for this issue, a second experiment was performed. Novices received a video training, and before and after the training, the visual recognition performance of the smash and the poke shot was assessed.

In Experiment 1, the action congruency effect was larger and set in for primes from earlier stages of the attack hits for athletes compared to novices. For novices, only primes depicting a beach volleyball player right before the hand-ball contact (i.e. temporal distance 1) and the hand-ball contact itself (i.e. temporal distance 0) were sufficient to evoke an action congruency effect. It is suggested here that the primes being sufficient to activate a motor response in novices unambiguously signal the movement that is shown in the prime picture. That is, the location of the ball in relation to the hand is markedly different between the two actions (see temporal distances 1 and 0; cf. Figure 1). In contrast, athletes also showed an action congruency effect for prime pictures taken from the strike phase of the smash and of the poke shot. Thus, even prime pictures from the strike phase were sufficient to activate the associated action category (e.g. smash vs. poke shot) in long-term memory (Schack 2012; Schack and Mechsner 2006). Notably, such activation especially refers to future aspects of the movement, that is, to body postures following the body posture shown at the prime picture (Güldenpenning et al. 2011, 2012). Thus, the simulation of the represented motor action might have enabled athletes to read movement-related patterns in the depicted athlete's body posture (e.g. the angle of the elbow; temporal distances 2) to recognize the smash and the poke shot at an earlier stage of the movements.

The analysis of the written questionnaire revealed that athletes and novices did not rely on different cues (i.e. body-related cues vs. superficial features) when classifying the target pictures. Both groups used superficial features (e.g. position of the hand in relation to the ball) to distinguish the target picture. Concerning processing of the prime picture, it is suggested that athletes implicitly processed body-related cues shown in the prime picture. That means that in athletes, a prime picture from the strike phase activates a motor response without being evaluated explicitly. The suggestion about an implicit processing of body-related cues is in line with the automatic information-processing approach. This approach claims that decisions in sport scenarios have to be made within a very short time window, often intuitively, and without any explicit evaluation of the perceived information (see Raab and Johnson 2008; Williams and Ward 2007, for overviews). Moreover, also the study of Güldenpenning et al. (2011) points out that processing a movement-related body posture might be automatic. That is, processing a body posture can independently of the task activate future representations of that movement even without conscious perception.

The intervention study (Experiment 2) revealed that participants did not improve their recognition performance after they received a visual training. This result points out that the recognition superiority in athletes found here is rather based on motor than on visual experiences. This result is in contrast to studies showing that a visual training is sufficient to improve action perception (Abernethy et al. 2012; Hagemann et al. 2006; Schorer et al. 2012). It is suggested here that a benefit of a perceptual training is maybe limited to test tasks being similar to the intervention task. That is, a video training improves the ability to predict dynamic movement displays, but does not suffice to implicitly process movement information shown at static pictures. Notably, as the beach volleyball athletes tested in Experiment 1 have only visual experience with dynamic movement information (e.g. observing team mates or opponents), one might speculate that motor expertise *generally* supports action perception, whereas visual expertise is rather *specific*. That is, a benefit of visual training might not transfer to unlearned situations. This issue is worthwhile to be investigated in further studies.

Taken together, the results comply with the idea that athletes possess more efficient means of discriminating between different movement techniques than novices (Müller and Abernethy 2006; Abernethy and Russell 1984, 1987; Rowe and McKenna 2001; Shim et al. 2005). The results are also in accordance with empirical studies pointing out that it might be rather motor than visual expertise that supports action perception (e.g. Calvo-Merino et al. 2006). In contrast to the study of Sebanz and Shiffrar (2009), athletes and novices also are differentially sensitive to *static* pictures depicting movement-specific body postures. Thus, athletes do not necessarily need to rely on *dynamic* visual information to discriminate between similar movements (e.g. smash vs. poke shot) at an early stage. Consequently, the experimental procedure applied here might represent a good opportunity to investigate fast running information processing as required in most real sport scenarios.

In conclusion, an athlete must be able to quickly predict forthcoming actions in a speeded sport scenario in order to initiate an appropriate motor response in time. It seems likely that the capability to execute a movement helps to better perceive the movement. Conversely, people are less able to recognize perceived movements if these movements are not represented within their own movement memory.

Conflict of interest The authors declare that they have no conflict of interest.

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