Auditory/acoustic feedback to optimise the boat motion

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Movement & Sound

- causal relationship
- sound is the acoustic consequence of kinetic events (Bruhn, Kopiez & Lehmann, 2008)

Background

Sport Science
- elite rowers rely on sport specific sounds of the boats forward motion (Lippens, 2005)
- provides support to the process of motor learning (Effenberg et al., 2009)

Neuroscience
- rich physiological connection between auditory & motor system
- acoustic information = „ideal synchronisation device“
- drives rhythmic organised motor behavior in humans (Thau et al., 2005)
- enables listener to anticipate future occurring events (Zatorre et al., 2007)

Acoustic Stimuli/Information

Characteristics
- direct effect on the motor system
- inherent time structure offers precise information about movement processes
- supports the timing subliminally
- continuous & anticipatory time reference

Auditory sensory system
- fast and precise processor of temporal information
- guides the focus of attention reliably
- simultan processing of multiple information streams

Feedback training in racing rowing

- experiences using visual feedback in on-water rowing training
  - for low stroke frequencies acceptable

Drawbacks of visual…
- posture of the head, focus (Mattes, 2012)
- visual observation is limited to the temporal resolution
- the effectiveness decreases as the boat velocity and the stroke frequency increase (>30 strokes per minute)

Sonification in racing rowing

Sonification of the boat motion aims to…
- guide athletes focus of attention
- enhance the feeling for the boat rhythm in different
  - training intensities (boat velocities and stroke rates)
  - boat categories (big and small boats)
- guideline for on-water training and rowing races
- final aim: increasing the mean boat velocity
Sonification

- synthetic transformation of data into sound systematically (Hermann, 2008)

- requirements
  - mapping the data objectively
  - precise definition
  - reproducibility

- sonification procedures
  - auralisation (whale sounds)
  - parameter mapping (algorithm)
  - model based (modelling)

Investigations

Participants
- Sighted Athletes
  - seniors & juniors (N=47)
  - 12 boats, 3 on-water training sessions
- Adaptive Athletes (N=6)
  - 2 visual impaired & 2 physically handicapped
  - Coxed Four (LTA4+), 2 weeks, 7 training sessions

Measuring system
- Sofirow (BeSB GmbH Berlin & Uni Hamburg)
  - $a_{\text{boat}}$ (MEMS acceleration sensor (125 Hz))
  - $v_{\text{boat}}$ (4-Hz-GPS)
  - Parameter Sonification

Measurement system: Sofirow

- BeSB GmbH Berlin (acoustic engineers) and University of Hamburg

- $a_{\text{boat}}$ (MEMS acceleration sensor (125 Hz))
- $v_{\text{boat}}$ (4-Hz-GPS)

Statistical Analysis

Data Capture
- Comparison of sections with and without alternately
  - ANOVA with repeated measures (SPSS 16.0)
  - 30 rowing cycles each
  - comparable stroke rate ($\pm 0.5$ strokes per minute)

Questionnaire
- perception & acceptance of acoustic feedback (AF)
  (standardised questionnaires)
  - all squad levels
  - Athletes (N=54) & Coaches (N=14)

Sonified boat motion

- JM8+
- M4x
Sonified boat motion

LTA4+

Results Data Capture

- Immediately after the sonification was presented…
  - significant increase of the mean boat velocity ($v_{\text{mean}}$)
  - qualitative changes in the boat acceleration trace
  - similar effect in all boat categories

Results Juniors & Seniors

Comparison with an “optimal” acceleration curve

Results Para-Rowing

RetentionPolicy Analysis

- 2 weeks intervention during regular training
- Pre-, post- and retention test
• High acceptance of sonification among athletes and coaches
• Intuitive understanding
• Athletes’ statement
  “focussed improvement of the weak points in the movement”
  “keeping the tone as constant as possible during recovery”
• Coaches’ statement
  “…smoother movement with the sound”
  “…more clearly and better”

