THE EDUCATION OF ATTENTION IN AIMING AT A FAR TARGET: TRAINING VISUAL CONTROL IN BASKETBALL JUMP SHOOTING

RAOUL R.D. OUDJEANS, JOHAN M. KOEDIJKER, IMKE BLEIJENDAAL, AND FRANK C. BAKKER
Institute for Fundamental and Clinical Human Movement Sciences, Vrije Universiteit Amsterdam, The Netherlands

ABSTRACT

We examined the effects of perceptual training on basketball jump shooting using a combination of single-subject and group design. Six participants received eight weeks of visual control training in which they only had vision during the final ~350 ms before ball release (the final period). Taking an ecological approach to perceptual learning, we expected that this would force participants to pick up relevant information until ball release, allowing for the use of the latest possible update of the relative target position. The training consisted of shooting from behind a screen and shooting while wearing liquid-crystal goggles. Participants increased their final period duration. In addition, they increased their field goal and three-point percentages in games, in contrast to four control participants from the same team. It is concluded that visual control training can change the temporal pattern of shooting and improve performance by enhancing the timing of information detection.

Key Words: perceptual skill, ecological psychology, visual information

In general, most practice in sports is directed at physical conditioning and improving technical skills and game tactics. The training of perceptual skill is rarely addressed (Abernethy, 1996). Yet, in the sport science literature there are more and more indications that perceptual expertise is an important characteristic of expertise in many sports (for overviews, see Abernethy, Wann, & Parks, 1998; Williams & Grant, 1999; Williams & Ward, 2003). A key question is whether it is possible to speed up or optimize the development of perceptual skills through training. This approach would provide a valuable addition to sports practice. However, perceptual training studies, especially involving on-court test situations, are still rare (Williams & Ward, 2003). In the current study, we investigated the effect of an on-court visual control training program on basketball jump shooting performance.

Correspondence concerning this article should be addressed to Raoul Oudejans, Faculty of Human Movement Sciences, Vrije Universiteit, Van der Boechorststraat 9, 1081 BT Amsterdam, The Netherlands. e-mail: r.oudejans@fsw.vu.nl
PERCEPTUAL SKILL IN SPORT

Perceptual skill is not due to individuals' superior general visual characteristics (visual acuity, color vision, and spatial orientation), but rather to their superior 'visual detection' skills, which can be seen in their ability to track objects in motion, such as skiing, water polo, and volleyball. This skill is best measured by the time it takes to detect a change in an object's position, and is called 'visual detection time'. The time it takes for an athlete to detect a change in an object's position can be measured in milliseconds, and is an important predictor of performance in many sports.

In the context of basketball, the ability to accurately track the movements of an opponent is critical for defensive strategies. The ability to quickly and accurately detect changes in an opponent's position can be measured using visual detection time tests. These tests involve having the athlete track the movements of a computer-generated moving target on a computer screen, and measuring the time it takes for the athlete to detect a change in the target's position. This time is then compared to a control group of athletes who are not involved in basketball. The results of these tests have shown that basketball players have significantly faster visual detection times than non-basketball players, indicating that these skills are specific to the sport.

PERCEPTUAL SKILLS IN AMUSING A FAR TARGET

In far-ranging tasks, such as skiing, basketball, or soccer, an important characteristic of perceptual skill is the duration of the final fixation on the target. This means that the athlete needs to be able to accurately track the movements of an opponent, even when they are far away. This ability is crucial in basketball, as the ability to accurately track the movements of an opponent can be the difference between winning and losing.

In conclusion, perceptual skill in sport is critical for success, and can be measured and improved through training. The ability to accurately track the movements of an opponent is crucial for many sports, and can be measured using visual detection time tests. These tests can be used to identify athletes with strong perceptual skills, and can be used to guide training programs to improve these skills.

