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Anticipation skill and susceptibility to deceptive movement

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Abstract

The ability to detect deceptive movement was examined in skilled and novice rugby players. Participants (14 per group) attempted to predict direction change from video of expert and recreational rugby players changing direction with and without deceptive movement. Confidence associated with judgments was recorded on each trial to seek evidence regarding use of inferential (heuristic-based) and direct-perceptual (invariant-based) judgments. Novices were found to be susceptible to deceptive movement whereas skilled participants were not; however, both skilled and novice participants were more confident on trials containing deceptive movement. The data suggest that the skill-level difference in sensitivity to advance visual information extends to deceptive information. The implications of this finding, and the importance of considering the underlying process of anticipation skill, are discussed.

PsycINFO classification: 2300; 2323; 3720

Keywords: Expertise; Perception; Deception; Sport

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1. Introduction

Perceptual skills are central to task performance in many different domains, including everyday activities such as reaching and grasping (Goodale, Westwood, & Milner, 2003) and recognizing people from their movement (Cutting & Kozlowski, 1977; Loula, Prasad, Harber, & Shiffrar, 2005), as well as activities in the military (Endsley & Smith, 1996), medical (Sowden, Davies, & Roling, 2000) and sporting (Smeeton, Ward, & Williams, 2004; Williams, Ward, & Smeeton, 2004) domains. In addition to examining sensitivity to visual information, many sport skills afford an opportunity to examine performance under time constraints that increase the importance of using 'advance' visual information to anticipate the actions of an opponent (Glencross & Cibich, 1977). The word 'advance' has been used to highlight skilled performers' ability to make accurate judgments based upon visual information that is present before unambiguous information (e.g., the flight characteristics of a ball) becomes available.

The ability to anticipate an opponent's behavior has proved a reliable discriminator of expert and novice performers in many reactive sports including badminton (Abernethy, 1988, 1991; Abernethy & Russell, 1987), cricket (Abernethy & Russell, 1984), soccer (Williams, 2000), tennis (Goulet, Bard, & Fleury, 1989; Jones & Miles, 1978; Rowe & McKenna, 2001; Shim, Chow, Carlton, & Chae, 2005; Singer, Cauraugh, Chen, Steinberg, & Frehlich, 1996) and squash (Abernethy, 1990a, 1990b; Abernethy, Gill, Parks, & Packer, 2001; Howarth, Walsh, Abernethy, & Snyder, 1984). Much of this research has employed the temporal occlusion paradigm, a method by which the amount of visual information presented to participants is systematically varied. In the laboratory setting, video clips are edited to provide varying amounts of information relative to a key event such as racquet-ball contact and this technique has also been applied to the field setting by using liquid crystal goggles to occlude vision manually (Farrow & Abernethy, 2002; Farrow, Abernethy, & Jackson, 2005). In both laboratory and field-based studies, researchers have typically found that experts perform above chance level and at a higher level than novices when video clips are occluded prior to ball-flight information becoming available. In addition, analysis of performance change across consecutive occlusion points has been used to determine the time period within which experts display greater pick-up of information relative to novices (Abernethy, 1990a; Farrow et al., 2005). Recent studies using the point-light method pioneered by Johansson (1973) have further highlighted the importance of kinematic information in making perceptual judgments in the sporting domain (Abernethy et al., 2001; Ward, Williams, & Bennett, 2002).

To date, video-based temporal occlusion studies have typically used test stimuli that depict two skilled performers executing the requisite skill. The vast majority of studies make no reference to the instructions given to the performers prior to filming (for exceptions, see work on soccer penalty kicks by Poulter, Jackson, Wann, & Berry (2005), Savelsbergh, Williams, van der Kamp, & Ward (2002)). As such, the presence of deceptive information or the ability of performers to disguise their intentions has neither been controlled nor systematically manipulated. In the present study, we make a distinction between an actor's attempt to disguise his or her intentions and their attempt to deceive an observer. In the case of disguise, an actor might attempt to minimise the availability or delay the onset of indicative cues. If effective, an observer would be reduced to guessing so that the minimum level of performance one would expect is chance level. In contrast, the aim of deception is to provide information that misleads of 'fools' an observer into making an incorrect judgment. In the case of deception then, it is theoretically possible for an observer to make no correct judgments.

For tasks such as the tennis serve, there does not appear to be any overt attempt to deceive the observer; however, deceptive movements are commonplace in skills such as football penalty kicks and the tackle situations in rugby. Deception can be considered in the context of a more general ability to infer intentions in the action of others, an ability that is fundamental to the survival of most animals (Blakemore & Frith, 2004). While there have been studies on various aspects of deception in other domains, including the ability to detect deception (Frank & Ekman, 1997) and the process of detecting deceit (Bond et al., 1992) when someone is lying, there has been no systematic research conducted on deception in the sporting domain in spite of a clear conceptual link with research on anticipation. In particular, if experts are better at anticipating the actions of an opponent, it seems reasonable to assume that opposing players will either try to disguise their actions by minimising the availability or onset of such information (Renshaw & Fairweather, 2000) or will attempt to present deceptive information.

