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THE EXAMINATION OF THE BIDIRECTIONAL RELATION BETWEEN VISUAL AND MOTOR PROCESSES AND ITS APPLICATION IN MOTOR LEARNING

– PhD thesis booklet –

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INTRODUCTION

Several theories emphasize the intimate relation between perception and action. One of these is the common coding theory. The theory claims that there is a shared representation (a common code) for both perception and action. Thus, seeing an event activates the action associated with that event, and performing an action activates the associated perceptual event (Hommel et al., 2001; Prinz, 1997). After the introduction the thesis booklet is partitioned: part I. discusses the effect of motor processes on visual processes, and part II. the effect of visual processes on motor processes. In part I, I summarize three experiments of two studies. In both studies we measured the visual mismatch negativity (vMMN) component of event-related potentials, using the passive oddball paradigm. In part II, we switch to the effect of perception on motion, summarizing another three studies. The third study is a literature review on the impact of laterality on soccer performance which introduces study 4 and 5, as in study 4 we examine the possible role of video feedback in developing footballers' two-footedness. Study 5 assesses the perceived usefulness of mirrored video self-modeling (introduced in study 4) in the development of bilateral competence in elite team-sports. The thesis booklet ends with a summary of the results.

PART I: THE IMPACT OF MOTOR PROCESSES ON VISUAL PROCESSES

The first two studies examined the effect motion and sport movement related attention window on automatic visual information processing. The vMMN is considered to be a reliable indicator of automatic visual information processing (e.g., Czigler, 2007; Kimura, Schröger, & Czigler, 2011). (Czigler, 2007; Kimura és mtsai., 2011). In the passive oddball paradigm task-irrelevant frequent (standard) and rare (deviant) stimuli are presented, while the participants perform an attention demanding task. The vMMN is an ERP component, elicited by (deviant) stimuli violating the regularity of sequential stimulation. The regular sequence can be defined by particular values of visual features, like orientation, spatial frequency, color, etc., perceptual categories (e.g., symmetry, numerosity, object-related regularities), higher-order visual (e.g., facial emotion, gender, left vs. right hand) and sequential characteristics, and even semantic characteristics (Stefanics et al., 2014). VMMN is generated in visual brain areas (within the occipital, temporal or parietal cortices). As the vMMN is elicited by task-irrelevant stimuli, this

ERP component is considered as an index of automatic change detection (Czigler, 2007; Kimura et al., 2011; Stefanics et al., 2014).

1. *The effect of hand motion and object orientation on the automatic detection of orientation: A visual mismatch negativity study.*[1]

Aims

Study I consists of two experiments. The aim of the first experiment was to investigate the possibility of vMMN modulation by motor activity as suggested by theories of common coding of perception and action. We expected larger vMMN when movement direction and standard orientation match than in case of a movement direction and standard orientation mismatch. The aim of Experiment 2 was to explore the possibility of vMMN modulation by the presence of an object in the visual field. This is because the features of an object (e.g., orientation) may adapt the visual structures similar to those involved in processing of the vMMN related stimuli, therefore change the sensibility of these structures for particular visual features (stimulus-specific adaptation) (Bodnár et al., 2017). In Experiment 2 the required movement direction was cued by a continuously presented rectangle. This way we investigated the possible effect of orientation-specific adaptation on vMMN.

Experiment 1
Methods

In our experiments the participants (n=24) moved a small disc on a display back and forth with a computer mouse between two targets. In Experiment 1 the required motion was cued by two circles as the endpoints of movements. The vMMN-related stimuli were background textures consisting of parallel, oblique bars with frequent (standard) and infrequent (deviant) orientation. We expected the emergence of a Deviant minus Standard difference ('traditional'vMMN) in the 100–350 ms latency range over the posterior locations (Astikainen et al., 2008; Czigler & Sulykos, 2010; File et al., 2017; Kimura et al., 2009; Takács et al., 2013). To separate the ERP

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[1] Petro, B., Kojouharova, P., Gaál, Z. A., Nagy, B., Csizmadia, P., & Czigler, I. (2020). The effect of hand motion and object orientation on the automatic detection of orientation: A visual mismatch negativity study. *PLOS ONE*, *15*(2), e0229223. https://doi.org/10.1371/journal.pone.0229223

changes of the standard (stimulus specific adaptation) from the deviant-related changes ('genuine' vMMN), we applied the equal probability control procedure (Jacobsen & Schröger, 2001; Kimura et al., 2009). The Deviant *minus* Standard and Deviant *minus* Control differences were expected over the posterior EEG locations. Accordingly we created an occipital ROI (O1, Oz, O2 locations). Participants moved the mouse in a direction of 26° or 170°, while unattended standard and deviant stimuli (background orientation) appeared on the screen. There were three kind of conditions: **Same**: mouse movement in 26˚- standard texture in 26˚ and mouse movement 170˚ - standard texture 170˚; **Opposite**: mouse movement 26˚ - standard texture 170˚and mouse movement 170˚ - Standard texture 26˚. The orientation of the deviant texture was 26˚ in case of a 170˚ standard texture, and vice versa. **Control** condition: mouse movement in 26° and 170°. In the Control blocks the bar textures appeared at equal probability and in random order in the following orientations: 26, 46.6, 67.1, 87.7, 108.3, 128.9, 149.4, 170 degrees.

