COGNITIVE AND MOTOR PROCESSES IN A VOLLEYBALL SPECIFIC ANTICIPATION TASK

Sina David[1] and Franziska Kalde[2]

Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands[1]

Institute of Psychology, Dept. Performance Psychology, German Sport University Cologne[2]

The purpose of the study was to investigate the relationship between cognitive and motor processes in a volleyball specific anticipation task with temporal video occlusion. Ten middle blockers of the national 2nd-4th division volleyball league were supposed to anticipate the setting direction presented on a screen, which occluded at three different occlusion times and respond with either a specific blocking movement (motor response) or key press (cognitive response). The participants showed only small significant differences in the kinematics of the block movement between the examined occlusion conditions. The participants showed a variable time of movement initiation with a shorter total duration with later occlusion although the movement time was shorter. The results illustrate a close temporal adaptation of the block movement to the presented setting situation.

KEYWORDS: decision making, agility, motor response, blocking, temporal occlusion.

INTRODUCTION: The anticipation to an opponent's actions or ball flight is a performance-determining factor in many sports (Loffing & Canal-Bruland, 2017). The coupling of perception and action seems to have a positive influence on anticipation in sport-specific tasks. Experts have a better prediction accuracy with a sport-specific motor response in contrast to unspecific responses (e.g. verbal or keypress, Travassos et al. 2013). However, it remains unclear, to what extent improved prediction accuracy is also reflected in a movement advantage. Müller and Abernethy (2012) show that earlier information perception leads to earlier movement initiation and global body movement, while later information is used to specify the movement. However, there is a limited number of studies of movement analysis after an anticipation task focussing on movement quality.
The study aimed to analyse the relationship between cognitive and motor processes in a volleyball specific anticipation task. It was examined whether different visual information affects the execution of block movement. Furthermore, the prediction accuracy in a coupled response condition with sport-specific movement response and an uncoupled response condition with keypress was compared. We hypothesized that the amount of information which was controlled by the duration until occlusion will affect the movement quality. Further it was hypothesized that a higher amount of information will result in a shorter initiation of the movement and therefore an overall shorter total duration.

METHODS: Ten female middle blockers of the national 2nd-4th division volleyball league were supposed to anticipate to the setting direction by different setting situations. The setting was presented on a video in front of the participants, which occluded at three different occlusion times (120ms pre, 60ms pre and 120ms after initial setters contact). The occlusion conditions were reported as the earliest occlusion time where experienced athletes can predict the block direction with >50% accuracy (Cañal-Bruland et al., 2011; Schorer et al., 2013). All videos had a duration of 1,980 seconds. The setting was always made after an optimal first pass and there were two possible setting directions to position IV (front set) and II (back set). The participants responded either with a predefined block movement with a three-step approach (motor response) to the anticipated attack position or with a keypress (cognitive response). The test was conducted in the following order:

1. 10x occlusion time 120ms post with block movement (Baseline condition)
2. 40x occlusion times 60ms pre and 120ms pre with block movement
3. 40x occlusion times 60ms pre and 120ms pre with a keypress

The motor response was investigated in a complex three-dimensional motion analysis set-up with 18 cameras (200Hz, Vicon, Oxford, UK) and two force plates (1000Hz, Kistler, Winterthur, Switzerland). The focus of the analysis was on the initiation of movement and the directional step (first step), so that the ground reaction forces, impulse and step length of the directional step, and the duration from video occlusion to movement initiation (TMov) were selected as parameters. The total time is defined from the time of video occlusion to landing after block jump. The movement time is defined from the time of movement initiation to landing after block jump. The end of landing was the minimum vertical COM position after block jump. The time of movement initiation is described as the first recognizable movement in the movement direction. The directional step is defined from the time of initiation of movement until the first ground contact of the first step. The pelvis orientation is calculated using the pelvis markers of spina iliaca. An angle of 0° corresponds to a pelvis orientation parallel to the net. The COM drift is the horizontal deviation of COM position between take-off and landing.
To analyze the prediction accuracy between occlusion times and response condition, dependent T-tests were calculated using the mean values of each subject. For the calculation of the kinematic and kinetic parameters, the mean values of each subject of the occlusion times were used. A multivariate ANOVA with repeated measurements was calculated. The statistics for pelvis orientation was done with statistical parametric mapping (SPM) in Matlab.

RESULTS: The results showed no significant differences in prediction accuracy of setting direction between the two occlusion times 120ms pre and 60ms pre. The subjects achieved a prediction accuracy of 74.70% ± 14.97 in both response conditions at the occlusion time 60ms pre, the prediction accuracy at the occlusion time 120ms pre was 68.68% ± 13.21. Furthermore, there was no significant difference of prediction accuracy with a coupled and uncoupled response condition (movement response: 69.21% ± 13.70; keypress response: 74.44% ± 14.74).

