Deployment of human-centered assistive technologies at work

A focus on users' acceptance

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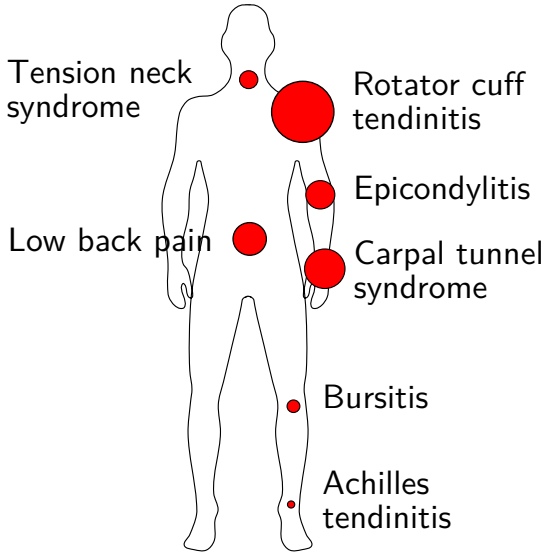
Why human-centered assistive technologies at work ?

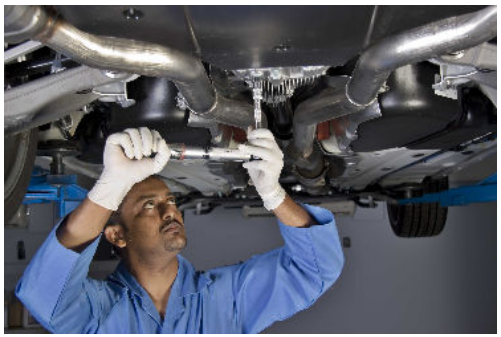
Work-related musculoskeletal disorders

- Over 50 % of industrial workers worldwide
- 1st occupational disease in Europe

Biomechanical risk factors

- Awkward postures
- High efforts
- Repetitive work



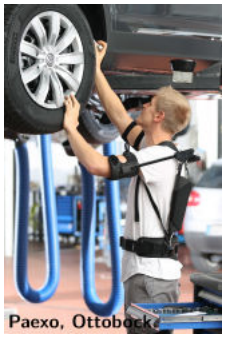


Collaborative and wearable robotics : A physical assistance for complex tasks

Robotic and wearable assistance at work

Collaborative robots and exoskeletons

- Direct physical assistance
- Weight compensation, strength amplification



Wearable sensors

- Warning, training, monitoring

Primary goal : Reduce awkward postures and high efforts

Evaluation metrics for human-centered assistive technologies

- Safety (e.g. ISO/TS 15066:2016)
- Efficacy w.r.t biomechanical and physiological metrics

Necessary but not sufficient for a smooth deployment of the technology

Reasons for rejection

- Comfort
- Expectations, fears
- Influence of social factors

Consequences

- Technology remains unused
- Increased stress at work

Technology acceptance: Attitude of end-users towards the technology

General opinion on human-centered assistive technologies at work

Prior to product development

- Identify expectations, concerns, fears
- Identify items critical for successful acceptance
- Provide social and ethical guidelines for design and deployment

Maurice *et al.*, *Ethical and Social Considerations for the Introduction of Human-Centered Technologies at Work*, IEEE ARSO 2018

`https://hal.archives-ouvertes.fr/hal-01826487`

Evaluation of general opinion in 2 communities

Population: 2 separate groups

- 4 industrial workers $\rightarrow$ Expectations and concerns of end-users
- 6 non-industrial workers $\rightarrow$ Social influence, image

Collaborative robots

Exoskeletons

Wearable sensors

Questions

- What does the technology evoke for you
- Envisioned applications and condition of use
- Envisioned advantages and drawbacks
- Previous experience

Tools for assessment of opinions

Focus group

- Small group ($\sim$4 to 12 participants)
- Discussion on a given topic with a moderator
  $\rightarrow$ Here: Discussion triggered by videos

Semi-directed interviews

- Individual
- Guided by a set of open questions

Opinions of participants

Collaborative robots → Mixed opinion

- Increase productivity
- Offload workers of tasks with no added-value
- Fear of being replaced by a robot

Exoskeletons → Positive opinion

- Reduce physical load
- Seen as a PPE
- Concern about comfort (workers), and safety and security (non-workers)

Wearable sensors → Positive opinion

- Help correct posture
- Training tool, medical device
- Concern about comfort (workers), and safety, security and misuses (non-workers)

Recommendations for smooth deployment

Overall positive opinion $\rightarrow$ Demand for physical assistance

Opinions differ between groups

- Industrial workers: Comfort
- Non-industrial workers: Safety, security and misuses

