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RESEARCH NOTE

The Influence of Visual Contextual Information on the Emergence of the Especial Skill in Basketball

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We examined whether basketball throwing performance in general and motor skill specificity from the free throw distance in particular are influenced by visual contextual information. Experienced basketball players ($N = 36$) performed basketball set shots at five distances from the basket. Of particular interest was the performance from the free throw distance (4.23 m), at which experienced basketball players are expected to show superior performance compared with nearby locations as a result of massive amounts of practice. Whereas a control group performed the shots on a regular basketball court, the distance between the rim and the free throw line was either increased or decreased by 30 cm in two experimental groups. Findings showed that only the control group had a superior performance from the free throw distance, and the experimental groups did not. Moreover, all groups performed more accurately from the perceived free throw line (independent of its location) compared with nearby locations. The findings suggest that visual context information influences the presence of specificity effects in experienced performers. The findings have theoretical implications for explaining the memory representation underlying the especial skill effect in basketball.

Keywords: motor control, expert performance, practice specificity, visual cues, free throw

In recent years, several authors have provided evidence for the coexistence of generality and specificity of practice in developing a memory representation for action (Breslin, Hodges, Kennedy, Hanlon, & Williams, 2010; Keetch, Schmidt, Lee, & Young, 2005; Keetch, Lee, & Schmidt, 2008; Simons, Wilson, Wilson, & Theall, 2009). According to Schmidt (1975, 2003), all skills belonging to one class of actions are suggested to be controlled by a generalized motor program and respective parameters via the recall schema that defines or scales the action. In that view, from the learning of one skill within a class of actions (e.g., learning a set shot in basketball at the 4.23-m distance), all other actions within that class should benefit from practice at 4.23 m owing to the learning of general principles (i.e., relative timing of the action). For the class of set-shot actions in basketball, such generality effects are evidenced by the force × variability hypothesis, which predicts a negative linear relation between throwing success as distance increases from the basket. However, an unexpected finding was that accuracy in performance at the 4.23-m distance (free throw line) was similar to that at distances nearer to the basket, a finding that was not in line with force by variability predictions (see Figure 1 in Keetch et al., 2005). Keetch et al. termed this an *especial skill*, which is a highly specific skill embedded within a more general class of motor skills. The especial skill was attributed to player's having accumulated massive amounts of specific practice at the 4.23-m distance. Although this is a reasonable explanation, and tends to favor specificity in motor learning, it has brought some debate as to whether the underlying structure of memory representations that govern motor learning are general or specific, and whether a motor learning theory that accounts for specificity within generality is required (for a review, see Breslin, Schmidt, & Lee, 2012).

Two hypotheses have been proposed to explain the especial skill effect: the learned-parameters hypothesis (e.g., Breslin et al., 2010) and the visual-context hypothesis (e.g., Keetch et al., 2008). The learned-parameters hypothesis proposes an improved force parameter specification at the free throw line resulting from the massive amounts of practice for that one skill. The visual-context hypothesis suggests that unique visual information at the free throw line is part of the memory representation and if removed leads to a detriment in performance. There has been support for both hypotheses (Breslin, Schmidt, & Lee, 2012); however, there remains the need for further clarification of the role of vision in the memory representation to support performance of this unique skill. In a recent study by Stöckel and Fries (2013), the presence of basketball court floor markings had an effect on expert basketball players' 3-point shooting performance (i.e.,

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performance from 6.75 m—the new 3-point throwing distance in European basketball—on a court with the newly introduced floor markings was worse than on a court displaying the familiar 3-point line); therefore, it remains to be seen whether the engagement of the specific motor response required for an especial skill is reliant on the presence of floor markings, and whether manipulating the position of floor markings degrades especial skill performance.

The aim of the current study was to examine whether manipulating the location of the free throw line on a basketball court influences throwing performance in general and the emergence of the especial skill effect at the free throw distance in particular. To achieve this, three groups of players performed 150 set shots from five distinct distances, which included the free throw (FT) distance (4.23 m). Whereas a control group (CG) performed all shots on a standard basketball court, for two experimental groups the court was manipulated wherein the distance between the rim and the FT line was either increased or decreased (by moving the backboard/rim back or forward by 30 cm). We predicted based on the learned-parameters hypothesis that all groups would show superior performance at 4.23 m independent of the location of the FT line owing to the great amounts of constant practice from this position. If the visual-context hypothesis accounts for the especial skill effect at the FT distance, we predicted that the FT line would influence the specific motor-response selection for the especial skill, and thus generate superior performance for the control group only, not for the experimental groups, at 4.23 m.