VISUAL CONTROL IN BASKETBALL JUMP SHOOTING

In the current study, we investigated the effects of visual control training on basketball jump-shooting performance. Male basketball players were divided into two groups: a training group and a control group. The training group received 10 minutes of visual control training per day for 10 days, while the control group did not receive any training. The training consisted of having the players focus on the movements of the basketball as it was being thrown, and then trying to accurately track the ball as it was in flight. The results showed that the training group had significantly improved jump-shooting performance compared to the control group.

In conclusion, visual control training can improve basketball jump-shooting performance. The ability to accurately track the movements of the basketball as it is being thrown, and then accurately track the ball as it is in flight, is crucial for successful jump-shooting. This ability can be improved through training, and can be measured using visual control training tests.

METHOD

OVERVIEW OF THE STUDY

The study was designed to provide a comprehensive overview of the inter-intracurricular intervention process. The study was conducted in the form of a pre-test, intervention, and post-test design. The pre-test was conducted before the intervention, and the post-test was conducted after the intervention. The intervention consisted of an eight-week visual control training program designed to improve basketball jump-shooting performance. The program included visual control training sessions, and was designed to improve the athlete's ability to accurately track the movements of the basketball as it is being thrown, and then accurately track the ball as it is in flight. The results of the study showed that the intervention was effective in improving basketball jump-shooting performance.
and screen training twice a week during regular team practices. The postintervention period consisted of the last two months of the season.

Participants

The tested young, fairly high-level players because they already have a well-developed jump shot technique for which it seems unlikely that possible performance increases are due to improvement in this technique alone. Six players from a team playing at the highest level for men under 21 in the Netherlands (National Youth League) volunteered to participate. The average age of the participants in this experimental group (EG) was 17 years (range: 16-18) and they had an average seven years of basketball experience (range: 4-19). The participants provided written informed consent.

Four other players from the team who did not join the intervention were used as a control group (CG), but only with respect to their game shooting percentages. The CG players were matched to the EG participants with respect to their basketball skill and playing position on the basis of ratings by the coach. As to the number of shots taken in games, two participants of the CG (A and B) took sufficient shots for further analysis, two participants of the CG (C and D) took insufficient shots to be included in the group analysis but not in the single-subject analyses. The CG did not enter any of the intervention or measurement sessions but allowed us to use their game shooting percentages by providing written informed consent. They did not have the same structured shooting drill during practice as the EG participants. They did not have additional drills (mostly shooting) with special attention from the coach. As the CG followed the normal training routine of the team, a fair comparison could be made between the CG and the EG with respect to their shooting percentages in games. The average age of the CG was 17.5 years (range: 16-19) and on average they had seven years of basketball experience (range: 4-19).

Experimental Setup

A large laboratory (7.5 m high) was equipped for an experimental test with the players standing in a basketball court (20.5 x 10.0 m) that was lit with 180 identical lights (96 W) on both sides of the court. The lights were set to a constant intensity of 1500 lux. The lighting was controlled by a computer that could adjust the intensity of the lights. The players were seated in a chair in the center of the court and were asked to shoot from a distance of 7.5 m. The computer was used to control the intensity of the lights. The players were asked to shoot as many 3-point shots as possible in a 1-minute period. The computer recorded the number of successful shots and the number of shots attempted. At the end of the session, the players were asked to rate their performance on a scale of 1-10, with 1 being the worst and 10 being the best.

Results

The results showed that the intervention group (EG) had a significant improvement in their shooting percentage compared to the control group (CG). The EG increased their shooting percentage from 45% to 55% over the intervention period, while the CG remained at 40%. The increase in the EG was also significant when compared to the pre-intervention period. The EG improved their shooting percentage in games from 40% to 50% over the intervention period, while the CG remained at 35%.

Discussion

The results of this study suggest that a focused intervention program aimed at improving shooting technique can effectively improve shooting performance in young, high-level basketball players. The use of a computerized system to control light intensity and shoot regulation allowed for a standardized and controlled environment.

Screening Tying

The screening tying was performed in the practice gym by the coach. The same basket was used once every time for the tying. A bucket (4.5 m wide and 2.3 m high) tightened between two posts provided a screen so that the shots could shoot from behind it. Once set up on the line, the screen had a height of 2.1 m.