$\rightarrow$ Need for **regulations and ethical rules** to protect workers

$\rightarrow$ Need for **information and education** to change image

Recommendations for design and development

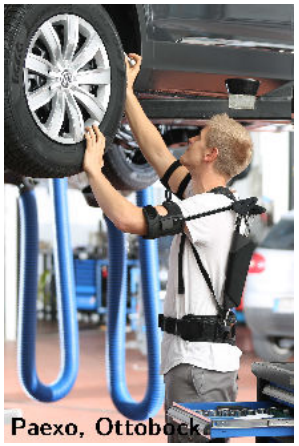
- **Human stays in control**: Added-value, workpace
- Adaptation of the robot, yes but not too much: Predictability, repeatability
- Voluntary and temporary use

Acceptance of one specific assistive technology – Exoskeleton

During product development

PAEXO (Ottobock): Passive exoskeleton for arm support in overhead work

`https://www.ottobock.com/en/company/ottobock-industrials/paexo/`



Maurice *et al.*, *Objective and Subjective Effects of a Passive Exoskeleton on Overhead Work*, IEEE TNSRE, 2019

`https://hal.archives-ouvertes.fr/hal-02301922`

Collaboration: JSI (Slovenia), Ottobock (Germany), IIT (Italy), IMK (Germany)

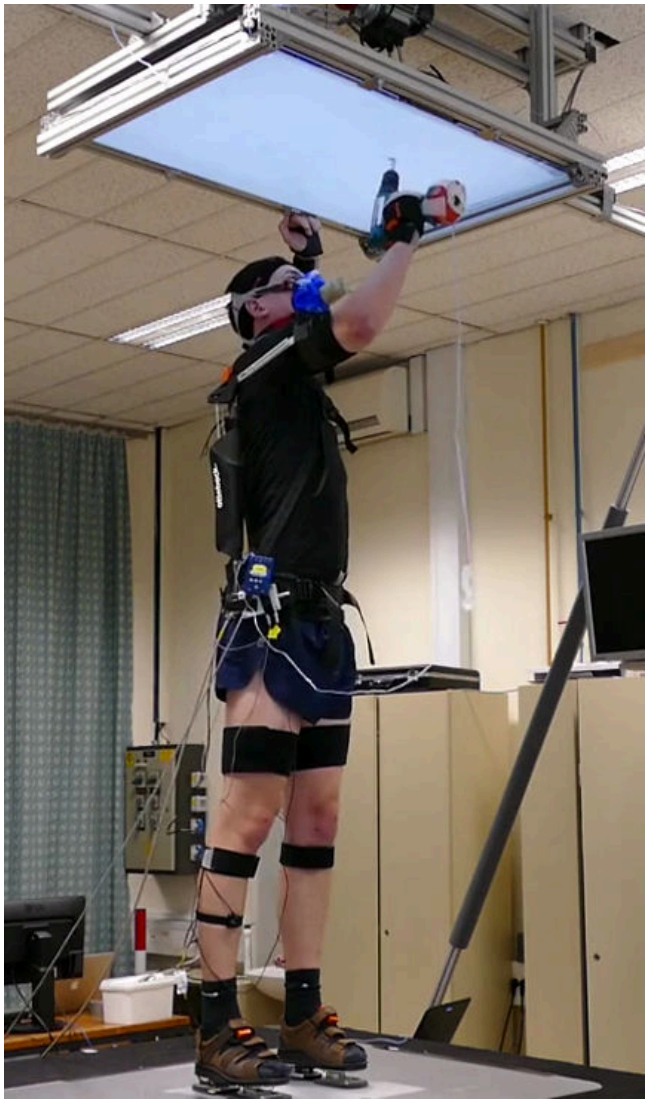
Laboratory and factory testing of PAEXO

Laboratory study

- 12 college students
- ∼2 hours/participant
  ∼15 min with exoskeleton
- Many sensors: motion capture, force plates, EMG, heart rate, VO2

Field study

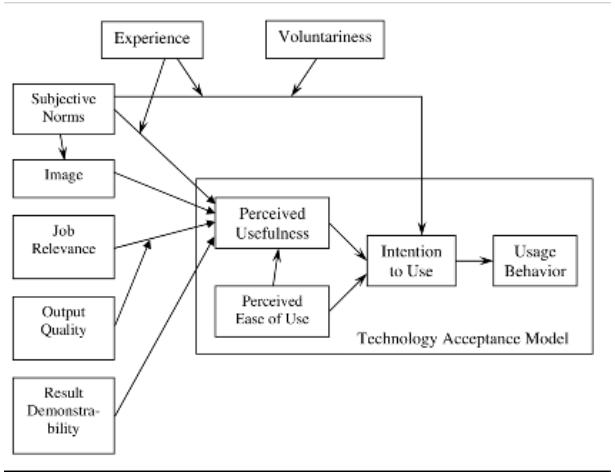
- 4 workers in automotive factory
- 20 workdays with exoskeleton
- Few sensors: video, heart rate