The research most closely related to this issue is that which examines the ability to make perceptual judgments from movement kinematics. Runeson and Frykholm (1981) demonstrated that observers could accurately judge the weight of a box carried by an actor from point-light type displays of the associated movement kinematics. Other judgments, including perceiving the distance of a thrown object, the gender of a walker (Runeson & Frykholm, 1983), and even the emotional qualities of dance movements (Dittrich, Troscianko, Lea, & Morgan, 1996) have been reported from dynamic point-light displays. Regarding deception, Runeson and Frykholm (1983) additionally found that actors were unsuccessful when attempting to deceive observers about the true weight of a lifted box, suggesting it was difficult to reproduce voluntarily the kinematic qualities affording a false judgment and/or that it was difficult to mask the kinematic pattern associated with lifting the genuine weight. This strengthens the argument for the 'non-substitutability' of actions (Richardson & Johnston, 2005): in attempting to provide deceptive information, it may be possible to approximate the kinematics of the genuine action but not its full characteristics.

Regarding the perception of deceptive movement in sport, one possibility is that skill-level differences in sensitivity to advance visual information simply extend to the ability to distinguish between genuine and deceptive movement. This leads to the related predictions that skilled players will perform better than novices on trials containing deception and, second, that the difference between performance on normal and deception trials will be smaller for skilled players than for novices. Alternatively, it is possible that because experts are attuned to information contained within 'normal' performance they will be particularly susceptible to deception. That is, an opposing player may be able to incorporate or exaggerate (Pollick, Fidopiastis, & Braden, 2001) critical kinematic information that triggers an (incorrect) anticipatory response in expert performers. By contrast, players who are not attuned to such information should not be susceptible to deception. For example, in their comparison of expert, intermediate, and novice French boxers' ability to respond appropriately to 'attacks', 'feints', and 'openings', Ripoll, Kerlirzin, Stein, and Reine (1995) found that experts had more false alarm responses than intermediates who in turn had more false alarm responses than novices in the more complex task.

To examine the relative susceptibility of skilled and novice performers to deception, it is necessary to consider what constitutes empirical evidence for deception. In experiments requiring forced-choice responses, one line of evidence is performance that is significantly *below* chance level. For example, Jones and Miles (1978) found that undergraduate students scored significantly below chance when attempting to determine tennis serve direction from video clips of an expert player that were occluded 42 ms prior to contact. Consistent with the rationale for inferring anticipation, a second line of evidence for deception would be a significant *decrease* in performance across consecutive occlusion points. Farrow et al. (2005) alluded to the possible presence of deceptive information in interpreting their finding that skilled tennis players became significantly poorer at discriminating serve direction when additional information was presented from 600 ms to 300 ms prior to ball-racquet contact (see also Farrow & Abernethy, 2002, Experiment 1). A third line of evidence for deception can be gathered by comparing performance on normal trials with performance on trials containing deceptive movement. If the deceptive movement proves effective, one would expect judgment accuracy to be suppressed relative to performance on normal trials. For example, in judging the weight of a lifted box, Grèzes, Frith, and Passingham (2004) found that observers were less accurate at classifying whether the actor was making a genuine lift or was trying to deceive the observer when the actions were in fact deceptive (60% correct) than when they were genuine (73% correct). A fourth line of evidence for deception can be obtained by comparing the confidence associated with judgments for normal and deception trials. If deception involves presenting visual information that is consciously perceived, effective deception should be indicated by higher confidence accompanying poorer performance. We discuss the rationale for this prediction in more detail in the following section.

1.1. Determining the underlying process of perceptual judgments in anticipation skill

Measures that have been used to trace the processes underlying anticipation skill include verbal reports, which aim to assess information that is consciously accessible, and assessment of point-of-gaze to determine the information sources upon which participants fixate when making judgments. While there is a considerable historical debate over the merits of both these approaches (e.g., Abernethy, 1991; Ericsson & Simon, 1980; Nisbett & Wilson, 1977; Poulter et al., 2005), neither attempts to determine the type of judgments that are made. Thus, it remains unclear whether advance visual information is directly perceived or whether it is consciously accessible and forms the basis of simple rules or heuristic-based judgments.

Recently, Runeson, Juslin, and Olsson (2000) proposed two methods for determining whether observers perform in a direct-perceptual (sensory) or an inferential (cognitive) mode, associated with the invariant-based and cue-heuristic models of perception, respectively. The first involves using observers' confidence ratings associated with their judgments to infer conscious processes and has previously been discussed by Dienes (2004) in relation to Higher Order Thought theory (Rosenthal, 2000). Essentially, the theory highlights the importance of having thoughts about a state to infer that the state itself is conscious. Applied to perceptual judgments, establishing that an individual can discriminate between, for example, a movement to the left and a movement to the right only establishes the first-order state but is not sufficient to infer that the judgment process is itself conscious. A second, higher-order state, in this case confidence, is required for this purpose. In terms of skill-level differences, Runeson et al. (2000) argued that inferential judgments would be characterised by over-confidence early in the learning process, with better calibration emerging as performers gained better knowledge about the validity of their cue-based inferences. In relation to deception, we further suggest that over-confidence is likely to be a defining characteristic of deception insofar as exaggerated movements are presented that trigger conscious, incorrect judgments.