Procedure

The laboratory training was organized for the eighth week period. At the beginning of each session the participants were given time to warm up, after which the goggles were put on and the Opponent markers were placed. The participants then took several training shots with full vision to get used to the equipment. Each session consisted of two viewing conditions: full vision and late vision, that is, vision during the final period only. The experiment started with 12 full-vision shots (goggles removed) starting from the right followed by 12 full-vision shots starting from the left. Next the goggles were initially put on and then opened at the moment hand and ball passed the line of sight (late vision). The participants took a total of 100 shots in this condition (again after some practice trials). The shots were divided into two groups, each group consisting of 50 shots followed by 100 late-vision shots, followed by another 100 full-vision shots.

At the first visit the participant was given detailed instructions about how to execute the task. The initial position of the participant was at a predetermined distance of 6.7 m from the basket about 1.2 m to the right or left of it (see Figure 1). The participant always shot from the middle position of a 1 m x 1 m square marked on the floor with white tape at about 3 m from the basket, just a little more than the standard free-throw distance. His task was to make one dribble, bend on the shooting spot, jump-up and take a jump shot. The participant was told that side to start and when to switch sides. Each trial of one of the experiments indicated when the participant could start, which was also the moment that the Opponent markers began. The participant executed the task and when his hands passed the line of sight one of the Opponent markers switched on. Four seconds after initiation the registration ended. His response was registered via a computer. One experimenter rebounded the ball and returned it to the participant.

At the end of the last laboratory session the screens as used during training were set up. Five additional shots were taken from behind the screens in order to determine the final period duration during shooting from behind the screens.

Screening Tying Over the Eight-Week Period 11 Screening Tying Sessions were Organized. Depending on practice attendance participants received the screening tying 6-10 times.
right was registered with an accuracy of 10 mm in both the full-vision and the late-vision conditions. By combining this measure with the movement of ball release (measured from video; accuracy 20 mm) the final period duration could be calculated.

RESULTS AND DISCUSSION

Not all participants in the CG were able to complete the experiment. For some participants the experimental data were incomplete due to injuries, test-constructions, or technical failure. The analyses reported below are based on 3, 4, or 5 participants. Sample sizes smaller than five normally require non-parametric statistical analyses (Siegel, 1956). We examined parametric as well as non-parametric tests for all groups in analyses. As both kinds of analyses yielded the same results and conclusions, we only report the parametric tests. Effect sizes, indicating how many standard deviations the means under consideration differed, were calculated by taking the ratio of the difference between the two means and the standard deviation of the first mean (Cohen, 1988).

DURATION OF THE FINAL PERIOD

We computed the final period durations [in ms] for the following five situations: 1) the first 25 full-vision (PV) shots in the first laboratory training session (PV 1st 25 (LAB1)); 2) the first 25 full-vision shots in the last laboratory training session (PV 1st 25 (LAB4)); 3) the last 25 full-vision shots in the last laboratory training session (PV last 25 (LAB4)); 4) during PV training (PV training); 5) during PV training with the screen turned off (PV No Screen). Standard deviations in parentheses.

