From eHealth to mHealth – 24-hours ambulatory assessment under real-life conditions

Annika Rieger
PhD Candidate & Research Assistant
Institute for Preventive Medicine
University of Rostock, Germany
Learning objectives

1. Understand that telemedical systems are able to assess complex health related parameters and to collect important health related information

2. Understand that a state of the art-system needs to combine eHealth and mHealth elements and work as distributed system with sensor elements, communication systems as well as complex information systems

3. Be aware that user compliance is an important issue for the applicability of ambulatory assessment in everyday life
Project eHealth MV

• Aims:
  1. Development of an ambulatory assessment system for individual diagnostics of psychophysiological stress
  2. Development of multiparametric models for stress and fitness estimation
Communication structure

- Heart rate/IBI
- Breathing Frequency
- Movement/Position
- Body Surface Temperature
- Blue-tooth
- Activity
- Mobile services
- Telematics Platform
- Secondary data
- Healthcare practitioners
- Fitness
- Stress
- Secondary data
- Subjective Workload

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User Interface of the mobile device

- Chosen category
- Current measurands
- Occupations (e.g. work, driving, sports, leisure)
- Connectivity
Telematics Platform

- Client-server architecture (x86, x64)
- Communication Clients-Server (HTTP/HTTPS)
- Ability to form clusters: simultaneous data processing from multiple clients
- Data security and privacy (Anonym, Encryption, Session models, Authentication)
- Online Web-based Portals integration (Admin, Center Admin, Coach and Vital web-based portals)
- Integration of hierarchical model (e.g. Admin → Center Admin → Coach/Doctor → Patient)
- Connection of mobile applications (Android, WM, Java and iPhone-based)
- Hosting of telemedical applications (Diabetes/Dermatology/Fitness/Stress, etc…)
- Scalable and extension ability of its core functionalities
Feasibility study in the framework of the project eHealth MV

Aims of the feasibility study

1. Practicability
   • Usability
   • Wearing comfort
   • Suitability for daily use

2. Compliance/Response Rates

3. Errors
Study design and study sample

• Ambulatory assessment up to 24 hours under real-life conditions
• Combined measurement of objective and subjective data (EMA)
• Follow-up survey
• Study period: August 2010 - March 2011
• 103 participants (58 men, 45 women)
• age: 27 ± 6 years; 84 % students
• Length of monitoring: Ø 19,5 hours
• 35,0 ± 10,0 self-reports per monitoring initiated by smartphone
• 30,6 ± 10,4 self reports per monitoring answered
Practicability

Handling of the System:
• 88 % „very easy“ or „easy“ to handle (others: „okay“)

Handling of self-reports:
• No problems with answering questionnaires on the touch screen

Wearing comfort of the belt
• not distracting (95 %)

Disruption by vibration
• 97,5 % not disrupted

Suitability for daily use
• 90 % did not feel bothered by the system
## Compliance

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Sum</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Released self-reports</td>
<td>7</td>
<td>58</td>
<td>3565</td>
<td>34.95</td>
<td>10.04</td>
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<tr>
<td>Physiological determined self-reports</td>
<td>3</td>
<td>48</td>
<td>2001</td>
<td>19.62</td>
<td>8.84</td>
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<td>Regularly released self-reports</td>
<td>4</td>
<td>26</td>
<td>1561</td>
<td>15.30</td>
<td>4.62</td>
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<tr>
<td>Completed self-reports</td>
<td>6</td>
<td>52</td>
<td>3116</td>
<td>30.55</td>
<td>10.38</td>
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</tbody>
</table>

**Response Rate: 87.6 %**

→ Participants (not compensated for their attendance) showed response rates that can be compared to paid samples or patients.
Mentioned problems

1. Relatively low battery power of smartphones
2. Missing announcement of battery power (at the beginning of the study)
3. Problems with the operating system (Windows Mobile)
4. Interruptions in mobile services
5. Involuntary deactivation of key lock
Real-time stress assessment

Background

• Stress can have serious health consequences
• Link between work stress and diseases
• In today’s society 40-50 % of all work-related absences are related to stress
• There is a need for a real-time personal stress monitoring over extended periods to detect health risks
• Challenge: Quantifying stress levels of an individual based on real-time physiological data analysis
HRV-based subjective workload modelling

Subjective Workload Score (NASA-TLX)
- Physical demand
- Mental demand
- Temporal demand
- Performance
- Effort
- Frustration