The second method relates to the distribution of solution probabilities for the perceptual judgment task. Runeson et al. (2000) argued that judgment errors based on the direct perception of invariant information would relate to the finite precision of sensory or perceptual systems. In simple terms, errors should relate to the difficulty of perceiving the relevant information rather than the validity of that information. As such, analysis of the solution probabilities for each test item (that is, the proportion of correct judgments) should reveal few, if any, items classified at below chance level. By contrast, judgment errors associated with cue-based inferences would additionally relate to the validity of the specified rule. The inferences drawn may be correct on many occasions but could lead to a high incidence of incorrect judgments on some items. Indeed, presenting effective deceptive information that relates to a commonly used heuristic could conceivably result in all participants being 'fooled' on certain items. The resulting prediction is for a wider distribution of solution probabilities for inferential judgments than for judgments based on directly perceived information. In support, test item solution probabilities have been found to be more widely distributed in cognitive than sensory tasks (Juslin, Winman, & Persson, 1995).

In the present experiment, we examined a skill in which deception is an integral part of performance: the 'one-on-one' tackle situation in the sport of rugby. In this skill, the attacking player attempts to run round their opponent while carrying the ball, often attempting to deceive them by performing a 'side-step' in which they try to give the impression of moving in one direction before going in the other (see Fig. 1). In the present study we employed the temporal occlusion paradigm to test skilled and novice performers' ability to predict direction change in rugby players under normal conditions, that is, when the player made no attempt to deceive the observer, and under deceptive conditions, that is, when the player attempted to deceive the participant. Consistent with research on anticipation in other sports skills, we predicted that skilled players would demonstrate an advantage over novices in their ability to judge run direction from advance visual information. Based on the reasoning that they would have had greater experience viewing deceptive as well as normal movement patterns, we further predicted that skilled players would be less susceptible to deception than novices. Applying the methods of Runeson et al. (2000), we predicted that there would be evidence of over-confidence on deception trials and that this tendency would be greater in novice than skilled performers. Second, we predicted a wider distribution of test-item solution probabilities on trials containing deceptive movement.

Previous research using the temporal occlusion paradigm has tested the ability of participants to predict events when viewing skilled performers. Of additional interest in the present study was whether any skill-level differences would generalise to video of less-skilled players. Specifically, it is possible that skill-level differences in previous experiments may have been confounded by the congruence between the skill-level of the participants and the performers depicted in the test items. Alternatively, if anticipation is based upon heightened sensitivity to characteristics of biological motion one might reasonably expect this ability to generalise across skill levels. Indeed, if less-skilled players are less good at either disguising their intentions (under 'normal' conditions) or presenting deceptive information

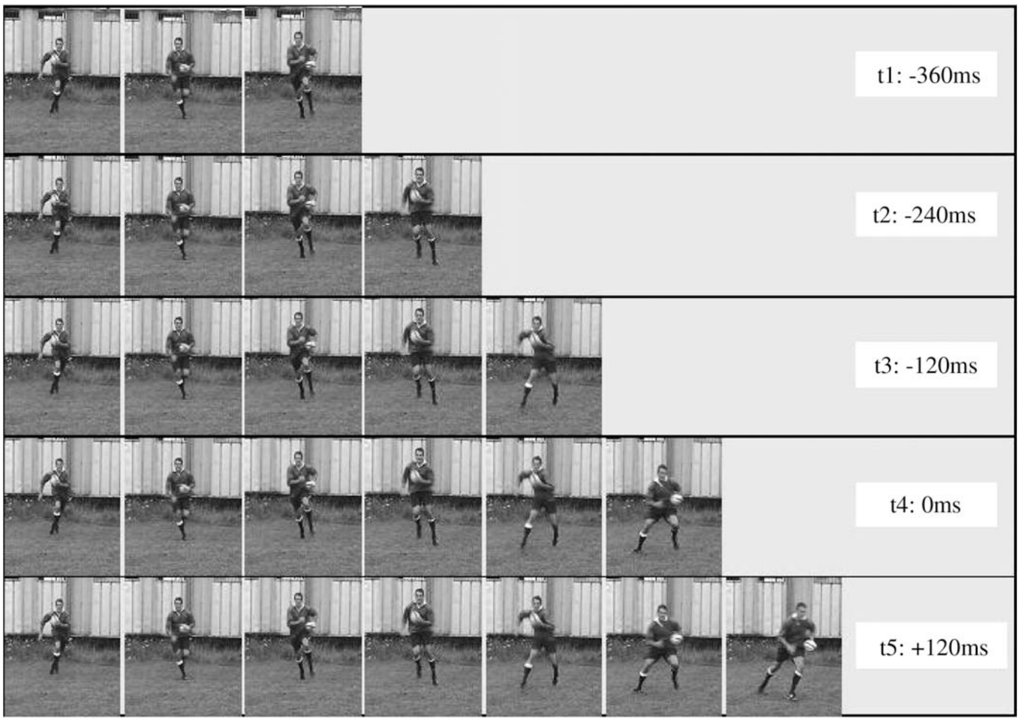

Fig. 1. A schematic representation of the five conditions of temporal occlusion. One of the expert players is shown performing a deception trial, with images depicting every third frame from 600 ms before to 120 ms after the foot that initiates direction change contacts the ground.