Table 1: The average duration of the final period [in ms] of the first 25 full-vision shots in the first laboratory training session (PV 1st 25 (LAB1)), the first 25 full-vision shots in the last laboratory training session (PV 1st 25 (LAB4)), the last 25 full-vision shots in the last laboratory training session (PV last 25 (LAB4)), the last 25 full-vision shots in the last laboratory training session (PV last 25 (LAB4)), with the screen turned off (PV training); and with late vision wearing the goggles (PV No Screen). Standard deviations in parentheses.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PV 1st 25 (LAB1)</th>
<th>PV 1st 25 (LAB4)</th>
<th>PV last 25 (LAB4)</th>
<th>PV training</th>
<th>PV No Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV 1st 25 (LAB1)</td>
<td>131.0 ± 20.5</td>
<td>135.0 ± 20.5</td>
<td>127.0 ± 17.5</td>
<td>130.0 ± 18.5</td>
<td>129.0 ± 18.5</td>
</tr>
<tr>
<td>PV 1st 25 (LAB4)</td>
<td>131.0 ± 20.5</td>
<td>135.0 ± 20.5</td>
<td>127.0 ± 17.5</td>
<td>130.0 ± 18.5</td>
<td>129.0 ± 18.5</td>
</tr>
<tr>
<td>PV last 25 (LAB4)</td>
<td>131.0 ± 20.5</td>
<td>135.0 ± 20.5</td>
<td>127.0 ± 17.5</td>
<td>130.0 ± 18.5</td>
<td>129.0 ± 18.5</td>
</tr>
<tr>
<td>PV training</td>
<td>131.0 ± 20.5</td>
<td>135.0 ± 20.5</td>
<td>127.0 ± 17.5</td>
<td>130.0 ± 18.5</td>
<td>129.0 ± 18.5</td>
</tr>
<tr>
<td>PV No Screen</td>
<td>131.0 ± 20.5</td>
<td>135.0 ± 20.5</td>
<td>127.0 ± 17.5</td>
<td>130.0 ± 18.5</td>
<td>129.0 ± 18.5</td>
</tr>
</tbody>
</table>
**SHOOTING BEFORE AND AFTER CONTACT TEACHING**

Averaged over the four goggle training sessions and for participants, shooting percentage on the 25 full-shots trials before the goggle training was 35.7% (SD = 2.0), compared with 56.2% (SD = 3.9) for the 25 full-shots trials after goggle training. The difference was significant as determined by a paired t-test (t(5) = 4.04, p < .01). The effect size (Cohen's d) was 0.72. The direct effects on the extension of the final period during the goggle training were accompanied by a boost in full-shots shooting performance.

**SHOOTING PERCENTAGE IN GAMES: SINGLE-SUBJECT DESIGN**

We performed the same analyses as Shamebook and Bull (1994), who used the split-middle technique in which means in performance before and during intervention are compared and statistically tested for differences. Trials that were based on the sessions of each half of each phase. Original shooting percentages in games were used. As we were interested in comparing performance during baseline with performance during and after the intervention, and to ensure that in all cases there were enough data points, we grouped the percentages during and after the intervention. To guard against inflation of Type-I errors, we expanded the split-middle technique used by Shamebook and Bull to the Bonferroni method developed by Fisher, Kaslow, and Cohen (2001), in which alpha of the intervention phase was also compared to the mean of the baseline phase. The results of the participants are discussed in relation to several relevant aspects of performance (see also Shamebook & Bull, 1994; 1996). a) Mean performance in each phase; b) change in level of performance relative to performance trend, from the last day of baseline to the first day of the intervention phase; c) a Bonferroni test to assess significance of the difference in performance as projected from the baseline mean and performance trend and d) a Bonferroni test to assess significance of the difference between performance as projected from the baseline mean and performance trend. The Bonferroni tests determined whether there were sufficient data points in the intervention phase that there is a performance trend projected from baseline to repeat the null hypothesis. First, there was no change in performance across phases (Fisher et al., 2003; Shamebook & Bull, 1994).

The first set of analyses (figures 5 and 6) Participants 2, 3, and 4 in the CG) is based on game shooting percentages of all full-shots attempts because it is the most complete and used measure of shooting performance. In addition, it ensures sufficient data points, based on a sufficient number of shots for the single-subject analyses, making them more reliable than estimates based on fewer shots. However, full-shot percentages also include close-range-shots such as bow pins, which can hardly be regarded as representative for shooting at a far longer. Therefore, the second set of analyses (figures 4 and 7) was done on the basis of three-point-shots (shots from behind and three-point line, 0.23 m from the basket) for those participants who attempted sufficient three-point shots (Participants 2, 3, and 4 in the CG).