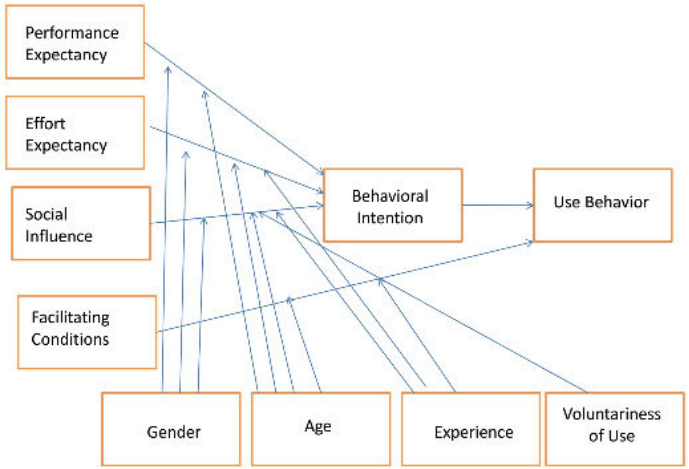
Acceptance of PAEXO – Tools for evaluation

- **Dedicated questionnaire based on TAM and UTAUT**

Technology Acceptance Model (TAM) [Venkatesh, 2008]



Unified Theory of Acceptance and Use of Technology (UTAUT) [Venkatesh, 2003]



I would prefer to use the exoskeleton if I had to do the task again

Not use it at all — Totally use it

0 1 2 3 4 5 6 7 8 9 10

I don't feel free in my movements when I am wearing the exoskeleton

Very free — Not free at all

0 1 2 3 4 5 6 7 8 9 10

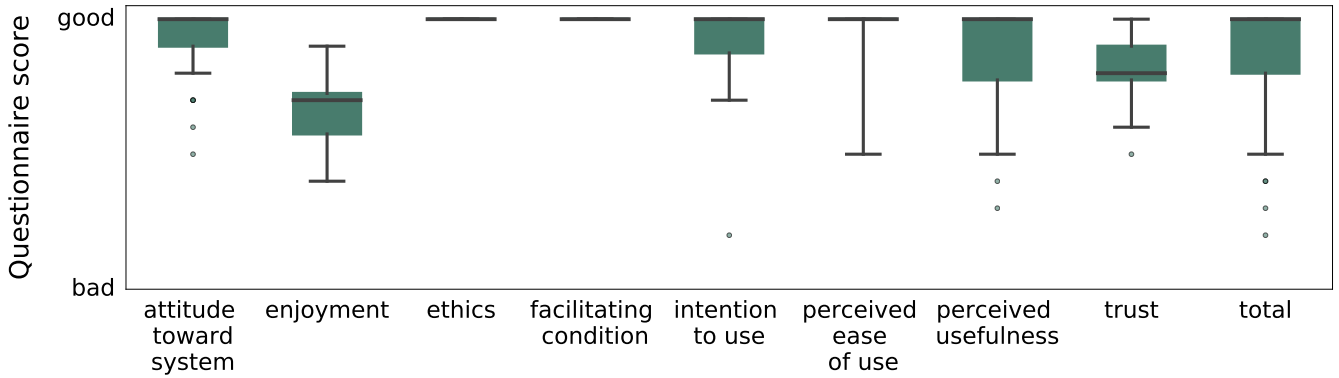
- **Post-experiment semi-directed interview** (lab only)

Lab study results of PAEXO testing

Objective measures: Promising results

- Reduction of shoulder effort
- Reduction of metabolic demand
- No side effects on back nor balance
- Productivity is maintained

Technology acceptance: Good scores for all topics



All participants said they would use the exoskeleton again

Acceptance of human-centered technologies at work – Conclusion

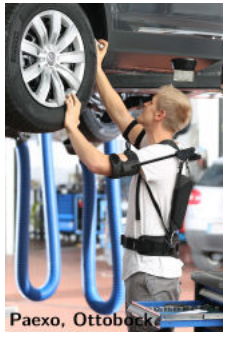
Tools for evaluation of acceptance

- Questionnaires based on technology acceptance models: TAM, UTAUT ...
- Semi-directed interviews
- Focus group

Recommendations

- Influence of social image
- Importance of training and education
- Voluntary use of assistive technologies
- **Keep the human in control!**

Technology acceptance must be integrated into any human-centered technology development and evaluation



Thank you!

https://andy-project.eu/

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