Methods

Participants

Thirty-six experienced male basketball players (mean age = 25.7 years, *SD* = 3.8 years) took part. All were semi-professional players of the 3rd and 4th highest-ranking basketball leagues in Germany, had at least 5 years of coached practice in a basketball club on the German regional level (i.e., up to 4th league; on average 9.2 years of coached practice, *SD* = 4.0), and had at least 10 years of experience in playing basketball. Players represented all positions on the team (i.e., guard, forward, and center) and all were right handed, as determined by the Edinburgh Handedness Inventory (Oldfield, 1971). Informed consent was obtained before participation in the experiment. Ethical approval was provided by the lead institution's research ethics committee.

Experimental Setup and Design

Each participant was asked to throw an official basketball (size 7, Molton), based on the rules of the International Basketball Association (FIBA), into a regular-sized basketball rim mounted 3.05 m above the floor of a standard basketball court, and with the participant's feet maintaining contact with the floor at all times (i.e., to perform basketball set shots). The shots were taken from five positions facing front on to the basket (see Figure 1). Masking tape (5 × 2 cm) was used to mark the five positions on the court.

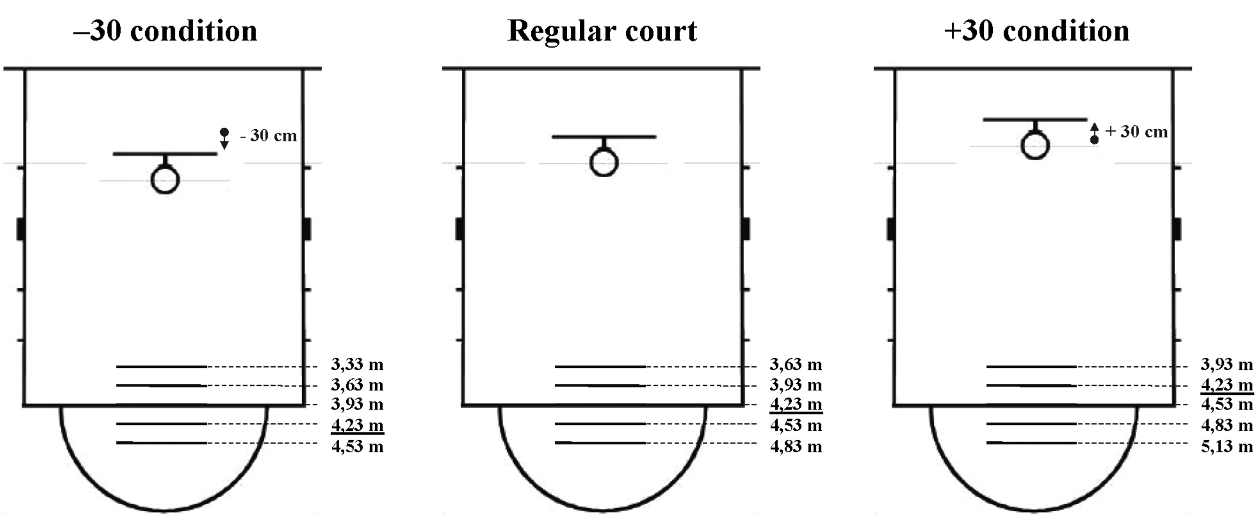

Figure 1 — Experimental setup. The control group performed basketball set shots on a regular basketball court (middle panel). The experimental groups performed either on a court with the rim 30 cm closer to the free throw line (left panel) or on a court with the rim 30 cm farther from the free throw line (right panel). The respective displacement of the rim is indicated by an arrow beside the basket. The lines around the FT line illustrate the markings of the five throwing positions. The critical free throw distance at 4.23 m is underlined in each panel.

Before the experiment, participants were randomly assigned to one of three groups. The line markings were distributed differently for each of the three groups, such that the perceived free throw line appeared in three different locations (actual positions are indicated here in boldface type): For the Control Group (CG), the five positions were at 3.63 m, 3.93 m, **4.23 m**, 4.53 m, and 4.83 m, with the FT position (and FT line) being, according to the official FIBA rules, at 4.23 m.[1] For a second group, the –30 group, the positions were 3.33 m, 3.63 m, **3.93 m**, 4.23 m, and 4.53 m, with the actual FT position being at 3.93 m. For the third group, the +30 group, the positions were 3.93 m, 4.23 m, **4.53 m**, 4.83 m, and 5.13 m, with the actual FT position being at 4.53 m. The basketball hoop was positioned before the participants entered the gym; participants were not informed about the manipulation. Throwing performance (hit or miss) was assessed by an expert rater (i.e., an active basketball player) positioned to the right of the player in a straight line with the rim.