Results

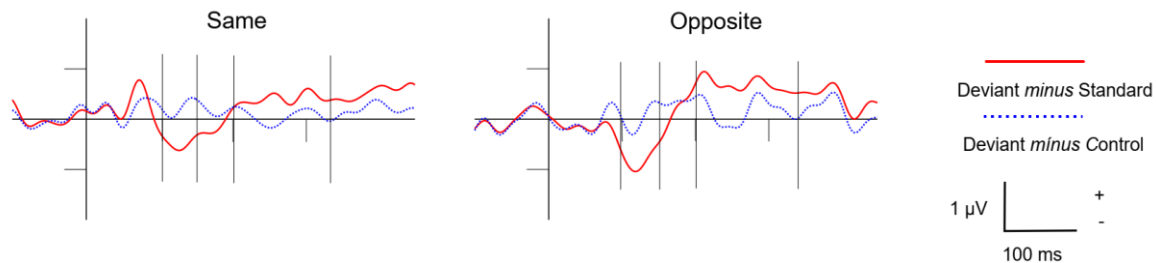Fig 1 shows the difference potentials.

Fig 1. The Deviant *minus* Standard and Deviant *minus* Control difference potentials in the occipital ROI.

We examined the 100-150, 150-200, 200-350 ms time windows. The Deviant *minus* Standard difference potential emerged, although similarly in the two conditions. The Deviant *minus* Control difference did not differed significantly from zero.

Although the expected negative difference potential emerged (regardless of condition), the equal probability procedure eliminated the negativity, showing that this negativity cannot be considered as 'genuine' vMMN.

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Experiment 2

The only difference between Experiment 1 and 2 was the replacement of the two target circles with the outline of a rectangle. The task was to move the disk back and forth between the two target areas within the rectangle.

Results

Fig 2 shows the difference potentials. In the first and third time window similarly to Experiment 1 the Deviant *minus* Standard difference potential emerged, but the equal probability procedure eliminated this negativity. However, between 150-200 ms the Deviant *minus* Control difference appeared more negatively than the Deviant *minus* Standard difference. This difference was mainly due to the negativity of the Opposite condition. Accordingly, in this latency range the continuous presence of an oblique rectangle and the congruent movement orientation influenced the emergence of 'genuine' vMMN.
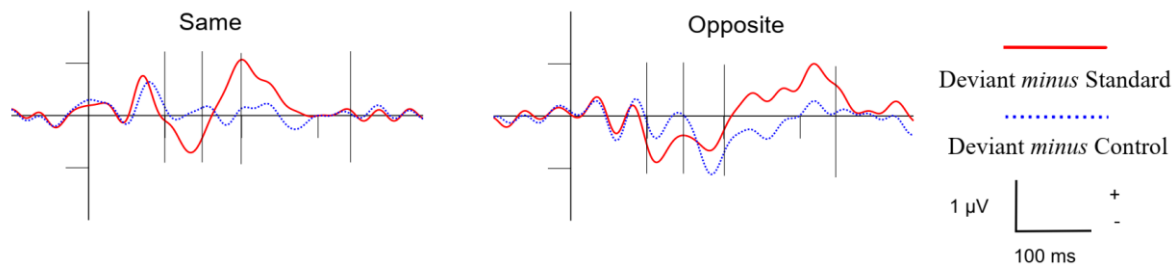

Fig 2. The difference potentials in Experiment 2.

Summary of Study 1

The continuous presence of an object determining the movement orientation was necessary for the 'genuine' vMMN to appear. The present results indicate that without the contingency of a voluntary action and a visual stimulus, specific low-level visual representations are not activated, at least at the level detected by ERP methods. We suggest that common coding of action and perception involves higher mechanisms of visual processing, where attentional processes might be at play as well.