(under 'deception' conditions), skilled observers would be predicted to have a greater advantage when viewing video of these players.

2. Method

2.1. Participants

A total of 28 male participants completed the study. The skilled group consisted of 14 male rugby union players (mean age = 22.3 years, SD = 3.2) who had played rugby for a mean of 14.5 years (SD = 3.5). All players were currently competing in a regional league with eight having also competed at national level and two having additionally competed at international level. The novice group comprised 14 male university students (mean age = 24.4, SD = 4.9) who reported no prior rugby-playing experience. All participants gave informed written consent prior to commencing the study.

2.2. Experimental task and construction of test stimuli

A two-choice prediction task was developed in which the participants were required to judge whether the player running towards the camera was going to change direction towards the left or right of the screen. The task represented a 'one-on-one' tackle situation in rugby in which the defending player must try to prevent the attacking player from progressing up field.

Two adult players currently competing at national level and two recreational players currently competing for their club team in a local league, were used to create the test stimuli. Players were filmed with a Panasonic digital video camera (model NVMX8B) recording at 25 Hz from a position located in front of the approaching player and at a height of 1.50 m. The camera position approximated the head height of a defending player adopting a slightly crouched stance in preparation for making a tackle. On each trial, the player ran from a start position located 16 m from the camera and then changed direction at a point located 6 m from the camera towards one of two targets placed at an angle of 45° to the initial approach. Two types of clips were filmed. On 'normal' trials, players were instructed simply to run towards the camera and change direction towards one of the two targets. On the 'deception' trials, players performed a 'side-step' prior to changing direction, that is, they tried to give the impression of changing direction towards one target before running towards the other target. The side-step is illustrated in Fig. 1 where it can be seen that the performer steps and shifts their centre of mass to the left (from the observer's perspective) before changing direction to the right. On both normal and deception trials, players were filmed changing direction to the left and to the right.

Video clips were digitised and edited using Pinnacle Studio software (version 8.4) to create the practice and test films. The practice film comprised 32 clips made up of two examples of each player changing direction to the left and right, with and without deception. The practice clips ended when the player disappeared from view, thus, the observer received trial-related feedback. The test film comprised 160 clips, constructed from 32 different examples, again containing two examples of each player changing direction to the left and right, with and without deception. Each clip was edited relative to the last downward movement of the foot used to initiate change of direction, and no augmented feedback was provided after each trial. Five following occlusion conditions were used: t1 (−360 ms), t2 (−240 ms), t3 (−120 ms), t4 (0 ms), and t5 (+120 ms) and are depicted in Fig. 1.

2.3. Design and procedure

The design was a 2(Group: skilled, novice) × 2(Deception: normal, deception) × 2(Model: video of experts, video of recreational players) × 5(Occlusion Point: t1, t2, t3, t4, t5) mixed-factorial design. The 160 test trials were presented in four blocks of 40, with each block containing clips from either the two expert or the two recreational players. Order of presentation was randomised with respect to occlusion point and deception condition, and block order was counterbalanced. The practice and test trials were presented on a Proview 17″ TFT flat screen monitor, viewed from a distance of approximately 1.5 m. To enhance the ecological validity of responses, participants were asked to imagine they were defending against the player depicted on the screen and were encouraged to make a physical response in the direction they thought the player would go. Each trial was followed by a 4-second inter-trial interval during which participants indicated their judgment on a two-choice response sheet and rated their confidence on a 10-point scale (1 = *not at all confident*, 10 = *extremely confident*).

After being informed about the nature of the task, participants were shown the 32 practice trials. This enabled them to become familiar with the viewing perspective and the time constraints for responding, as well as the running actions of the performers used in the test stimuli. This was followed by a break of approximately 3 min, during which the procedure for the test session was explained. The four blocks constituting the test phase were then presented, incorporating an inter-block interval of approximately 1 min. The test session lasted approximately 45 min after which participants were debriefed about the purpose of the study.

2.4. Analysis of data

Initial inspection of mean performance scores revealed that performance was at ceiling level at occlusion points t4 and t5 (see Fig. 2). Consequently, analysis was focused on occlusion points t1, t2, and t3.

2.4.1. Comparison of video models

Prior to the main analysis, the data for the two models used to create the recreational and expert video clips were compared. Performance data for the expert and recreational models were entered into separate 2(group) × 2(deception) × 2(player) × 3(occlusion point) ANOVAs with repeated measures on the deception, player, and occlusion point factors. In both cases, the analysis revealed non-significant effects of player and non-significant interactions involving the group and player factors. One significant effect emerged: there was a significant Player × Deception × Occlusion Point interaction ($F(2,52) = 5.01$, $p < .05$, $\eta^2 = .16$) for recreational models. This simply reflected that the difference between performance on normal and deception trials was greatest at t1 for one of the recreational models and at t2 for the other. As neither this nor any other effects involving player interacted with group the data were collapsed across the two expert and two recreational models for the main analysis.