Development of Fuzzy-Models using experimental data

Adaptation to Individuals and different settings

Stress

HRV-Analysis
Correlation between subjective and fuzzy-modelled stress

→ Adequate stress prediction algorithm ←
Ambulatory assessment at the workplace –
Intraoperative stress of surgeons

Study design and study sample

• Prospective cross-sectional study
• Period of investigation: April 2011 - June 2011
• 25 physicians (trauma/orthopedic/general/neurosurgery)
• 4 MS4, 6 residents, 5 fellows, 6 attendings, 4 chiefs of medicine
• Duration of monitoring: 16.9 ± 4.8 hours including work and leisure time
• Documentation of occupations, function during surgery, wear of lead aprons, level of complication, type of surgery
• Psychophysiological measures: HR, BR, ST, STAI, NASA TLX, SAM
Design of user interfaces
Time points of self reports

- Assessment of stress via NASA TLX, SAM and STAI
- Monitoring of physiological parameters via Equivital sensor
- Assessment of stress via NASA TLX, SAM and STAI

preoperatively    intraoperatively    postoperatively
## Work-Specific information

<table>
<thead>
<tr>
<th>Grade</th>
<th>n</th>
<th>Age (Yrs)</th>
<th>Working hours/week Mean ± SD</th>
<th>Years of practice Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS4</td>
<td>4</td>
<td>25.8 ± 0.5</td>
<td>36.0 ± 5.4</td>
<td>0.4 ± 0.1</td>
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<tr>
<td>Residents</td>
<td>6</td>
<td>31.2 ± 2.9</td>
<td>61.6 ± 6.7</td>
<td>3.8 ± 1.9</td>
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<tr>
<td>Fellows</td>
<td>5</td>
<td>37.0 ± 2.7</td>
<td>62.2 ± 10.2</td>
<td>8.4 ± 2.9</td>
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<tr>
<td>Attendings</td>
<td>6</td>
<td>40.0 ± 1.7</td>
<td>54.8 ± 3.3</td>
<td>12.1 ± 2.1</td>
</tr>
<tr>
<td>Chiefs of medicine</td>
<td>4</td>
<td>47.8 ± 9.0</td>
<td>59.2 ± 6.3</td>
<td>17.7 ± 9.0</td>
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<tr>
<td>Total</td>
<td>25</td>
<td>36.2 ± 8.0</td>
<td>55.5 ± 11.4</td>
<td>7.8 ± 6.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surgery</th>
<th>Number of procedures</th>
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</thead>
<tbody>
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<td>trauma/ orthopedic</td>
<td>34</td>
</tr>
<tr>
<td>neurosurgical</td>
<td>15</td>
</tr>
<tr>
<td>vascular</td>
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</tr>
<tr>
<td>abdominal</td>
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### Psychophysiological Analysis

<table>
<thead>
<tr>
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<th>Stress</th>
<th>No Stress</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAI pre</td>
<td>11.00 ± 1.10</td>
<td>12.91 ± 2.60</td>
<td>2.85</td>
<td>&lt; 0.001</td>
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<tr>
<td>STAI post</td>
<td>13.14 ± 1.45</td>
<td>10.73 ± 2.13</td>
<td>-3.33</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>NASA pre</td>
<td>34.91 ± 15.69</td>
<td>42.47 ± 13.97</td>
<td>1.79</td>
<td>n.s.</td>
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<tr>
<td>NASA post</td>
<td>46.83 ± 22.89</td>
<td>33.65 ± 14.11</td>
<td>-2.46</td>
<td>&lt; 0.05</td>
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<tr>
<td>SAM pre</td>
<td>14.00 ± 1.77</td>
<td>17.00 ± 1.53</td>
<td>6.36</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SAM post</td>
<td>17.21 ± 1.72</td>
<td>15.32 ± 2.39</td>
<td>-3.16</td>
<td>&lt; 0.01</td>
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<tr>
<td>HR intraoperative</td>
<td>94.5 ± 13.6</td>
<td>82.8 ± 11.4</td>
<td>-3.10</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>BR intraoperative</td>
<td>22.3 ± 2.9</td>
<td>21.3 ± 3.9</td>
<td>-0.92</td>
<td>n.s.</td>
</tr>
</tbody>
</table>
Real-time visualization
Summary

- Proven feasibility and practicability in a concrete field of work with high demands
- No negative influence on the work
- Subjective ratings were neither time-consuming nor distracting
- Significant differences between the 2 stress groups
- All 25 participants declared their willingness to contribute their part to future investigations
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Annika Rieger | Institute for Preventive Medicine | University of Rostock, Germany
annika.rieger@uni-rostock.de | www.ipm.uni-rostock.de