Table 1: Kinematic and kinetic parameters of the block movement at the three occlusion times 120ms post, 60ms pre and 120ms pre. *= differs significantly from the occlusion time 120 ms post, #= differs significantly from the occlusion time 60 ms pre, °= differs significantly from the occlusion time 120 ms pre.

Parameter	120ms post M ± SD	60ms pre M ± SD	120ms pre M ± SD
	N=10	N=10	N=10
Jump height [cm]	42.05 ± 3.59	42.95 ± 2.64	43.30 ± 2.80
COM drift [cm]	71.68 ± 16.51	71.65 ± 20.96	71.46 ± 21.86
Total time [sec]	2.01 ± 0.14#°	2.18 ± 0.11*	2.24 ± 0.13*
Moving time [sec]	2.15 ± 0.11	2.15 ± 0.11	2.17 ± 0.12
T_{Mov} [sec]	-0.1360 ± 0.1044#°	0.0240 ± 0.1103*	0.0676 ± 0.1248*
Step length [cm]	79.14 ± 9.79	80.05 ± 8.32	83.03 ± 8.61
max. GRF [N/kg]	19.53 ± 1.82	20.16 ± 1.98	20.29 ± 2.32
Impulse [Ns/kg]	715.20 ± 78.78	705.46 ± 56.39	721.70 ± 67.77

The kinematic and kinetic parameters of the block movement differed significantly between the occlusion times for the parameters movement initiation (TMov) and total time (table 1). At the occlusion condition 120 ms post, the subjects initiated the movement on average 0.1360 ± 0.1044 seconds before video occlusion, which differs significantly from the occlusion time 60ms pre (0.0240 ± 0.1103, p=0.012) and 120ms pre (0.0676 ± 0.1248, p=0.001). The total time also differed significantly between the occlusion times 120ms post and 60ms pre (p=0.018), and 120ms post and 120ms pre (p=0.001). The other kinematic and kinetic parameters of the block movement showed no differences between the occlusion times. The pelvis orientation at the directional step (figure 1) presented a significant difference between the occlusion times ($p < 0.001$) and showed a stronger rotation in movement direction with earlier occlusion (60ms pre and 120ms pre) than with later occlusion (120ms post).

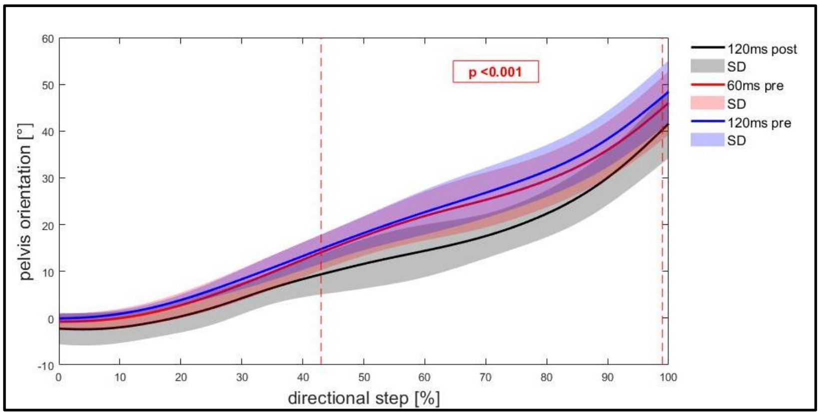

Figure 1: Pelvis orientation in the directional step at the occlusion times 120ms post, 60ms pre and 120ms pre. The red lines indicate the range in which the occlusion conditions 60 ms pre and 120 ms pre differ significantly from the occlusion condition 120 post.

DISCUSSION: Against expectation, there was no improved prediction accuracy in later occlusion time. It can be assumed that the information used by experts to anticipate the setting direction in this study does not relate to the examined period between 120 and 60 ms before initial setters contact. To identify the perception of relevant information within a time sequence, several occlusion points should be chosen. Occlusion times after the setter's contact should also be selected since Müller and Abernethy (2012) consider ball flight information to be the most relevant and specified in the athlete's decision-making process. In this way, ball flight information enables a specifically adapted motor response. According to Milner and Goodale (1995), a coupling of action and perception leads to increased activation in information processing. The authors assume two separate, neuroanatomically and functionally different visual systems in information processing. The integration of the so-called dorsal path, which is increasingly activated during movement, leads to a better anticipation performance and faster movement initiation in a coupled condition, as it has a direct connection with the premotor cortex. In this context, van der Kamp et al. (2008) and Mann et al. (2010) could observe an improved anticipation performance with specific motor response compared to an uncoupled response condition. However, these results could not be confirmed in the present study. Indeed, there was a slightly improved prediction accuracy with keystroke response compared to motor response condition (+5.23%). Since the time of movement initiation was after video occlusion in most of the cases, there was no direct coupling of perception and movement. For this reason, no increased activation in information processing and anticipation performance could be expected. Another explanatory approach could be the study design, where no counterbalanced-measured design was chosen so that the learning effect of the participants cannot be excluded.
The results of the motion analysis showed no differences in performance outcome parameters jump height, COM drift and movement velocity between the three examined occlusion times. Since no differences in anticipation performance were observed between the occlusion times 60ms pre and 120ms pre, and thus no relevant visual information on anticipation was available in this time window, no differences in motor response were observed. The results showed no significant differences in any kinematic or kinetic parameters of the block movement between these two occlusion points. However, this could be due to the choice of parameters. Changes are probably covered by using end-point variables instead of e.g. joint angles, which are supposed to be more sensitive to changes (Preatoni et al. 2013).