There were two dependent variables in the main analysis: the mean number of correct judgments and mean confidence ratings in each condition. The data were analysed in two stages. First, the performance and confidence data were entered into separate 2(Group) × 2(Deception) × 2(Model) × 3(Occlusion Point) ANOVAs, with repeated measures

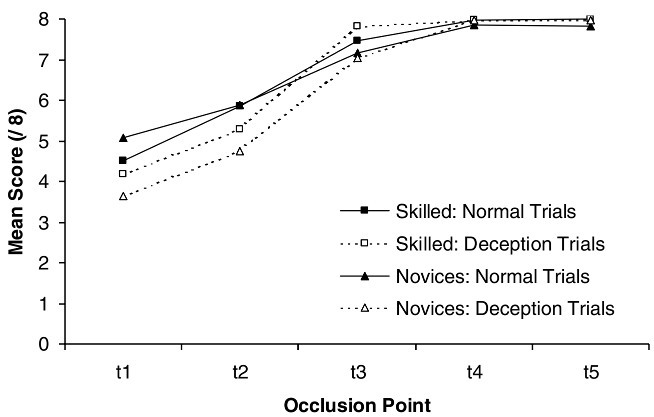

Fig. 2. Mean number of correct decisions (out of 8) for the skilled and novice groups when viewing normal and deception trials.

on the last three factors. Univariate output was assessed with alpha set at .05, and Greenhouse–Geisser adjustments to the degrees of freedom were applied, where necessary, to adjust for any violations of the sphericity assumption. In addition, orthogonal contrasts were used to test the specific predictions with the Bonferroni correction applied, where appropriate, to control for increased experimentwise error.

3. Results

3.1. Performance

The analysis of variance revealed significant main effects for occlusion point, model, and deception. Performance improved from t1 ($M = 4.59$, $SE = 0.11$) to t2 ($M = 5.44$, $SE = 0.12$) to t3 ($M = 7.38$, $SE = 0.10$), all of which were above chance level ($p < .001$). Performance was better when viewing the recreational models ($M = 6.24$, $SE = 0.10$) than when viewing the expert models ($M = 5.36$, $SE = 0.10$), and was better on normal trials ($M = 5.99$, $SE = 0.11$) than on deception trials ($M = 5.61$, $SE = 0.09$). In all cases, the maximum mean score was 8, with a score of 4 being equivalent to chance level. The main effect of group was non-significant.

3.1.1. Model

In addition to the significant main effect of model, there was a significant interaction between model and occlusion point ($F(1.61, 41.75) = 4.49$, $p < .05$, $\eta^2 = .15$). As can be seen in Fig. 3, the relative difficulty of making judgments on video of experts was greatest at t1 (M Difference = 1.29) then t2 (M Difference = 1.05), with a smaller difference apparent at t3 (M Difference = 0.29).

3.1.2. Deception

The significant main effect of deception was superseded by significant two-way interactions with occlusion point ($F(1.65, 42.81) = 5.50$, $p < .05$, $\eta^2 = .18$) and group ($F(1, 26) = 5.86$, $p < .05$, $\eta^2 = .18$). With respect to the occlusion point, performance was poorer on deception

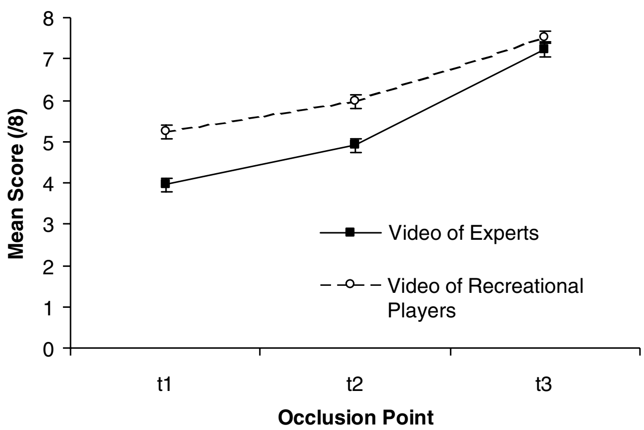

Fig. 3. Mean number of correct decisions (out of 8) in each occlusion condition for video of expert and recreational models. The data are collapsed across groups and displayed with standard error bars.

trials than on normal trials at t2 ($t(27) = 3.59$, $p < .017$; 95% CI for Difference = 0.75–2.75), but not at t1 or t3. As noted in the individual model comparisons, the timing of this difference varied slightly across the two models used in the recreational video clips. To assess whether this was due to differences in the timing of the onset of deceptive movement, we conducted a frame-by-frame analysis of relevant test stimuli and found onset to be highly consistent across the four models. This is perhaps not surprising given the biological constraints associated with making an overt upper-body movement in time with placement of the foot that initiates direction change. It would appear instead that the precise time period during which performance is suppressed is specific to the spatiotemporal characteristics of each individual's deceptive movement.

