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Auditory/acoustic feedback to optimise the boat motion


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Movement & Sound


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



Background


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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 (Thaut et al., 2005)
- enables listener to anticipate future occurring events (Zatorre et al., 2007)

Acoustic Stimuli/Information


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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


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- 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


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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_{boat} (MEMS acceleration sensor (125 Hz))
 - v_{boat} (4-Hz-GPS)
 - Parameter Sonification

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Measurement system: *Sofirow*



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

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

Statistical Analysis



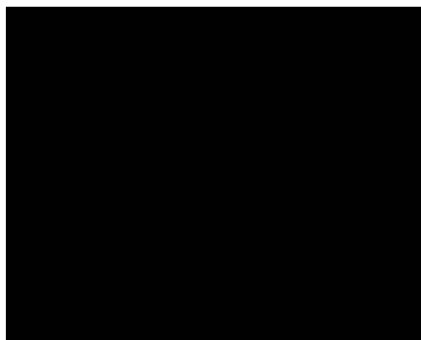
Data Capture

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

Questionnaire

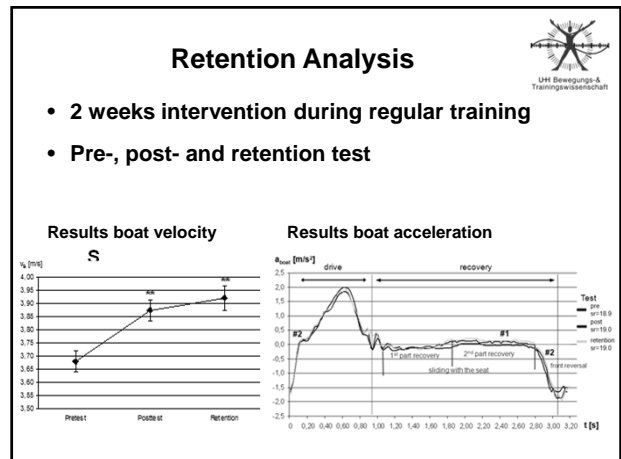
