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Workload of Virtual Environments – A Literature Review

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22nd Triennial Congress of the International Ergonomics Association (IEA2024) &
3rd International Conference on Human Systems Integration (INCOSE HSI2024),
Aug 25-29, 2024, ICC Jeju, Seogwipo-City, Republic of Korea

Agenda

- Concerns of OSH regarding VR/VE
- HFE: workload assessment of VR/VE
- Literature Review
- VR/VE and physical workload
- VR/VE and mental workload
- Additional Findings
- Conclusions
  - findings are available,
  - but often not always very specific


[Nickel et al. 2015, https://doi.org/10.1109/VR.2015.7223457]

Workload of Virtual Environments (VE) and Virtual Reality Techniques (VR)

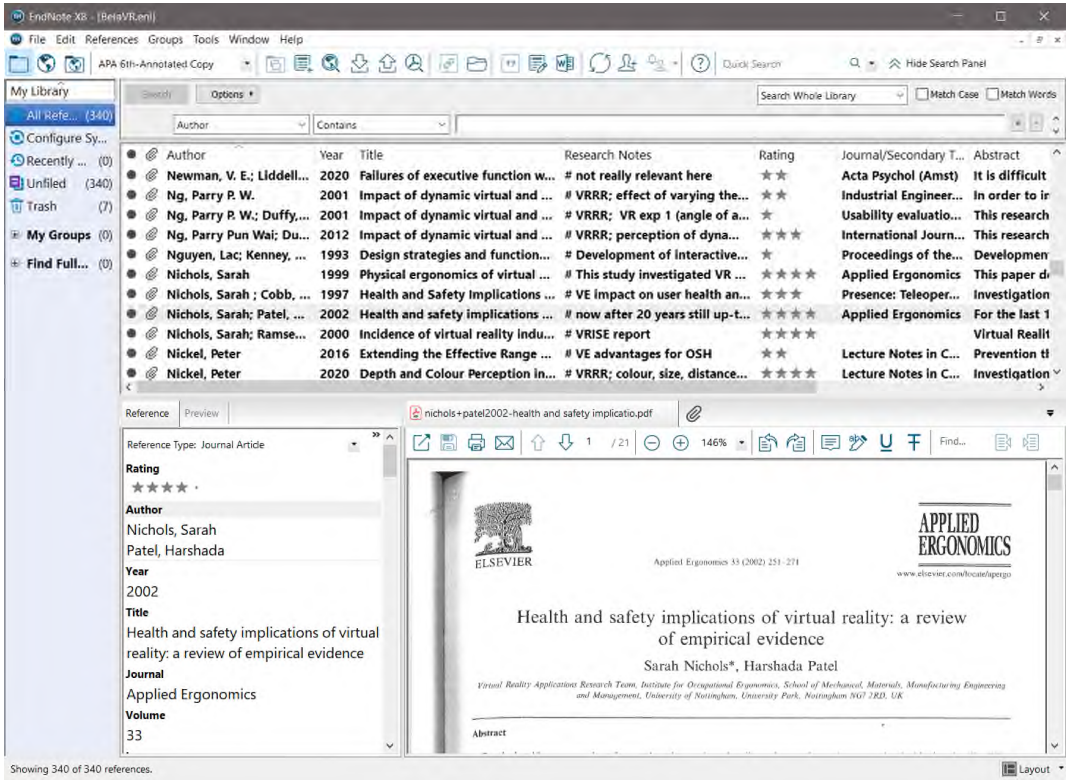
- Virtual reality (VR) techniques are popular
- Virtual environment (VE) is integrated at work
- Occupational safety and health (OSH) concerns with safety and health risks of VR/VE
  - How to assess hazards and risks of VR/VE?
  - What are preventive measures?
  - How to design safe and healthy VR/VE?
- Criteria for design of work systems:
  - Physical and mental workload
  - What is the workload of VR/VE?