Between the occlusion times 60ms and 120ms pre and 120ms post, significant differences in total duration, time of movement initiation and pelvis orientation in the directional step were observed. The mean values of the total duration in each occlusion condition indicated that the subjects always completed the movement at the same time, regardless of the time of occlusion. The results showed an exact temporal movement adaptation of the participants to the given visual information. The participants did not show different mean movement velocities in the conditions, but a variable time of movement initiation. In the occlusion condition with ball flight information, the participants initiated the movement even before video occlusion. Pinder, Davids, Renshaw and Araújo (2011) also observed an earlier initiation of movement and uniform movement velocity in cricket in situations where participants expected high ball flight velocities. The results showed a reduced time for movement initiation in tasks with high time pressure, although this is associated with a higher degree of uncertainty, in order to have sufficient time for an adequate movement response. The mean pelvis orientation in the occlusion condition 120ms post showed less pelvis rotation in movement direction in the second half of the directional step. The lower uncertainty and the more specific visual information in the occlusion condition 120ms post led to the expectation of improved movement performance. No explanation can be given for the lower pelvis rotation in this condition, which is also associated with a smaller step length.

CONCLUSION: The analysis of cognitive and motor processes in volleyball showed a close temporal adaptation of the block movement to the presented setting situation. With an approximately uniform duration of movement, the time of movement initiation was adapted to the different occlusion times, which affected the total duration time. Perception-specific differences in the execution of the block movement could not be detected in the present study. Since the visual information used by experts to anticipate the setting direction does not lie in the examined time window between 120 and 60 ms before initial setters contact, no significant differences in the movement response between these occlusion points could be observed. Overall, no improved prediction accuracy of the setting direction with later occlusion time or specific motor response could be observed. In the future, the focus of analysis should lie on providing further visual information and a detailed analysis of the entire block movement in order to investigate new insights in the adaptation of movements to varying visual information and the coupling of perception and action in anticipation.

REFERENCES

Loffing, F. & Cañal-Bruland, R. (2017). Anticipation in sport. Current opinion in psychology, 16, 6-11.

Mann, D. L., Abernethy, B. & Farrow, D. (2010). Action specificity increases anticipatory performance and the expert advantage in natural interceptive tasks. Acta psychologica, 135 (1), 17-23

Milner, A. D. & Goodale, M. A. (1995). The visual brain in action. Oxford psychology series. 43, Oxford: Oxford University Press.

Müller, S. & Abernethy, B. (2012). Expert anticipatory skill in striking sports: a review and a model. Research quarterly for exercise and sport, 83 (2), 175-187.

Preatoni, E. Hamill, J., Harrison, A.J., Hayes, K., van Emmerik, R.E.A., Wilson, C., & Rodano, R. (2013). Movement variability and skills monitoring in sports. Sports Biomechanics/ International Society of Biomechanics in Sports, (12(2), 69-92.

Pinder, R. A., Davids, K., Renshaw, I. & Araújo, D. (2011). Manipulating informational constraints shapes movement reorganization in interceptive actions. Attention, perception & psychophysics, 73 (4), 1242-1254.

Travassos, B., Araújo, D., Davids, K., O'Hara, K., Leitão, J. & Cortinhas, A. (2013). Expertise effects on decision-making in sport are constrained by requisite response behaviours – A meta-analysis. Psychology of Sport and Exercise, 14 (2), 211-219.

Van der Kamp, J., Rivas, F., van Doorn, H. & Savelsbergh, G. (2008). Ventral and dorsal system contributions to visual anticipation in fast ball sports. International Journal of Sport Psychology, 39 (2).

Cañal-Bruland, R., Mooren, M. & Savelsbergh, G. J. P. (2011). Differentiating experts' anticipatory skills in beach volleyball. Research quarterly for exercise and sport, 82 (4), 667-674.

Schorer, J., Rienhoff, R., Fischer, L. & Baker, J. (2013). Foveal and peripheral fields of vision influences perceptual skill in anticipating opponents' attacking position in volleyball. Applied psychophysiology and biofeedback, 38 (3), 185-192.