2. *Automatic detection of peripheral stimuli in shooters and handball players: An event-related potential study* [2]

<u>Aims</u>

In study 2 we examined the practice-related sensitivity of the system behind automatic, peripheral change detection. Whereas effective performance in handball requires processing of a wide visual field, effective performance in shooting requires concentration to a narrow field. According to Hüttermann et al. (2014), practice in sport of horizontal attentional demand is associated with larger attentional sensitivity in the horizontal dimension. We hypothesized that team sports demand not only high attentional performance, but also high efficiency of automatic visual information processing. Thus, the aim of study 2 was the comparison of automatic processing of peripheral stimuli between handball players and sport shooters, using vMMN methods. We hypothesized that the laterally presented stimuli would elicit larger effects in the handball players' group than in the shooters' group, due to the demands for a wider field of information intake in the former group.

<u>Methods</u>

Participants performed a tracking task, while task-irrelevant checkerboard patterns (a frequent and an infrequent type) were presented in the lateral parts of the visual field. We created the deviant pattern from the standard by reversing the locations of the dark and bright squares.

<u>Results</u>

We obtained larger vMMN in the handball players' group indicating larger sensitivity to peripheral stimuli (Fig 3). This group difference manifested already in the P1 component: in the handball players' group the frequent checkerboard patterns elicited larger P1 amplitude than the infrequent ones.
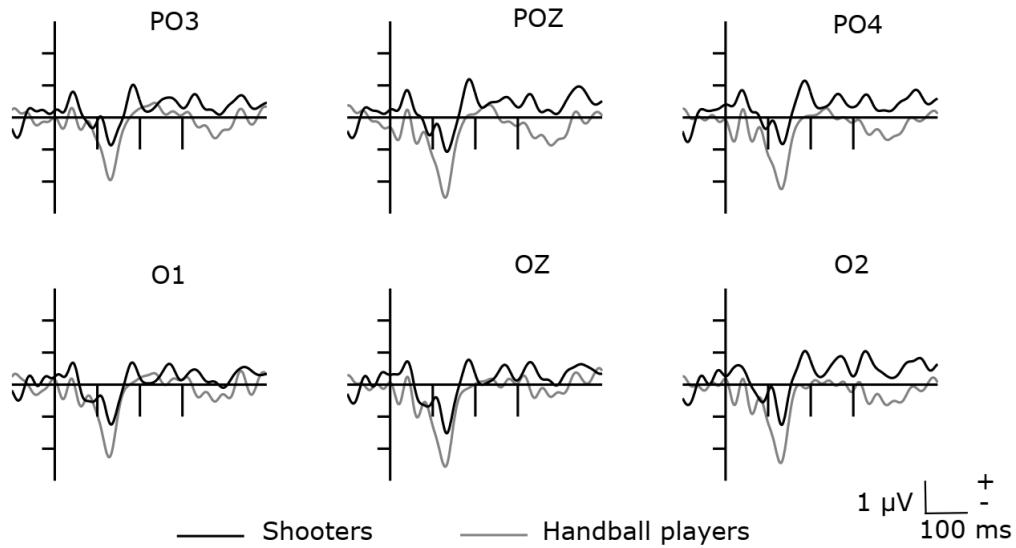
Fig 3. The Deviant *minus* Standard difference potentials over the 6 posterior electrode locations.

Conclusion

Our results suggest the specific demands of various sport activities are present not only in attentional performance, but also in the fields of automatic (pre-attentive) processing, and this can be captured even in a short experimental session in the laboratory.

PART II: THE IMPACT OF VISUALITY ON MOTOR PROCESSES

Increasing body of evidence suggest that motor areas are recruited not only when actions are executed, but also when actions are imagined or observed (Jeannerod, 2001). Video self-modeling is an application of this relation. According to the video self-modeling literature, watching an edited video of the viewer doing an action they have not done before but they are capable of and willing to do, promotes their motor learning (Dowrick, 2012). As in study 4 we tested the improvement of soccer players' subdominant footed kick supported by video self-modeling, I introduce this with the literature review on the impact of laterality on soccer performance.

3.   The impact of laterality on soccer performance [3]

Aims

Considering that the ratio of left-handed athletes is higher in some sports than in the general population (10%) (Grouios et al., 2000), the question arises what is the situation like in soccer in this respect. The impact of laterality on soccer performance is important because a significant proportion of the athletes can be trained to become more mixed-footed (a definitive advantage, as we will see later). In this literature review, we looked for the answer whether left-footed players have an advantage, how advantageous mixed-footedness is, and how much effort for mixed-footedness can be observed in soccer.

Methods

The initial search of the databases of SPORTDiscus and MEDLINE was complemented by additional Internet (Google Scholar) search guided by the pertinent citations contained in each article.

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[3] Petro, B., & Szabó, A. (2016). The Impact of Laterality on Soccer Performance. *Strength & Conditioning Journal*, 38(5), 66–74.