[Nickel et al. 2017, https://doi.org/10.1007/978-3-319-72323-5_12]

Methods – Systematic Literature Review

- PRISMA guidelines [Tricco et al. 2018]
- EBSCO Discovery Service

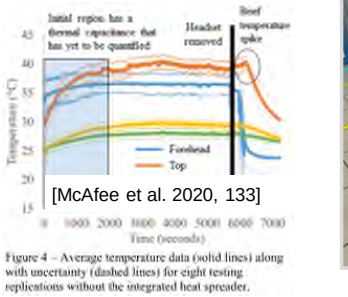
  Rheinische Fachhochschule Köln
  University of Applied Sciences
- Development of search strings (engl./dt.)
  - {[("virtual reality" OR "virtual environment") AND (load OR demand OR effort OR fatigue) TX Full Text] AND ["virtual reality" OR "virtual environment" AB Abstract]}
  - Sources:
    6.200 (total) > 340 (title fit) > 155 (abstract fit)
  - Report available at [https://www.vbg.de/]



Results – Workload through VR and VE

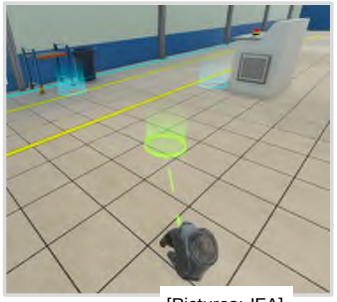
- Physical workload [ISO 26800:2011]
  - regarding anthropometry and biomechanics (e.g. view field, postures, weight)
  - requirements and recommendations (e.g. cover field of view, size of controls, heat)

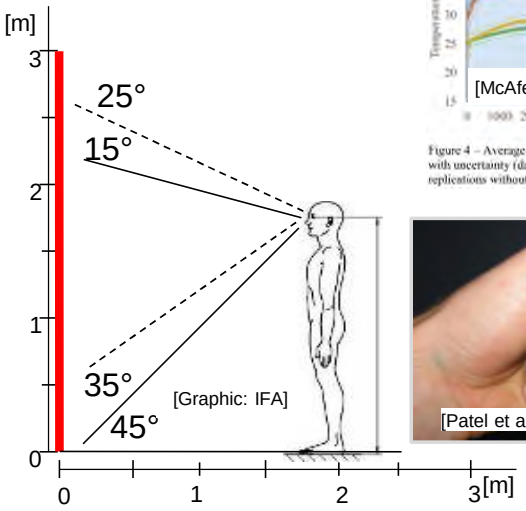
- Mental workload [ISO 10075-1:2017]
  - regarding human information processing, social interaction (e.g. perception, teamwork)
  - requirements and recommendations (e.g. visual, auditive, tactile, olfactory, vestibular feedback, interpersonal communication)



[McAfee et al. 2020, 133]

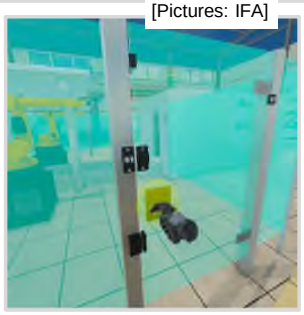
Figure 4 – Average temperature data (solid lines) along with uncertainty (dashed lines) for eight testing replications without the integrated heat spreader.

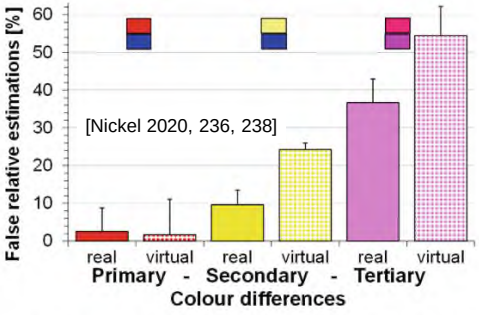

[Pictures: IFA]



[Graphic: IFA]


[Patel et al. 2006, 216: The Hornet]





[Nickel 2020, 236, 238]