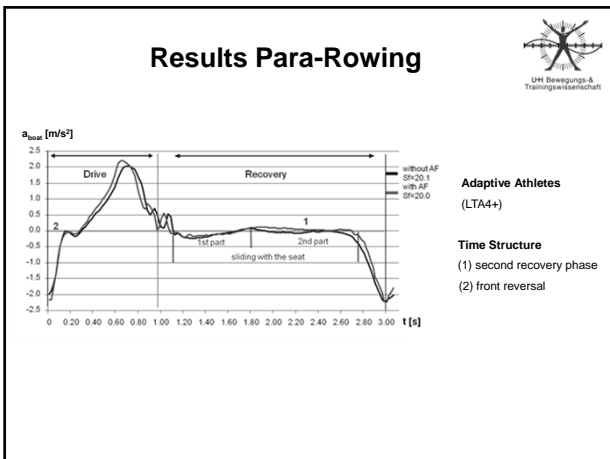
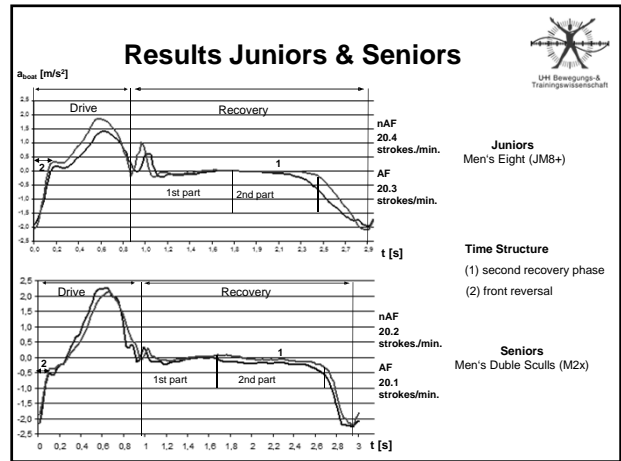
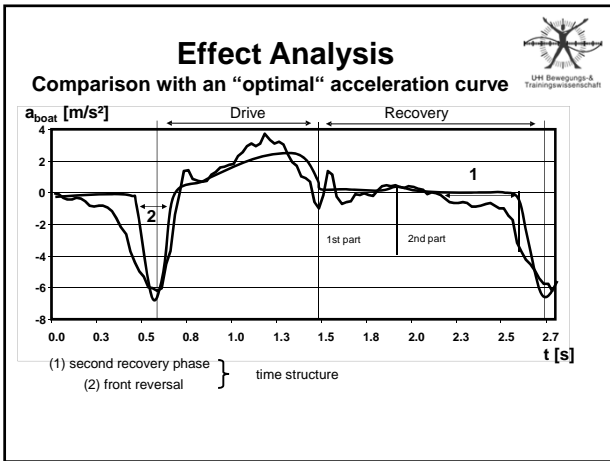
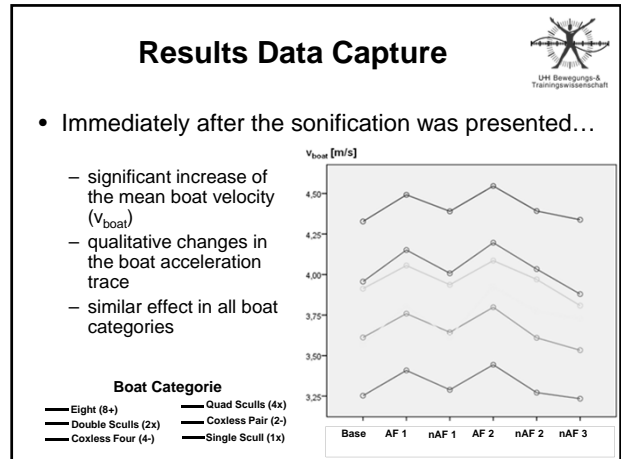
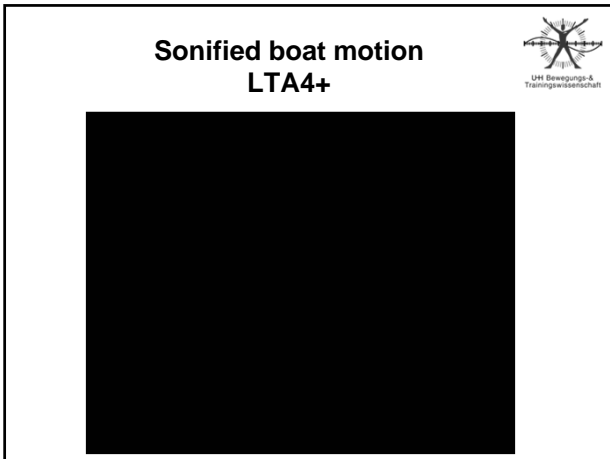
- perception & acceptance of acoustic feedback (AF) (standardised questionnaires)
 - all squad levels
 - Athletes ($N=54$) & Coaches ($N=14$)

Sonified boat motion JM8+



Sonified boat motion M4x





Results Questionnaire



- 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"



Conclusions



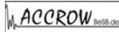
- enhances the perception for movement execution
- synchronises the crew with increase in boat velocity
- guides attention to characteristic phases within the movement
- reduces intracyclic interruptions in the boat acceleration trace
- contributes to technique training in elite rowing



Further Developments



- Conception, development and field-testing of a measuring and analysis system for on-water rowing training and rowing races



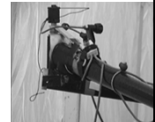
- Tested with the German National Rowing Team
 - Training and Training camps
 - regional and international regattas
 - heats and finals of the Juniors World Championships from 2009 until the present
 - preparation for the Olympics