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Results

There may be a small left-footed advantage, and mixed-footed has a definitive advantage in soccer. Accordingly, training of bilateral skills is increasingly emphasized, and the experiments on young players suggest that increased subdominant sided training has its expected impact on performance.

4. *A possible role of video feedback in developing footballers' two-footedness*[4]

Aims and methods

Targeted kicks of 11-13 years old soccer players were recorded from a frontal view. The mirrored version of the preferred footed kick appears as the ideally executed subdominant footed kick. The experimental group received their videos manipulated this way for home viewing, and we examined the effect of this intervention on the improvement of their subdominant kicking technique, supposing that this observation supports it. The experiment was conducted in video (n= 14) and control group (n=14, they received their videos after the experiment) design with measurement before and after the 4 weeks training period.

Results

There was no significant change in the preferred footed kicks. In kicking accuracy of the subdominant foot the video group improved significantly. It must be noted however, that the two groups unfortunately began the experiment on a different level. In the execution of the subdominant footed kicks the performance of the control group decreased, and the video group had no significant change. As even within the video group not all participants viewed their videos, we examined in a post-hoc manner the change in the execution of the subdominant kicks of all participants as a function of the number of their video views. From those 11 participants who viewed their videos at least once a week, 8 improved in their execution, while from the other 17 participants only two improved.

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[4] Petró, B., & Bárdos, Gy. (2014). A videó visszacsatolás lehetséges szerepe labdarúgók kétlábasságának fejlesztésében. *Magyar Sporttudományi Szemle*, 15(4), 28-34.

Conclusion

The results do not show definitive differences between the two groups in their improvement. However, the general aspect, including the opinion of the participants, suggests the conclusion that the method might probably be helpful for those who have an inner motivation to improve their subdominant footed kicks.

5. *Perceived Usefulness of Mirrored Video Self-Modeling in the Development of Bilateral Competence in Elite Team-Sports*[5]

Aims

Besides soccer, bilateral skills are important in several other sports. Thus, the attitude towards mirrored video self-modeling might be positive as well in these sports. The aim of the interviews was the assessment of this attitude.

Methods

A total of 20 elite athletes, from four popular team sports, were interviewed regarding the following three issues using semi-structured interviews: (1) the perceived importance of bilateral skills; (2) the current use / practice of video feedback for individual skill development; and (3) elite athletes' attitude toward using mirrored video self-modelling.

Results

The results indicate that bilateral skills are perceived as the most important in the following order: soccer, basketball, handball, and water polo. The study also revealed a current shortage or lack of individual video feedback in performance enhancement. The attitude of soccer and basketball interviewees was the most optimistic whether the method could be applied in their sports. Thus, the method can be further tested and/or applied in these sports.

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[5] Petro, B., Ehmann, B., Bárdos, Gy., Szabó, A. (2018). Perceived Usefulness of Mirrored Video Self-Modeling in the Development of Bilateral Competence in Elite Team-Sports. *Journal of Human Sport and Exercise* 13(3) 621-630.

SUMMARY

The results of Experiment 1 in study 1 indicate that without the contingency of a voluntary action and a visual stimulus, specific low-level visual representations (that would represent congruent orientation with the movement) are not activated, at least at the level detected by ERP methods. In Experiment 2 in study 1 the continuous presence of an oblique rectangle (and the congruent movement orientation) already led to the automatic perception of deviant orientation. In study 2 a group of handball players and a group of shooters performed the same sport-independent tracking task in the middle of the screen, while we examined the neural correlates of changes in peripheral stimuli. We registered larger vMMN in the handball players' group, which implies larger sensitivity to peripheral stimuli. These results suggest that the automatic visual processing can adapt to sport-specific demands together with attentional visual processing. In study 3 we reviewed the impact of laterality on soccer performance. It has been confirmed that there is a need for mixed-footed players in soccer (Bryson et al., 2012; Carey et al., 2001; Grouios et al., 2002). Accordingly, the development of the subdominant footed technique is of paramount importance, and the training devoted for it has its benefits, at least in case of young participants (Cobalchini & Silva, 2008; Haaland & Hoff, 2003; Teixeira et al., 2003). In study 4 we examined the possibility of developing soccer players' subdominant footed kicks with the support of visual information complementing trainings. Thus, we provided the mirrored video of the dominant footed kicks. Despite the fact that even within the video group not all participants viewed their videos, the experiment yielded relatively promising results. In study 5 we examined the perceived usefulness of mirrored video self-modeling in the development of bilateral competence in elite team-sports. The overall attitudes are positive towards the method, and soccer and basketball can be highlighted in this respect. Bilateral skills are perceived as the most important in the following order: soccer, basketball, handball, and water polo. Besides, there is a general discrepancy between the demand of video feedback and the actual application of it.

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