The significant deception by group interaction was caused by skilled participants being less susceptible to deception than the novice group (see Fig. 5). Orthogonal contrasts revealed that the skilled group performed equally well on normal and deception trials ($t(13) = 0.18$, $p = .43$) but novices performed worse on deception trials ($t(13) = 3.68$,

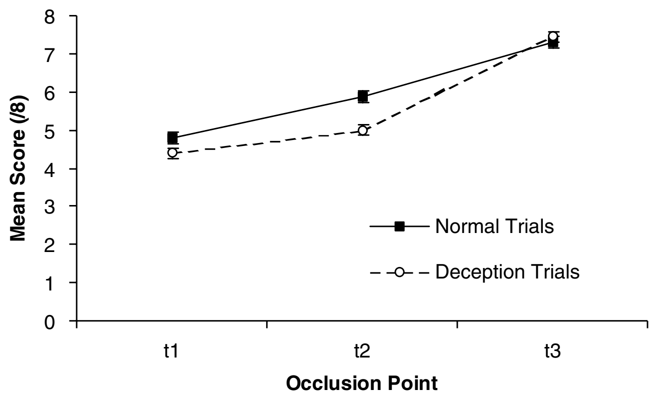

Fig. 4. Mean number of correct decisions (out of 8) for normal and deception trials in each occlusion condition. The data are collapsed across groups and displayed with standard error bars.

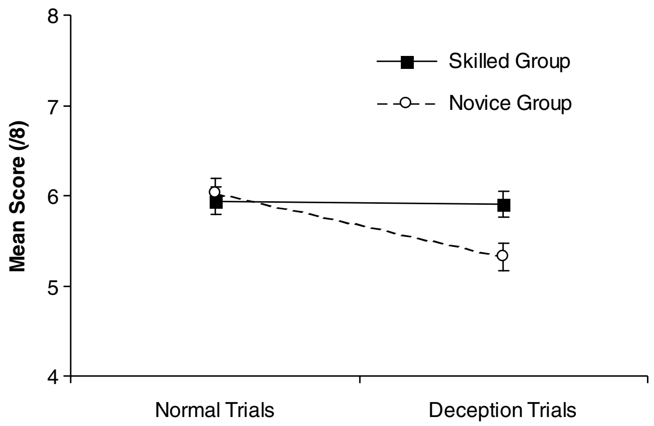

Fig. 5. Mean number of correct decisions (out of 8) by skilled and novice groups for normal and deception trials, with standard error bars.

$p < .025$). This was reflected in a significant advantage for the skilled group on trials containing deception ($t(26) = 3.14$, $p < .025$) but not on normal trials ($t(26) = 0.42$, $p = .34$).

3.2. Confidence ratings

The analysis of variance revealed significant main effects for occlusion point ($F(1.27, 33.08) = 129.36$, $p < .05$, $\eta^2 = .83$), model ($F(1, 26) = 9.19$, $p < .05$, $\eta^2 = .26$), and deception ($F(1, 26) = 44.06$, $p < .05$, $\eta^2 = .63$), and a non-significant main effect of group ($F(1, 26) = 0.78$, $p = .39$, $\eta^2 = .03$). Consistent with the performance data, confidence increased from t1 ($M = 3.87$, SE = 0.36) to t2 ($M = 4.49$, SE = 0.35) to t3 ($M = 6.71$, SE = 0.30), and was higher when viewing video of recreational players ($M = 5.24$, SE = 0.34) than video of experts ($M = 4.81$, SE = 0.32, see Fig. 6). In contrast to the performance data, confidence was markedly higher on deception trials ($M = 5.46$, SE = 0.30) than on normal trials ($M = 4.59$, SE = 0.35), a finding that was consistent across both groups of participants ($F(1, 26) = 1.31$, $p = .26$, $\eta^2 = .05$).

3.2.1. Deception and model

Significant interactions between model and occlusion point ($F(2, 52) = 4.08$, $p < .05$, $\eta^2 = .14$) and between model, occlusion point and deception ($F(2, 52) = 3.48$, $p < .05$, $\eta^2 = .12$) were also observed. This reflected that judgment confidence on video of recreational players increased relative to video of expert players from t1 (M Difference = 0.17) to t2 (M Difference = 0.39) to t3 (M Difference = 0.72; see Fig. 6) with the three-way interaction reflecting that this only occurred for the trials containing deception.

In summary, the performance and confidence data indicate that participants had higher confidence on deception trials, yet performed more poorly. Confidence increased across occlusion conditions, but did so more rapidly for recreational than expert models on trials containing deceptive movement. Performance was above chance level in all three occlusion conditions and was better when viewing the recreational models than when viewing the experts.

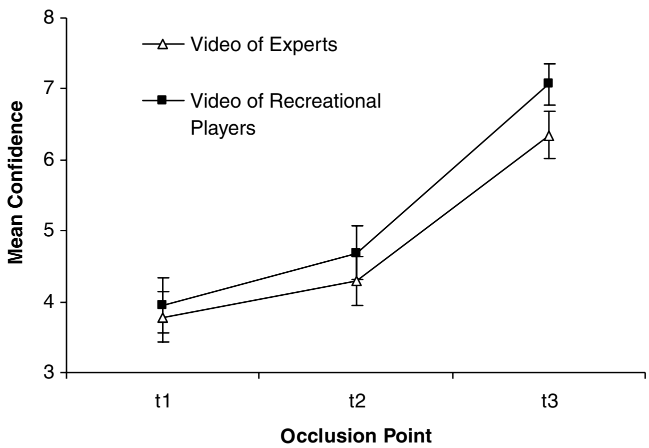

Fig. 6. Mean confidence ratings (out of 10) for all participants on video of expert and recreational models, with standard error bars.