Biomechanical Diagnostic in racing boats



- 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



System Requirements



- 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

Accrow: Technical Data



- 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



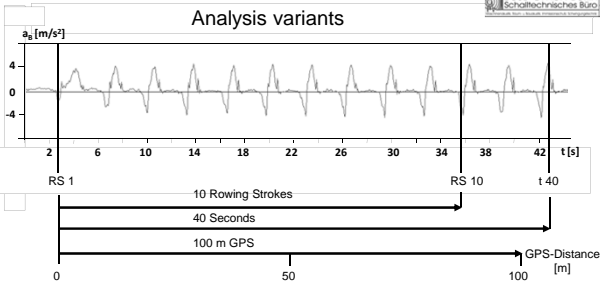
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Accrow – rowing specific analysis routines



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Analysis variants



RS = Rowing Stroke

Analysis Routines



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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



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

Absolute Values

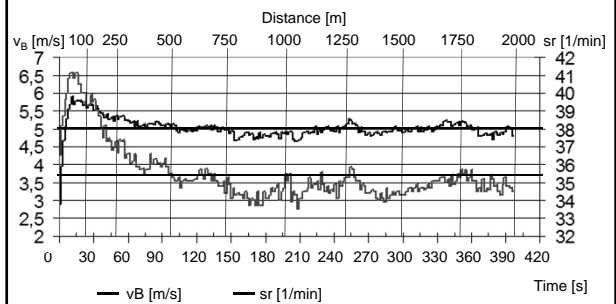
Section	t [s]	Number of strokes	sr [1/min.]	vB [m/s]	sB [m]	Sum t [s]
0-100m	21.2	14	40	4.73	7.1	21.2
0-250m	48.2	32	39.3	5.19	7.92	48.2
250-500m	48.3	29	36.4	5.18	8.54	96.5
500-750m	50	29	35.2	5	8.52	146.4
750-1000m	51.6	30	34.3	4.84	8.47	198
1000-1250m	51.1	30	34.7	4.89	8.47	249.1
1250-1500m	50.3	29	34.7	4.97	8.6	299.4
1500-1750m	49.7	29	34.8	5.03	8.66	349.1
1750-2000m	50.4	29	35	4.96	8.51	399.5
Total	399.5	236	35.5	5.01	8.46	2000

2000m-Race Progress



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Race profile



Start Analysis



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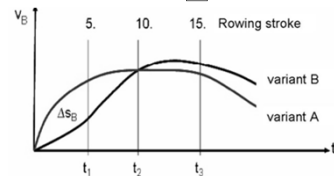
Analysis of the first 15 rowing strokes

Number of strokes	Sum t [s]	t [s]	sr [1/min.]	vB [m/s]	sB [m]	Sum sB [m]
1	2	2	29.4	0.92	1.88	1.88
2	3.4	1.4	43.3	3.34	4.62	6.51
3	4.8	1.4	44.1	4.49	6.11	12.61
4	6.2	1.4	44	5.21	7.11	19.73
5	7.5	1.4	43.2	5.68	7.89	27.62
6	8.9	1.4	43.2	5.99	8.32	35.94
7	10.3	1.4	42.9	6.2	8.68	44.62
8	11.7	1.4	43.3	6.23	8.64	53.26
9	13.1	1.4	42.5	6.36	8.98	62.25
10	14.6	1.4	41.8	6.39	9.18	71.43
11	16	1.4	42.2	6.32	8.99	80.42
12	17.4	1.5	41.4	6.08	8.81	89.23
13	18.9	1.5	41.1	6.29	9.19	98.42
14	20.4	1.5	40.8	6.12	9	107.43
15	21.8	1.5	40.8	6.1	8.97	116.4

Start Analysis



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Start phase/ Data	Maximal boat acc. (1.- 5. RS)	Pick up acceleration (6.- 10. RS)	Maximal boat velocity (10.- 15. RS)	Transition (from 16. RS)
a_B	A > B	A < B	A = B = 0	negativ
v_B	A > B	A > B	A < B	A < B
s_B	A > B	A > B	A > B	A = B

a_B boat acceleration; v_B boat velocity; s_B distance travelled

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"

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

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

Rowing measuring and feedback systems



www.accrow.com