Procedure

Participants were tested individually with three experimenters in the gym. Experimenter 1 gave instructions, Experimenter 2 scored each shot, and Experimenter 3 returned the ball to the participant immediately after each shot. Each participant took 20 warm-up shots, and then performed 30 shots at each distance, for a total of 150 shots. The attempts at each position were performed in blocks of six shots. After each block of six shots, the participant moved to the next position. Similarly to Keetch et al. (2005, Exp. 2), a repetition of the five positions was completed in each set of five blocks (30 trials per set) before another repetition was started. The order of shooting positions was randomized within each set of 30 shots and counterbalanced across groups. Shots were taken at the participant's own pace.

Data and Statistical Analysis

Task performance was assessed using a 2-point scoring system in which each shot was registered as hit or miss according to official basketball rules. For each trial, percentages of hits were calculated across the 30 trials from each position. These data were then submitted to a Group (CG, –30, +30) × Distance (Position 1–5) mixed factorial analysis of variance (ANOVA) with repeated measures on the last factor. Pearson's correlational statistic was used to examine the relation between distance and throwing performance. To test specifically for the presence of the especial skill, individual linear regressions were calculated on the basis of the four positions other than the actual FT position at 4.23 m to generate predicted values for the FT distance (see Keetch et al., 2005, for this procedure). The predicted values for the FT distance were then compared with the actual percentage of hits from that position. The three groups' (CG, –30, +30) actual and predicted percentage scores were contrasted via a further ANOVA. Bonferroni corrections were made to adjust the alpha level for conducting two ANOVAs (i.e., $\alpha = .05/2 = .025$). For any significant main or interaction effects, post hoc pairwise comparisons using the Sidak adjustment were performed between any two given conditions. Partial eta squared (η^2_p), a measure of effect size, was reported.

Results

Actual percentages of hits at each of the five positions as well as the predicted values for the FT position at 4.23 m are displayed in Figure 2 for all three groups. The percentages of hits decreased with increasing distance in all three groups, which was supported by negative linear correlations (all rs < –0.86, ps < .001) and a significant distance effect, $F(4,132) = 23.03$, $p < .001$, $\eta^2_p = .41$. Simple comparisons of neighboring positions confirmed the performance decrease from Position 3 (66.4%) to 4 (55.7%) and from Position 4 to 5 (50.1%) to be significant (all ps < .01). There was no significant main effect for Group or a Group × Distance interaction.

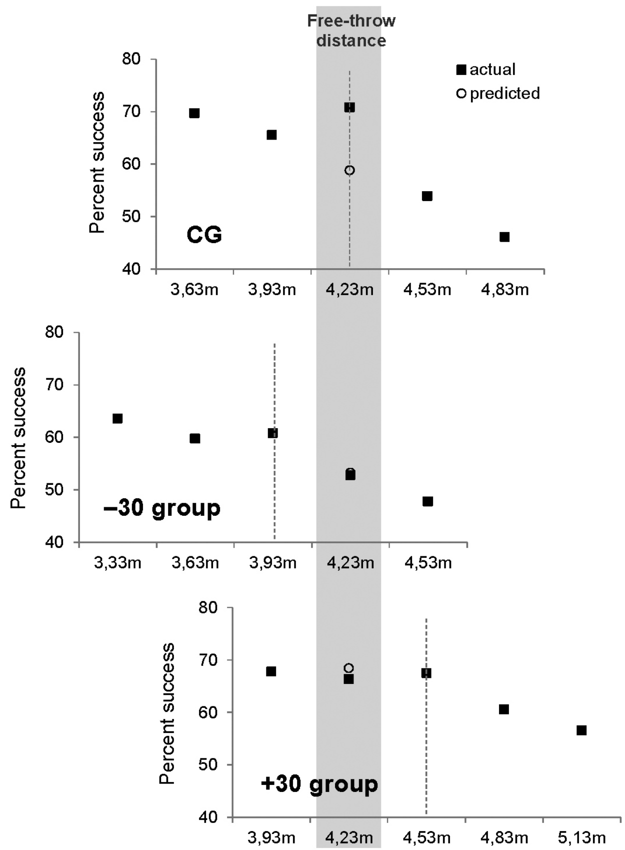

Figure 2 — Actual success rates (filled squares) from each of the five positions for the control group (CG) and the two experimental groups (+30 and –30 groups). Predicted values based on regression analysis are displayed (open circles) for the free throw distance. The gray pillar highlights the success rates in each group from the free throw distance, while the dashed lines mark the actual location of the free throw line in each group.

