NEUROPHYSIOLOGICAL DETERMINANTS OF VISUOMOTOR REACTION TIME IN TABLE TENNIS

Prof. Dr. Andreas Mierau, Dr. Thorben Hülsdünker
LUNEX International University of Health, Exercise and Sports
Department of Exercise and Sport Science

thorben.huelsduenker@lunex-university.net
## Content

1) **The experiment**  
Identifying visuomotor performance determinants in the brain

2) **Table tennis study**  
Neurophysiological determinants of visuomotor reaction time in table tennis players

3) **Visual Training**  
Improving visuomotor performance using stroboscopic training

4) **And where from here?**  
Future perspectives in research and training
1) The experiment

The idea

stimulus $\rightarrow$ perception $\rightarrow$ transformation $\rightarrow$ EMG onset $\rightarrow$ VMRT

Step 1: Visuomotor performance **determinants** in **table tennis**?

Step 2: Visuomotor **training** interventions in **table tennis**?
1) The experiment

Experimental setup

Stimulus programming

Stimulus generator

screen

EEG System

Synchronized

(ms precision)

Stimulation screen

Stimulus programming

EEG
1) The experiment

**EEG setup**

- **64 EEG channels**
  - Visual regions (perception)
  - Motor regions (transformation)

- **EEG cap**
- **Visual stimulus**
1) The experiment

**EEG preparation**

1) Head circumference

2) nasion-inion distance

3) Establish connection

4) Check raw signal

Select cap size

Adjust cap position

Electrode ↔ scalp

Control signal quality

*nasion*  
*inion*
1) The experiment

**Experimental protocol**

**Contrast stimulus**

- Activate V1

**Motion stimulus**

- Activate MT

**contrast perception speed**

- P100
- N75

**motion perception speed**

- N2
LET’S START THE TEST 😊
2. THE STUDY

Neurophysiological determinants of visuomotor reaction time in table tennis players
2. Table tennis study

**Badminton**

**Table tennis**

Reaction time ↔ visual system

Determinants of reaction time???
2. Table tennis study

Working title:

Neurophysiological determinants of visuomotor reaction time in table tennis players

In cooperation with

China table tennis college Europe

INS Luxembourg

Deutsche Sporthochschule Köln
German Sport University Cologne

German Sport University Cologne
2. Table tennis study

17 participants (experienced youth table tennis players) 13 years of age, 6 years experience, 18h/week

Experiment 1: visual contrast stimuli
Experiment 2: visual motion stimuli

Parameters: perception/transformation speed, EMG onset, VMRT

Stimulus → perception → transformation → EMG onset → VMRT

- CRT (120 Hz)
- 64-channel EEG (1000 Hz)
- 1-channel EMG (1000 Hz)
- Response pad (1000 Hz)
2. Table tennis study

**Stimulus**

**perception**

**transformation**

**EMG onset**

**VMRT**

**Perception:**
- Identifiable N2 potential

**Transformation:**
- Identifiable BA6 negativity potential

**Visuomotor reaction time??**

---

Visuomotor reaction time?

<table>
<thead>
<tr>
<th>Reaction Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMG onset</td>
</tr>
<tr>
<td>VMRT</td>
</tr>
</tbody>
</table>
2. Table tennis study

**Badminton**

Regression

\[ R = 0.80 \]

\[ R^2_{corr.} = 0.63 \]

**Table tennis**

Regression

\[ R = 0.88 \]

\[ R^2_{corr.} = 0.73 \]
2. Table tennis study

Practical relevance?

Badminton

Table tennis

Athlete 1: slow visual

Athlete 2: slow motor
2. Table tennis study

Summary

1) Visuomotor reactions activate **visual** (N2) and **motor** regions (BA6 negativity)

2) **Neurophysiological** processes determine visuomotor reaction time

3) Crucial importance of **visual processes**

Visual training
3. VISUOMOTOR TRAINING

Improving visuomotor abilities using stroboscopic training
3. Visual training

What we already know...

**athletes < non-athletes** *(table tennis)*

(Bhabor et al. 2013)

situation *(visual cue)*

athletes < non-athletes *(Ando et al. 2001; Zwierko et al. 2008)*

situation *(visual cue)*

Train the brain!

premotor time *(150-200 ms)*

motor time *(50-100 ms)*

reaction *(movement)*

athletes = non-athletes
3. Visual training

What we also know...

Badminton

Table tennis

Perception (MT)
Transformation (BA6)

Train the brain
Train the visual system!
3. Visual training

How shutter glasses work

*Shutter glasses*

The idea of shutter training

*Stroboscopic effect*

*Stimulation protocol*

4 Hz, 50% duty cycle

1s

*Visual adaptation!?*
3. Visual training

Why shutter glasses?

1) No extra training time  

2) Easy to use by athletes and coaches  

3) Variable training intensity  

4) Promising research results  

What about training practice?
3. Visual training

Training the visual system – a pilot study

Athletes (N=10)

Experience: 13 (±3) years
Training: 21 (±2) hours

Pre-Test

Smash defence (visuomotor)

EEG (motion perception)

Intervention (n=5)

4 week training

Stroboscopic training (12-15 min/day)

Control (n=5)

Normal visual conditions

Post-Test

Smash defence (visuomotor)

EEG (motion perception)

Smash defence (80 balls)

(A) high
mid
low

(B) right
mid
left

(C) 2 points 1 point 0 points

Point score

Motion perception

16 channel EEG

N2 potential
3. Visual training

Training the visual system – a pilot study

**ANOVA**

![Graph showing ANOVA results]

**ANCOVA**

![Graph showing ANCOVA results]

Stroboscopic training => stronger performance gains
3. Visual training

Pre-training perception speed

Post-training perception speed

Visual perception speed (N2 potential)

Visuomotor performance (point score)

\[ r_{10} = -0.55 \]
\[ p = 0.099 \]
3. Visual training

Summary

1) Stroboscopic training improves visuomotor performance

2) Visuomotor performance $\Leftrightarrow$ motion perception

Promising training approach for elite athletes in visuomotor demanding sports...

**BUT**...

- Small sample size (n=10)
- Short training duration
- No retention test
AND WHERE FROM HERE?
And where from here?

Ecological validity

Visuo... ...motor

Neurophysiological processes determining table tennis performance
And where from here?

**Longitudinal research**

**Pilot study** => visuomotor training using shutter glasses

- Small sample size (n=10)
- Limited training time (4 weeks)
- No retention test

---

**Pre-Test** → **10 week training** → **Post-Test** → **6 week retention** → **Retention-Test**

- Behavioral data
  - Sport-specific performance
- Neurophysiological data
  - Neurophysiological adaptations

**N>40**

- Neurophysiology/ -plasticity
- Sport performance

---

Deutscher Badminton Verband e.V.

Lu:Nex
And where from here?

Sensitive periods!?  

What should be trained?  

When should be trained  

13 years  15 years  17 years

Sensitive periods for visual system training?

China table tennis college Europe

INS Luxembourg
In summary

We know...

1) Visuomotor reaction time determines table tennis performance

2) Visuomotor reactions are determined by the brain and especially the visual system

3) Shutter trained seems to be effective to improve visuomotor reactions

For the future...

1) Improving ecological validity

2) Detecting (possible) sensitive periods

3) Establish the link between visual training and neural plasticity
THANK YOU 😊

Dr. Thorben Hülsdünker
thorben.huelsduenker@lunex-university.net