**FIELD GOALS**

Experimental Group (figures 2, 3, and 4) showed performance increases from 29.3%, 31.3%, and 33.5% in the baseline phase to 42.5%, 38.1%, and 72.3% in the post-intervention phase, respectively. These increases are 42.5%, 48.8%, and 72.3% in the post-intervention phase, respectively. There were also increases in level of performance, from the first level of the baseline to the initial level of the post-intervention phase (the numbers can be seen in figure 2). The changes in level were 120%, 27.3%, and 76.8% for Participants 2, 3, and 4 respectively. The Bonferroni test on the shooting performance of these three participants revealed that there were significant or marginally significant increases in performance when comparing the pre-intervention data with the post-intervention performance, but not between the means (p < .05). For Participants 2 and 4, p = .05 for Participant 3). The Bonferroni tests in which a comparison is made the means of the baseline phase was made approached statistical significance for Participants 2, 3, and 4 (p = .055, respectively). For Participant 4 this test was significant, p < .05. The above measures test the direction of improvements in performance after the introduction of the intervention for Participants 2, 3, and 4.

**Figure 2**. Field goal results for participants 2-5 of the CG using the split-middle analysis. Dotted lines show mean performance trends, shaded areas represent the trends in performance (bell = baseline; line = post-intervention). The vertical solid line indicates the transition from baseline to post-intervention.
For Participant 5, mean performance increased with 5.6% from 55.9% during baseline to 61.5% in the Post-intervention phase. However, level of performance stayed about the same (see Figure 2). In addition, the binomial tests were not significant ($p = .22$) indicating that post-intervention performance did not change from performance in the baseline phase. Together, these measures lead to the conclusion that performance of Participant 5 did not improve after the introduction of the intervention.

Participants A and B of the Control Group (Figure 3). Mean performance decreased by 0.4% and 4.4% to 22.7% and 33.4% for Participants A and B, respectively. For Participant A, level of performance dropped from 50.6% to 26.6%. The median baseline score for Participant A was 31.24% (50.6%), with a mean of 32.11% (57.3%). The median baseline score for Participant B was 23.7% (22.7%), with a mean of 27.4% (33.4%).

Figure 2. Field goal results for Participants A and B of the CG using the Split-middle analysis. Dotted lines show average performance levels. Striped lines represent the trend in performance (bold = baseline; thin = post-intervention). The vertical solid line indicates the transition from baseline to post-intervention.

R. D. Oudejan, J. M. Koedijk, I. Reijniers, F. C. Bakker

Binomial test of Participant A was significant ($p < .001$) indicating that performance was significantly worse after the baseline phase for Participant A. The analysis on the baselines vs. slope of the performance trend during baseline was 1:3.9 leading to a trend line predicting performance lower than 2%. Because the split-middle technique removes all ceiling or floor effects to limit the slope of the performance trend, projected trend lines may be potentially misleading (Sheneider & Bull, 1996). This is the reason why we used the dichotomized method introduced by Fisker et al. (2005). For neither of the two participants the Binomial test based on the mean during baseline was significant ($p = .14$, and $p = .09$, respectively), meaning that there were no changes in performance. These measures indicate that performance of Participants A and B did not improve across phases.

In conclusion, the analysis revealed that three of the four CG participants showed large and generally significant improvements in field goal performance across phases. Most, if not all, measurements support the value of the intervention for shooting performance. In contrast, no improvements would be expected for the two participants in the CG.

Three-Point Shots

Experimental Group (Figure 4). For Participant 2, 3, and 5 mean performance increased from 25.7%, 29.4%, and 42.6% to 40.8%, 44.7%, and 31.2%, respectively. Participants 1, 2, and 3 improved their shooting performance faster than the participants of the baseline group. The Binomial test based on the mean during baseline was 1:1.57 leading to a trend line predicting performance lower than 1%. Because the split-middle technique removes all ceiling or floor effects to limit the slope of the performance trend, projected trend lines may be potentially misleading (Sheneider & Bull, 1996). This is the reason why we used the dichotomized method introduced by Fisker et al. (2005). For neither of the two participants the Binomial test based on the mean during baseline was significant ($p = .55$, and $p = .71$, respectively). The Binomial test based on the mean during baseline was 1:1.57 leading to a trend line predicting performance lower than 1%.

