Abstract. We examined whether a goalkeeper can influence a penalty-taker’s actions by assuming postures that mimic Müller-Lyer configurations. The results of two studies indicate that (i) goalkeeper posture affects the perception of the goalkeeper’s height in a manner consistent with the Müller-Lyer illusion; (ii) this influences penalty-taking accuracy; and (iii) a posture which resembles a wing-out Müller-Lyer configuration results in wider and lower throws.

The odds of blocking a penalty throw in handball (ie a 7 m throw) or a penalty kick in soccer typically do not favour goalkeepers. With insufficient time to react, goalkeepers can try to increase the chance of making a save by anticipating where the ball will go, using information from the penalty-taker’s movements (eg Savelbergh et al 2002). Alternatively, goalkeepers can attempt to influence the direction and accuracy of the throw or kick. Masters et al (2007), for example, demonstrated that goalkeepers can influence to which side of the goal a penalty-taker is likely to kick the ball by standing off-centre by as little as 6 to 9 cm. At these distances the kicker tends to be unaware that the goalkeeper has influenced the direction of the kick.

We report two studies that show that goalkeepers can, by raising or lowering their arms, mimic Müller-Lyer configurations in order to bias the perception of their size, particularly their height. Consequently, the goalkeeper can subtly influence the location to which the penalty-taker directs the ball. The studies have theoretical relevance because they speak to the contributions of the ventral and dorsal streams in action; an illusion bias in penalty-taking would highlight the engagement of the ventral steam in action (Milner and Goodale 2008).

We are unaware of other examinations of the advantages (or disadvantages) of visual illusions in sports, and even examples of their influence on our daily life are scarce. Literature on visual illusions almost exclusively deals with abstract geometrical line figures. One exception is evident in the fashion world. Morikawa (2003) showed that high-cut bathing suits make the legs look longer, even when the actual length of the legs is clearly visible. Morikawa argued that the Y-shaped contours formed by the high-cut leg openings and the inner contours of the legs configure as an amputated Müller-Lyer illusion.

In our first study, fifteen male undergraduates made size judgments of photographs of a goalkeeper in different postures. The photographs were edited in order to obtain symmetrical postures. In each photograph, the goalkeeper appeared at a height of 8.0 cm, 7.2 cm, or 6.4 cm in one of four postures. In the arms-out posture, the goalkeeper’s arms were stretched to either side at shoulder height (figure 1a). In the arms-up posture, the arms were raised skyward to resemble a wings-out Müller-Lyer configuration (figure 1b). In the arms-down posture, the arms were lowered toward the ground to resemble a wings-in Müller-Lyer configuration (figure 1c). Finally, in the arms-parallel posture the goalkeeper’s arms were held alongside his body (figure 1d).
This posture is sometimes assumed by goalkeepers when defending a penalty. Each posture was presented five times, with the order of presentation randomised between participants. The participants indicated the height of the goalkeeper (the distance between the bottom of the shoes and the top of the head) by marking the corresponding distance on a vertical comparison line that was printed on a separate sheet.

We tested whether the difference between the height estimates for the arms-out posture (ie the typical control Müller-Lyer configuration) and the other postures differed from zero in the direction predicted by the Müller-Lyer illusion. Participants overestimated the height of the goalkeeper for the arms-up posture by an average of 0.24 cm ($t_{14} = 2.63, p = 0.01$), and underestimated his height by an average of $-0.35$ cm and $-0.51$ cm from the arms-down and the arms-parallel postures, respectively ($t_{14} = 5.79, p < 0.001; t_{14} = 6.27, p < 0.001$). These effects were not mediated by the size of the goalkeeper. The results thus demonstrated that, by raising and lowering the arms to emulate a Müller-Lyer illusion, goalkeepers can make themselves look approximately 3% to 5% bigger or smaller, which amounts to 6 to 9 cm for an average-height goalkeeper (1.86 m).