Results Questionnaire

• enhances the perception for movement execution
• synchronises the crew with increase in boat velocity
• guides attention to characteristic phases within the movement
• reduces intracyclic interruptions in the boat acceleration trace
• contributes to technique training in elite rowing

Conclusions

• Conception, development and field-testing of a measuring and analysis system for on-water rowing training and rowing races
• Tested with the German National Rowing Team
  - Training and Training camps
  - regional and international regattas
  - heats and finals of the Juniors World Championships from 2009 until the present
  - preparation for the Olympics

Further Developments

• Mobile Measuring and Training System 2010 (Institute FES)
  – Advantages:
    • complexity in diagnostic evidence
    • feedback training in racing boats
  – Drawbacks:
    • high expenditure of time and staff
    • requires measuring experts

Biomechanical Diagnostic in racing boats

• Easy-to-use and less time-consuming operation
  – Measuring process
  – Data analysis
• Low mass, suitable for single scull boats
• Analysis parameters
  – Boat velocity, stroke rate, distance travelled per stroke
  – Number of rowing strokes, times for measured distances
• Applicable in rowing races
• Performance diagnostic, scientific studies
• Different standardised analysis modes

System Requirements

• MEMS-acceleration Sensor:
  ±2 g Measuring Range, 50 Hz Sampling Rate, 1% Measuring Error
• GPS-Sensor: Position up-date rate: 4 Hz
• Velocity: 0.1 m/s
• Power Supply: 5 V – 32 V co-flow (accumulator)
• Data Storage: SD-Card
• Data Transfer: WLAN
• Dimension: 98 x 64 x 34 mm
• Mass (incl. Accu): 336g

Accrow: Technical Data
Accrow – rowing specific analysis routines

Analysis variants

Analysis of the first 15 rowing strokes

Start Analysis

Example 1: Race analysis 2000m

Analysis referring to the distance,
Sub-sections GPS-measured

2000m-Race Progress

Analysis Routines

The analysis with the Software Regatta consists of different rowing specific analysis routines:

- load analysis for on water training
- race analysis (alternatively for 2000m, 1000m or 500m rowing races)
- start analysis

### Example 1: Race analysis 2000m

#### Analysis referring to the distance,
Sub-sections GPS-measured

<table>
<thead>
<tr>
<th>Section</th>
<th>t [s]</th>
<th>Number of strokes</th>
<th>vB [m/s]</th>
<th>sr [1/min]</th>
<th>sB [m]</th>
<th>Sum t t [s]</th>
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#### Start Analysis

Start Analysis

Start Analysis

### 2000m-Race Progress

Race profile

- Race progress
- Time [s]
- vB [m/s]
- sr [1/min]
**Accrow-Live**

*Notebook & Smartphone (iOS)*

**Online-Mode**
Real-time visualisation of acceleration- and velocity trace of the rowing stroke

- Mean boat velocity [m/s]
- Mean velocity of the last 5 rowing strokes [m/s]
- Travelled distance (last stroke) [m]
- Stroke frequency [1/min]
- Calculated 500-m-time velocity [min:ss]

**Offline-Mode**
Viewing the stored data retrospectively in "real-time"

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**Conclusions**

- **Accrow’s Characteristics**
  - easy-to-use and less time-consuming operation
  - suitable for rowing races and on-water training
  - provision of data on the time, stroke and/or distance travelled
  - access to all raw data
  - easy data export via excel
  - suitable for performance analysis and physiological field investigations in racing rowing

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**Rowing measuring and feedback systems**

www.accrow.com

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**Conclusions**

- **Analysis of on-water training**
  - precise planning and control of on-water training sessions
  - effect analysis of the total method (endurance and technique training, crew formation and seating position)

- **Evaluation of rowing races**
  - total race (course and split times, mean boat velocity, stroke frequency, propulsion and their relationship)
  - proportions of typical race phases

- **Start analysis and optimising of different start variants**