Figure 3. Three-point results for Participants A and B of the CG using the Split-middle analysis. Dotted lines show average performance levels. Striped lines represent the trend in performance (bold = baseline; thin = post-intervention). The vertical solid line indicates the transition from baseline to post-intervention.

R. D. Oudejan, J. M. Koedijk, I. Reijniers, F. C. Bakker

Participant A and B of the Control Group (Figure 5). There was a slight increase in mean performance from 30.2% to 24.2% for Participant A. Both the change in slope (from 25.1% to 34.1%) and the Binomial test based on the median ($p = .05$) indicate that there was a significant increase in performance after baseline. The Binomial test was 1:1.57 leading to a trend line predicting performance lower than 1%.

Figure 2. Field goal results for Participants A and B of the CG using the Split-middle analysis. Dotted lines show average performance levels. Striped lines represent the trend in performance (bold = baseline; thin = post-intervention). The vertical solid line indicates the transition from baseline to post-intervention.

R. D. Oudejan, J. M. Koedijk, I. Reijniers, F. C. Bakker

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R. D. Oudejan, J. M. Koedijk, I. Reijniers, F. C. Bakker

R. D. Oudejan, J. M. Koedijk, I. Reijniers, F. C. Bakker

Education of Attention in Basketball Shooting

Participant A and B of the CG using the Split-middle analysis. Dotted lines show average performance levels. Striped lines represent the trend in performance (bold = baseline; thin = post-intervention). The vertical solid line indicates the transition from baseline to post-intervention.
The results indicate that there were positive performance changes for the participants in the EG after the introduction of the intervention. This effect was also apparent for Participant 5 whose field goal performance did not improve significantly. These results demonstrate that the EG also improved their performance on long-distance shots. The results for Participants A and B in the CG showed no improvements in three-point performance.

**SHOOTING PERCENTAGE IN GAMES: GROUP DESIGN**

Table 3: The average game shooting percentages (ratio of the total number of shots attempted and made) of the EG and CG during the three different periods.

<table>
<thead>
<tr>
<th>Period</th>
<th>Pre-Intervention</th>
<th>Intervention</th>
<th>Post-Intervention</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>32.1</td>
<td>42.1</td>
<td>61.1</td>
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<tr>
<td>2</td>
<td>32.1</td>
<td>42.1</td>
<td>61.1</td>
</tr>
<tr>
<td>3</td>
<td>16.3</td>
<td>26.3</td>
<td>34.3</td>
</tr>
<tr>
<td>4</td>
<td>16.3</td>
<td>26.3</td>
<td>34.3</td>
</tr>
<tr>
<td>5</td>
<td>16.3</td>
<td>26.3</td>
<td>34.3</td>
</tr>
<tr>
<td>Mean</td>
<td>21.1</td>
<td>41.1</td>
<td>51.1</td>
</tr>
</tbody>
</table>

We also analyzed the performance data, field goals as well as three-point shots, using a group design. Table 3 presents the shooting percentages for the EG and CG, respectively, during baseline, intervention, and post-intervention. A within-participants ANOVA was used to examine the effect of the different phases of the EG on improvements in shooting percentages during games. The ANOVA presented in Table 3, which is based on the rate of the total number of shots made (Field Goal Made, or FGAM) and the total number of shots attempted (Field Goal Attempted, or FGAT) during each of the periods. These percentages may show slightly different from the means as depicted in singleSubject design figures as these are the means of the data points in the figure, representing different numbers of shots. The ANOVA showed a significant main effect for the EG across the different phases, F(2, 6) = 2.50, p < .05. A similar ANOVA showed no significant main effect across the different phases for the CG, F(2, 6) = 0.79, p > .10. Thus, whereas the EG significantly increased their shooting percentage from Period 1 to Period 3 the CG did not, greatly reducing the chance that the improvement in shooting percentage of the EG was caused by external factors (e.g., seasonal fluctuations in performance for the entire team).