Regression analyses generated mean predicted values of 58.8% for the control group, 53.2% for the –30 group, and 68.4% for the +30 group at the "real" FT distance (4.23 m). Actual percentages of hits from 4.23 m were 70.8% (CG), 52.8% (–30), and 66.4% (+30). Data analysis yielded a significant main effect for success, $F(1,33) = 5.00$, $p < .05$, $\eta^2_p = .13$, with higher actual values compared with predicted values, and a significant Group × Distance interaction, $F(2,33) = 9.78$, $p < .001$, $\eta^2_p = .37$, indicating differences between the three groups regarding actual versus predicted percentages of hits from the "real" FT distance. Post hoc simple comparisons revealed the difference between actual and predicted values from 4.23 m to be significant only in the control group ($p < .001$) but not in the –30 ($p = .85$) and +30 groups ($p = .42$). Further inspection of the data (see Figure 2) indicated that in both experimental groups (–30, +30), percentages of hits at the "fake" FT line position, which was at 3.93 m in the –30 group and at 4.53 m in the +30 group, did not follow the expected linear trend. To test whether these two groups showed superior performance at the (displaced) FT line, again we used the same regression analysis procedure and submitted actual and predicted percentages of hits at the FT line to a Group (–30, +30) × Success (actual, predicted) ANOVA. Data analysis revealed a main effect for Success, $F(1,22) = 6.49$, $p < .05$, $\eta^2_p = .23$, in the absence of any other significant main or interaction effects. Hence, averaged across both groups, the difference between the actual (64.2%) and predicted values (59.7%) was significant, indicating that performance from the "fake" FT lines in the experimental groups was higher than expected by chance based on the performance at nearby positions.

Discussion

We examined the influence of visual context information on basketball players' performance at the free throw position, where an especial skill effect has been reported previously (Breslin et al., 2010; Fay, Breslin, Czyż, & Pizlo, 2013; Keetch et al., 2005, 2008). Three groups of experienced basketball players performed set shots from various distances, including the FT distance either on a regular basketball court or on modified courts in which the rim was 30 cm closer to, or farther from, the FT line. Findings indicated that the control group's performance was superior at the FT line compared with performance at nearby locations. Furthermore, we showed that the especial skill effect was present in the control group at the FT line (4.23 m), but not at this distance for the experimental groups at 4.23 m. The –30 and +30 groups exhibited an especial skill effect at 3.93 m and 4.53 m respectively, which suggests that the visual context is a key determinant of especial skill performance, not necessarily massive amounts of practice at one particular distance. The fact that participants in the current study were not members of the highest leagues in basketball, as in the studies mentioned previously, indicates that motor-skill specificity is achieved early in practice (see Breslin, Hodges, Steenson, & Williams, 2012).

With regard to recent literature on the especial skill effect (Breslin et al., 2010; Keetch et al., 2005), one should have expected athletes to show superior performance from the FT distance at 4.23 m compared with nearby locations independent of the location of the FT line. Most interestingly, participants of the +30 and –30 groups (with the fake FT lines), did not show superior performance from the FT distance (4.23 m) as shown for the control group. This finding has led us to conclude that it is very likely that besides an explanation through massive amounts of practice for that one specific action, stable visual-context information during skill acquisition accounts for the especial skill effect. This finding is contrary to recent studies that indicate that specificity effects appear independent from the environmental context (Keetch et al., 2005, Exp. 2; Simons et al., 2009). The finding that specificity effects from the FT distance fail to appear when the (usually constant) distance between the FT line and the rim is altered suggests an influence of the location of the FT line on motor-skill specificity. Hence, we argue that the studies of Simons et al. (2009), in which the regular baseball pitch was performed out of sport-specific context, and the experiment by Keetch et al. (2005), in which the floor markings were obscured when performing set shots in basketball, did not sufficiently examine the influence of visual-context information on motor-skill specificity. In both studies, athletes were not able to use the visual-context information (i.e., incidental cues) typically available in the respective natural sport setting and, thus, athletes probably used the information provided by the intentional cue for motor-response selection, that is, the rim in basketball throwing and the target in baseball pitching. So, both experiments were not designed to detect whether athletes acquired the markings on the court or on the field as visual cues or even as the primary source of information for motor-response selection. Thus, these studies do not allow for a general conclusion regarding the role of incidental visual cues (cf. Wright & Shea, 1991) on motor-skill specificity whereas the current study contributes to this knowledge.