3.2.2. Solution probabilities for test items

The distribution of solution probabilities for the 48 normal and 48 deception trials plotted separately for the skilled and novice groups is presented in Fig. 7. These represent the proportion of correct responses recorded for each item and are plotted against the mean confidence rating recorded for the relevant group on that item. As can be seen in Fig. 7A and B, there were more test items with solution probabilities below chance level on deception trials ($n = 10$) than on normal trials ($n = 3$) for the novice group. Furthermore, the variance in solution probabilities was larger for deception trials ($s^2 = .064$) than for normal trials ($s^2 = .035$). Hartley's variance ratio test indicated that this difference was marginally significant ($F(47, 47) = 1.83, p = .05$). For the skilled group, the number of test items with solution probabilities below chance was again greater on deception trials ($n = 10$) than on normal trials ($n = 6$; see Fig. 7C and D); however, there was no significant difference between solution probability variance on normal ($s^2 = .061$) and deception ($s^2 = .073$) trials.

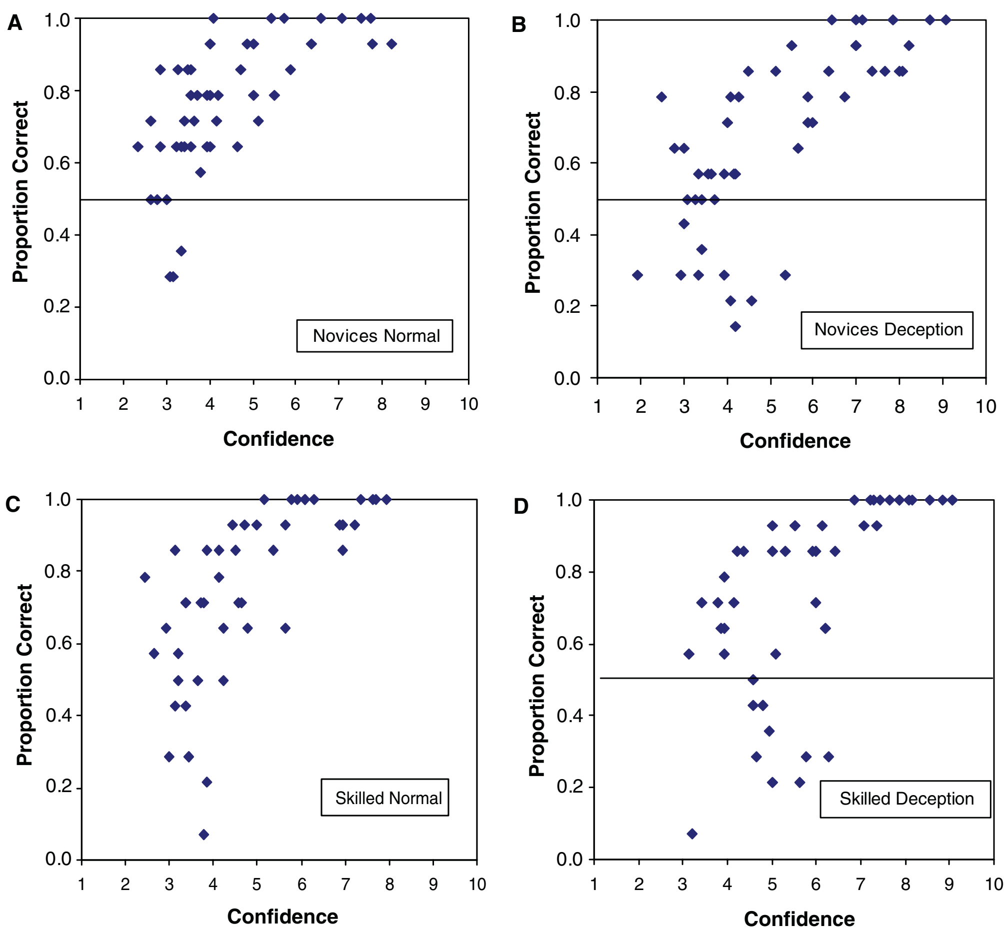

Fig. 7. Process-indicator results. The proportion of correct responses on each trial plotted against the mean confidence rating for that item. Panels A and B show data for the novice group and Panels C and D show data for the skilled group on normal and deception trials, respectively.

4. Discussion

The primary purpose of the present study was to examine susceptibility to deception in skilled and novice sports performers. To gather behavioral data on this issue, we extended the temporal occlusion design in several ways. First, trials containing deceptive movement were included alongside 'normal' trials; second, participants were asked to rate their confidence in their decisions; and, third, test stimuli were constructed from both expert and recreational performers. In addition, by focusing on the one-on-one tackle situation, the generalisability of the expert advantage at using advance visual information was assessed. In the following section, we first discuss the performance data in terms of the evidence for deception and the relative susceptibility of skilled and novice performers to deception. We then go on to discuss evidence regarding the process underlying the perceptual judgments made in the present task.