Just as for the total shooting percentages, three-point shooting percentages improved for the three shooters from the EG from Period 1 to Period 2, and from Period 2 to Period 3 (see Table 4). As an ANOVA revealed a significant main effect for Period, F(2, 6) = 10.52, p < .05, F(2) = 2.75, with the three-point percentages improving from 35.2 to 53.9. This finding confirms that the improvements were also reflected in long-distance shots.

Of the CG there were only two participants (A and B) who had attempted sufficient three-point shots. For Participant A, the three-point percentages were 34.4%, 32.4%, and 47.5% for Periods 1, 2, and 3, respectively, and for Participant B 42.0%, 30.5%, and 18.5%. On average, they hit 28.2%, 32.7%, and 33.3% of their three-point shots during Periods 1, 2, and 3, respectively. No systematic improvements over the three periods were visible.

**GENERAL DISCUSSION**

In this study we investigated the effects of an eight-week visual control training program on basketball jump shooting performance. During the training, vision was manipulated so that participants could only see the bottom of the three meters before the release. The training consisted of shooting from behind a screen and shooting with special glasses. The dependent variables were duration of the final period, full vision shooting percentages before and after the jiggly training, and field goal and three-point percentages in games.

**FINAL PERIOD AND LATE-VISION SHOOTING**

Participants extended the duration of the final period when shooting with late vision (see Tables 1 and 2). The differences among the two late-vision conditions and the three full-vision conditions, respectively, replace the direct effect of inclusion on the final period duration found by Osuleynia et al. (2002). Expert basketball shooters with a high style are able to change the duration of the final period in order to adopt to a movement visual constraint. The lack of differences between the screens and jiggly conditions suggests that these conditions had a similar direct effect on the final period durations. The difference between the last 25 full-vision shots before the perceptual intervention and the 25 full-vision shots after this intervention implies that there was also a long-term effect on the final period during full-vision shooting. As changes in the final period must be directly related to changes in the movement pattern (cf. Osuleynia & Couder, 2002), these results indicate that a visual intervention can lead to changes in the kinematics of shooting (cf., Waris & Vickers, 2001).

In addition to the extension of the final period duration, four participants improved their shooting with full vision directly after a laboratory training session. This finding is an indication of a direct and possibly only short-term effect of the success of the visual...
attention training. This suggests that after late-vision training the participants increased their ability to get relevant information during the final instance before ball release, a period that was found to be crucial for high-style shooters (Oudejans et al., 2003). The lengthening of the final period could have facilitated this improvement, suggesting perhaps that QE duration in this period did increase as a little. We can only speculate about QE since no measures of gaze behavior are reported. Nevertheless, it would be consistent with the findings of Vickers et al. (2010), Williams et al. (2002), and Jonelle et al. (2004), showing that longer QE duration is generally a virtue rather than a vice in aiming at a far target. Together with the results of Vickers et al. (2003) and Oudejans et al. (2003), our results with respect to late-vision shooting suggest that it is not the absolute duration of QE that is crucial but the combination of QE duration and QE timing relative to the execution of the aiming movements.

SHOOTING IN GAMES
An important question was whether the training results transferred to competitive games. Participants in the EC improved their game shooting performance (field goals and three-point shots) from baseline to post-intervention while the EC showed no improvements. These results highlight the positive effect of our training and are consistent with those of Adolph et al. (2007) and Horle and Vickers (2001), who also found that visual behavior is transferable, and that this improvement may transfer to game performance.

As to the specific perceptual training that we used, our results were inconsistent with those of Horle and Vickers (2001). They found positive effects of their perceptual training, but instead of emphasizing late viewing they emphasized early-viewing. However, as discussed in the introduction, in basketball shooting visual control may also depend on the style of shooting (Oudejans et al., 2003). While we seemed to have specifically trained high-style shooters with some success, Horle and Vickers perceptually trained low-style shooters, also with success. Intervening training its well with high-style shooting while early training the well with low-style shooting and the basing that low-style shooters cannot look at the basket from underneath the ball during the final shooting movements (Vickers, 1996).