Having established that the posture assumed by the goalkeeper influences perception of his or her size, we examined how this would affect far-aiming accuracy. We used a simulated handball penalty throw (a 7 m throw) rather than the equivalent penalty kick in soccer, because pilot work showed that our participants were more accurate in throwing than kicking. Twenty-four male undergraduates threw balls (diameter = 12 cm) at a handball goal (204.5 cm x 134.6 cm) projected onto a screen (figure 2). The participants were instructed to imagine that the goalkeeper could move only his arms and legs to stop the ball and to “score a goal by throwing the ball inside the posts and out of reach of the goalkeeper”. The four goalkeeper postures from the first study were used. Both the projected goal and goalkeeper were down-scaled to 68% of their normal size (ie the goalkeeper measured 119.5 cm in height with an arms-out span of 125.2 cm). The participants stood in front of the screen at a distance of 478 cm (68% of 7 m). Two additional arms-out posture figures of different size (125.0 cm x 113.5 cm and 131.0 cm x 118.9 cm) were used in catch trials. Each figure was presented 10 times. Two cameras of a Qualisys® 3-D motion-capture system recorded the trajectory of the ball at 100 Hz. Reflective tape was used to make the ball visible. The reconstructed 3-D coordinates were used to compute the ball’s landing location on the screen.

We determined the ball’s landing location relative to the goalkeeper’s body midline and tested whether the difference in landing location on the horizontal plane between the arms-out posture and the other postures differed from zero. Consistent with a Müller-Lyer illusion, participants were expected to throw farther from the body in response to the increased perceived size of the goalkeeper in the arms-up posture, but closer
in response to the decreased perceived size in the arms-down posture. A difference was evident for the arms-up posture ($t_{23} = 2.15, p = 0.02$). On average, participants threw the ball 3.9 cm further from the body. The differences for the arms-down and arms-parallel postures were not significant (2.1 cm and 2.3 cm further from the body, respectively). Goalkeeper posture did not affect the percentage of balls that were thrown wide of the goal-post, although it was slightly higher for the arms-up than for the arms-out posture (9.6% versus 7.5%). As one might expect, goalkeeper posture did affect the ball’s landing location on the vertical plane. Balls landed significantly lower for the arms-up and arms-out postures (both at approximately chest height, 69.4 cm) compared with the arms-down and arms-parallel postures (both at approximately shoulder height, 82.1 cm and 79.0 cm) ($t_{23} s \geq 2.27, ps \leq 0.03$). Significantly fewer balls were thrown over the cross-bar when the goalkeeper had his arms up (1.3%) than when he had his arms down (4.2%) ($t_{23} = 2.60, p = 0.02$).

These results demonstrate that the posture goalkeepers assume influences the perception of their size, with bias that is consistent with the Müller-Lyer illusion. In fact, the generalisation of the illusion to far-aiming provides evidence for a ventral stream contribution in action (Milner and Goodale 2008). For goalkeepers it is important to recognise that the posture they assume is not perceptually neutral. Conventional wisdom holds that goalkeepers should make themselves look big. Our work takes no account of the psychological impact of a goalkeeper ‘looking big’, but nevertheless suggests that, with the arms raised skywards, penalty-takers are likely to direct the ball further from the goalkeeper (without missing wide of the goal-post), making it more difficult to make a save, so alternative postures (e.g., arms-out), which make the goalkeeper look smaller are likely to result in the penalty-taker aiming the ball nearer to the body (extrapolation to real-life sizes indicates that the difference amounts to 5.7 cm), which may increase the likelihood of a save. Analysis of real-life goalkeeper behaviour may bear this out.

Figure 2. The average ball landing locations to the left and right of the goalkeeper for one participant in the second study (error bars represent 95% confidence intervals for height and width).
Acknowledgment. We thank Kitty Man, Lam Chung Hang, Lam Wai Man, and Tang Chun Keung for their help in collecting the data.

References
Milner A D, Goodale M A, 2008 “Two visual systems re-viewed” Neuropsychologia 46 774 – 785
Conditions of use. This article may be downloaded from the Perception website for personal research by members of subscribing organisations. Authors are entitled to distribute their own article (in printed form or by e-mail) to up to 50 people. This PDF may not be placed on any website (or other online distribution system) without permission of the publisher.