4.1. Susceptibility to deception

Support was found for three of the four proposed lines of evidence for deception. First, while performance did not fall significantly below chance level when averaged across all test items, examination of the solution probabilities revealed the fact that performance was below chance level on 10 of the 48 deception trials for both the skilled and novice groups (see Fig. 7). In terms of the second line of evidence, there was no evidence of a decrease in performance across consecutive occlusion points; indeed, the data indicated that recognition became progressively easier as more visual information was presented. In contrast, there was considerable support for the third line of evidence for deception. Overall, performance was significantly poorer on deception trials than on normal trials (see Fig. 4) and skilled participants were found to be less affected by deceptive movement than were novices (see Fig. 5). Averaged across both groups, the difference was significant at t2 but not at t1 or t3; however, the skilled participants' advantage over novices on deception trials was consistent across t1, t2, and t3 (see Fig. 2). These findings reflect the fact that skilled participants performed equally well on normal and deception trials at t1 and t3, while novice participants were clearly inferior on deception trials at t1 and t2 but not at t3 (see Fig. 2). The pattern of results suggests that skilled players are better able to detect and respond appropriately to advance deceptive visual information, highlighting an additional characteristic of anticipation skill. In terms of the time course of deception, t1 corresponded to 360 ms before the foot that initiated direction change made contact with the ground. This suggests that effective deceptive information is present from prior to that point and up to at least 240 ms before foot-ground contact.

It is interesting to note that the skilled groups only performed significantly better than novices on the deception trials. One possibility is that the task of determining direction change in normal trials drew upon general skills relating to the perception of biological motion. Thus, participants in the novice group will have accumulated considerable experience observing humans moving and changing direction in a range of other sport, recreational, or day-to-day contexts that may have facilitated performance on the normal trials. Certainly, there is evidence that the ability to discriminate certain features of biological motion emerges very early without domain-specific and deliberate practice; for example, 3-month-old infants can already discriminate point-light displays of a walker and runner (Booth, Pinto, & Bertenthal, 2002). The deception trials, by contrast, contained exaggerated movement patterns that were unlikely to have been encountered outside of the present context. Critically, the fact that the skilled group performed equally well on normal and deception trials indicates that sensitivity to features of the visual display that facilitate anticipation did not increase their vulnerability to deception. It seems that skilled performers, at least in the present task, have also learned to discriminate genuine from deceptive visual information. Finally, support for the fourth line of evidence for deception was apparent from analysis of the confidence data, which we now consider in the context of evidence for indirect inferential and direct perceptual judgments.

4.2. Evidence for inferential judgments

Evidence from analysis of the distribution of solution probabilities was inconclusive in the present experiment; however, there was evidence of over-confidence on deception trials in both the skilled and novice groups. In particular, participants were more confident about their judgments on trials containing deceptive movement than on normal trials even though skilled performers performed no better on deception trials, while novices performed significantly worse than on normal trials. This is indicative of deceptive movement invoking more inferential or heuristic-based judgments and is consistent with observation of the deception trials, which were characterised by an exaggerated movement in the opposite direction to the final run path (see Fig. 1). Logically, exaggerated or salient stimuli should facilitate heuristic-based judgments as exaggeration draws attention to a particular feature of the movement. For example, Pollick et al. (2001) found that novices who learned to discriminate different types of tennis serve were better at categorizing those in which the spatial characteristics (the deviation of various markers from the 'grand average') had been exaggerated.

4.3. Task limitations

In considering both the performance data and nature of judgments being made, it is important to note that while participants were encouraged to imagine they were tackling the individuals depicted in the video, response time was not constrained as it would be in a real tackle situation. Judgment accuracy has proved consistent across laboratory and field settings (Farrow & Abernethy, 2003; Farrow et al., 2005); however, time constraints may influence both the speed of responding (Shim et al., 2005) and type of judgments that are made. For example, deceptive movement may trigger an incorrect behavioural response in a time-pressured situation that is not evident when the performer has longer to respond. This issue could be examined by having participants perform shadow tackles and recording response time in relation to key events on the video clips. Finally, strategic or tactical information that is present in the live setting may also influence the nature of judgments that are made. Abernethy et al. (2001) recently demonstrated the importance of such information by finding that expert squash players could predict stroke depth and direction above chance levels in simulated match situations even when vision was occluded prior to initiation of any preparatory movement.

5. Conclusion

Inferring intent in others is a fundamental facet of human behavior. Over the past 30 years, a considerable amount of research has established that one of the hallmarks of skilled performers is their ability to anticipate the intentions of an opponent. Surprisingly, there has been very little research examining performers' ability to disguise their intentions (see Pollick et al., 2001, for an exception) and none that systematically manipulates the presence of deceptive information. The present study is the first to examine skill-level differences in observers' ability to make judgments when the actor attempts to deceive them. The results indicate that the expert advantage in anticipating intentions extends to the detection of advance deceptive movement. Determining the nature of the judgments being made continues to present a challenge for researchers in this area (Jackson & Farrow, 2005), and confidence ratings as well as analysis of test item solution probabilities warrant further investigation as possible alternatives or additions to other process-tracing measures such as point-of-gaze and retrospective verbal reports.

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