Surprisingly, in the current study all groups exhibited superior performance from the perceived FT line, regardless of whether it was located at the familiar FT distance (4.23 m) or 30 cm closer to / further from the rim. This finding may indicate a hierarchy of vision being dominant in activating a specific motor program before performing the especial skill. Although this finding was surprising, it supports the notion that viewing the FT line provides relevant information to prepare the throwing action and enhances the presence of specificity effects—independent of its location on the court. Moreover, the incidental cues provided by the FT line seem to provide a more reliable estimate of actual task demands (i.e., the distance to the rim) for experienced performers than the location of the rim (i.e., the intentional cue) itself. This is contrary to previous findings suggesting that athletes estimate the demands of throwing in basketball by using direct visual online information until ball release (cf. Oudejans, van de Langenberg, & Hutter, 2002) from the location of the rim in relation to their current position (e.g., de Oliveira, Oudejans, & Beek, 2009) as the primary or even sole source of information (Keetch et al., 2005). Although we agree with de Oliveira et al. (2009) and Keetch et al. (2005), that information about the location of the rim in relation to player's own position is essential for achieving skilled throwing performance, our results indicate that (a) the FT line is an incidental visual cue that becomes associated with throwing in basketball owing to extensive amounts of practice and (b) the information from the FT line is predominantly processed in experienced basketball players, when information from the basket (i.e., the intentional cue) (cf. de Oliveira et al., 2009) and from the floor markings (i.e., the incidental cue) are available. This conclusion was supported by the absence of specificity effects at the actual FT distance and its presence at the "fake" FT line (–30, +30). How informational cues provided by the floor markings are processed and used to estimate the distance to the rim and to what extent cue selection is influenced by expertise are currently being explored in our laboratories.

With regard to the structure of the memory representation that underlies the especial skill, we propose two observations from our data: (a) the visual-context hypothesis (Keetch et al., 2008) may be the key determinant of the motor program that is selected to achieve a successful performance and (b) parameterization as argued by Breslin et al. (2010) cannot alone account for the specificity effects inherent in the especial skill, supporting a view that both learned parameters and visual context account for the phenomenon of especial skills. This conclusion is in line with the finding of Keetch et al. (2008). Furthermore, it can be suggested that motor-skill specificity in basketball free throwing is strongly related to the visual cues provided by the FT line (and probably other floor markings), as already evidenced for 3-point shooting (Stöckel & Fries, 2013).

In future, researchers could explore the emergence of the especial skill effect across different tasks, in the form of learning studies employing measures of visual attention and full-body movement kinematics, or in studies exploring the role of self-efficacy. The types of tasks that could be explored include serving an ace ball in tennis or volleyball, scoring triple 20 in a game of darts, or hitting the middle target in archery across varying distances. It is not clear whether the automaticity of the especial skill effect is resilient to the effects of fatigue, distraction, competitive pressure, or performance anxiety, so the application of especial skills remains unclear.

In sum, our findings indicate that specificity effects at the FT distance are not robust against an alteration of familiar visual-context information (i.e., the lines on the court). It can be suggested that visual cues provided by the FT line are used for motor-response selection in experienced athletes. Moreover, if information from both the rim and the floor markings are available, information provided by the lines on the court seem to be processed primarily for preparing the throwing action. Together with the findings of Stöckel and Fries (2013), the data of the current study suggest that the lines on the court impact throwing performance, especially on shots that are conducted at (or near to) a line on the court. The use of visual cues (like the floor markings in basketball) by experienced performers, on the one hand, probably enable athletes to hasten motor-response selection and even retrieve an appropriate motor response when intentional cues are not available (e.g., when vision of the rim is obscured by a defender) but, on the other hand makes their performance prone to slight differences between familiar and unfamiliar environments (e.g., the home-court advantage) or also changes in rules, as shown for the 3-point shooting performance (Stöckel & Fries, 2013).

Note

1. Note that 4.225 m is the official distance of the free throw line to the rim according to the official FIBA rules. In the National Basketball Association (NBA), this line is at 15 feet. Since the 4.225 m according to FIBA rules is measured from the center of the rim and the 15-foot distance in the NBA is measured from the edge of the backboard, both distances are quite similar. The metric equivalence of the distance in the NBA is 4.191 m (13 ft. 9 in.). Here, we refer to shooting distances in meters, although most of the previous studies on the topic used the English imperial distances (e.g., Breslin et al., 2010).

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