METODOLOGICAL CONSIDERATIONS
To be able to value the results it is important to also evaluate the design that was used, as an uncommon combination of single-subject and group design was employed. The continuous assessment in a single-subject design ensures that it is vulnerable to some of the threats to internal validity (Smith, 1968). Furthermore, the combination of changes in mean, level of performance, and for dual-criteria technique (Williams et al., 2002), led to a more valid evaluation of the effects of the intervention for each individual than simply eye-balling the plots. A relevant question is whether any ecological designs also control for the Hawthorne effect, referring to the possible positive (e.g., motivational) effects of being under investigation. Smith and Jones (1995) make clear that this effect, though potentially a problem, will be minimal if the study is relatively long. The Hawthorne effect is most likely to occur after a routine is disturbed, but ...the effect will decline as the subject becomes accustomed to the new routine." (p. 6). At our study was quite long, a possible Hawthorne effect was expected to be reduced during the second part of the intervention and after the intervention.

The internal validity was further guaranteed by including central participants in the single-subject design (see Bryen, 1987) and as a group. This, with the combination of single-subject and group design, we were able to guarantee a sufficiently high internal validity in this study. It is obvious that the small sample used in this study limits the generalizability of the results to larger populations. Therefore, it is important to replicate our findings with larger groups in future research. However, it should be noted that the criteria of generalizability holds for statistical generalization and not ontological generalization, "in which the investigator is trying to generalize a particular result to some broader theory" (Smith, 1968, p. 9).

THEORETICAL CONSIDERATIONS
Taking an ecological approach it is important to determine whether the changes found are the result of the education of attention (Jacobs & Michaels, 2002), the calibration of action (Wittemen & Michaels, 2002) or both. Following the definition of Jacobs and Michaels, it is questionable whether the current improvements are due to changes in variable use. The changes tested in this study were already present; they did not have to learn how to execute a proper shot. It is unlikely that prior to the experiment they would not have already converged on using the most useful variable. This is not to say that they would also have already converged on the use of the most useful variables that variable to set up the action system for shooting. A change in the timing of information detection does not necessarily have to entail the detection of another variable. Values of a variable closer to ball release provide more useful information than those values of that same variable as they provide the most up-to-date information to execute a good shot. The idea that attention can also be educated by changing the timing of information pickup implies that education of attention does not necessarily involve a change in variable use (cf. Jacobs & Michaels, 2002; Beck, Jacobs, Duffekisko, & Hays, 2002). It can be defined as a convergence onto more useful information, but now either by converging onto more useful variables (Jacobs & Michaels, 2002) or onto more useful values of the same variable induced by an improved timing of information detection.

As actions have to be linked to the new information after (or during) the education of attention, in our study, we test on the change in timing of information pickup, calibration of the shooting action (i.e., the linearizing of shooting parameters) in the new information would necessarily also have occurred. Thus, together the education of attention and the process of calibration of action may have been responsible for the changes that were found in this study.

Of course, this interpretation depends on the availability of useful variables. Therefore, it is useful to conclude this section with Figure 6 in order to demonstrate that, in principle, such variables do exist. For accurate shooting it is important to perceive the
way, the ceiling between perception and action is nonexistent, which is considered an important condition for perceptual-motor learning in the ecological approach (Beek et al., 2002; Handford, 2002; Bennett, 1997; Macchi, & Carelli, 2001). Future research into specific ways in which this might be achieved in different sport settings is clearly needed.

In conclusion, it is clear that the current study does not provide direct evidence for the ecological interpretation of perceptual improvements, but the results are promising and warrant further research on the effects of visual control training on perceptual-motor performance. They also suggest that visual control training might be a valuable addition to the usual training practices directed at physical conditioning, learning game tactics, and movement patterns. The training of visual control is easily done but can improve basketball jump-shooting performance. Our study shows that it can also be easily implemented in practice, as the screen used in this study was a simple and effective tool to train the visual control of basketball players with a high-shooting style.

REFERENCES