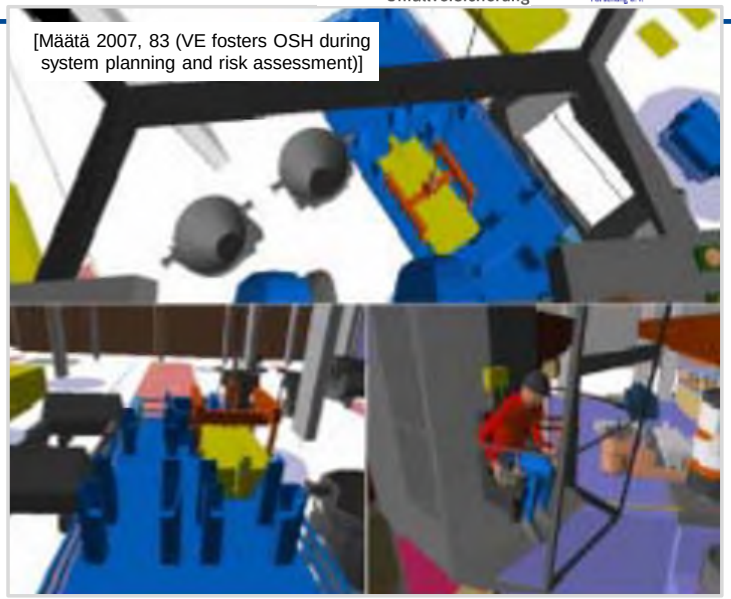
Fig. 6. Deviations from correct relative estimations for two colours of primary, secondary and tertiary hues (RGB colour wheel) in RE and VE.

[Podkosova et al. (2016) doi10.1109/SEARIS.2016.7551581]

Figure 1: (a) : Two users in the tracking area during an immersive VR experience. (b) : Their avatars in a shared VE.

Results – Additional Findings of Individual Studies

- Transfer of Human Factors/Ergonomics knowledge into design of VR techniques and VE for task performance
  - when better walking, when better teleporting in VE
  - new world with 6 fingers …
- Transfer of VE findings into RE (real environments)
  - modelling and simulating (new) work systems in VE for analysing, assessing, designing work systems in RE

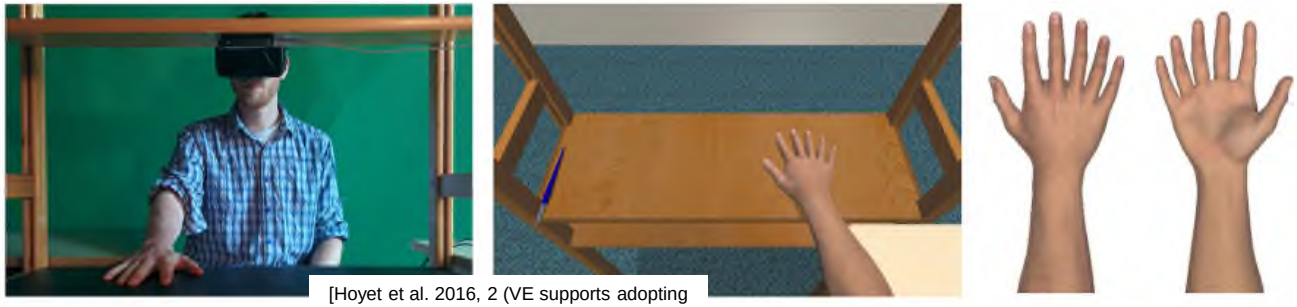


[Määtä 2007, 83 (VE fosters OSH during system planning and risk assessment)]

[Suma et al. 2020, 692 (Walking for fast, efficient navigation and realistic walking behaviour, otherwise teleporation is ok)]

(a) (b)

Fig. 1. (a) When using the real walking technique, participants can naturally walk around about the space. (b) When using a virtual travel technique, physical movement is restricted and travel is accomplished using a handheld device.



[Hoyet et al. 2016, 2 (VE supports adopting new individual charactieristics and roles)]

FIGURE 1 | Setup of the experiment. Left: physical experimental setup. Middle: corresponding virtual setup including the six-digit virtual hand used in the experiment. Right: six-digit virtual hand model used in the experiment.

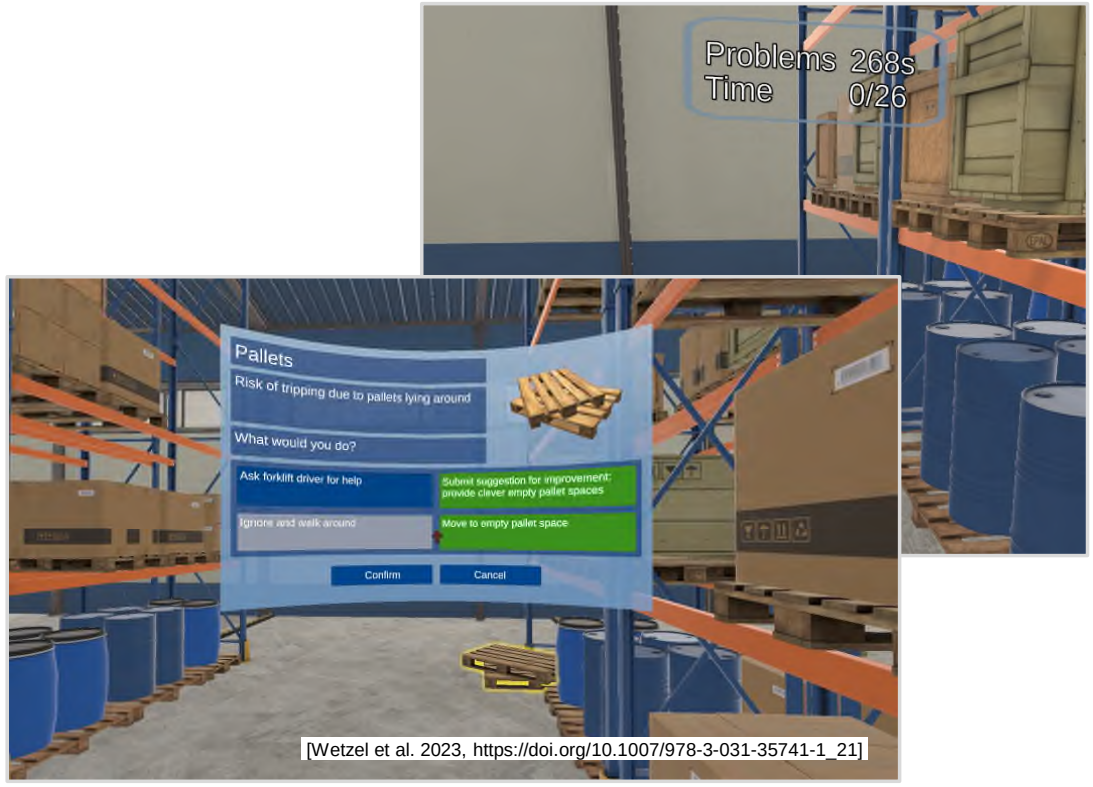
Results

- Mental and physical workload of VR/VE is addressed
  - in some studies, relative to all studies
  - several studies investigate in VE without addressing not being in RE
  - some studies report workload ratings
  - few studies explicitly evaluate workload of VR/VE
- Requirements and recommendations for safe and healthy design of VR/VE suitable across technologies is
  - not well recognised
  - and (too) limited

[Huis & Nickel 2019, Risk assessment training]

Conclusions

- VR/VE studies highlight similarities to RE (e.g. look and feel) but rarely point out differences (e.g. sensual representation and social factors)
- Given the sole focus on visual representation, transfer of findings in VR/VE to RE is limited
- Sometimes, study design and confounding factors hamper guidance on VR/VE design
- Sometimes, discussion sections are driven by wishful thinking regarding successful VR/VE, transfer to RE, practical relevance etc.
- Well-designed OSH evaluation studies of VR/VE are always welcome when considering workload effects and the simulation-reality gap



[Wetzel et al. 2023, https://doi.org/10.1007/978-3-031-35741-1_21]

Thank you very much for your attention!

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