Assessment of Wellbeing Parameters in the Factories of the Future – Comparison between Levels of Automation and Activity Level

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1 INTRODUCTION

Factories of the future, so called *Smart Factories*, are characterized by the ongoing digitalization and automation of most process steps. However, the factory workers will still maintain an important role. In the future, dynamic adaptation of production processes provides the possibility to adjust to preferences and the current wellbeing of workers [1]. The Factory2Fit research project (funded by the European Union under H2020, grant agreement number 723277) aims at developing automation solutions that match work and task requirements to experience, preferences, and the wellbeing of the workers to increase satisfaction and productivity. However, the effects of levels of automation (LoA) on wellbeing and methods for assessing wellbeing parameters in an industrial environment have hardly been studied, up to today. Wearable devices, such as smartwatches, provide the possibility to assess physiological data via integrated sensors [2]. Additionally, small queries can be presented to the worker [3]. In this study, we have been investigating, whether small changes in the work environment can be displayed in wellbeing measures that are assessed via short queries presented on a smartwatch. We hypothesize, that an increasing LoA [H1] and increased activity level [H2] will increase wellbeing parameters.

2 METHOD

- Factory-like laboratory environment, with 3D-printers as manufacturing equipment
- 23 participants (M_{age} = 23 years, SD_{age} = 3.8; $range_{age}$: 19–34; 12 man)
- Independent variables: LoA (manual, semi-automatic, automatic) & activity level (low = small walking distance, high = long walking distance between printers)
- Dependent variables assessed via short querries presented on smartwatch: subjective workload [3], arousal, pleasure, mental wellbeing, physical wellbeing, stress & satisfaction

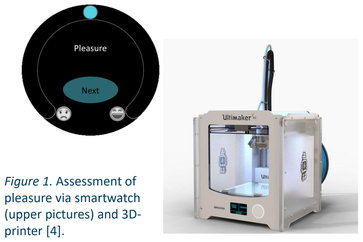

Figure 1. Assessment of pleasure via smartwatch (upper pictures) and 3D-printer [4].

3 RESULTS

- **Subjective workload:** effect of LoA, $F(2,44) = 6.87$, $p = .003$, $\eta^2 = .11$
  > contrary to hypotheses: higher workload in partly automated condition compared to manual ($p = .019$), no difference in activity level

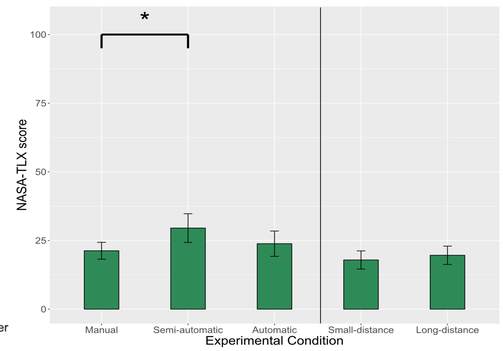

Figure 2. Results of subjective workload (mean) for all conditions, +/- 95% CI.

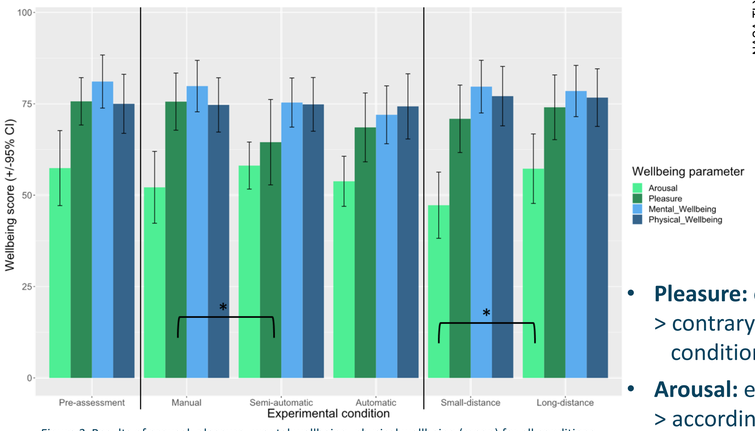

Figure 3. Results of arousal, pleasure, mental wellbeing, physical wellbeing (mean) for all conditions.

- **Pleasure:** effect of LoA, $F(3,57) = 4.86$, $p = .004$, $\eta^2 = .06$
  > contrary to hypothesis: pleasure lower in semi-automatic condition compared to manual ($p = .02$)
- **Arousal:** effect of activity level, $t(18) = 3.77$, $p = .001$
  > according with hypothesis, arousal higher in high activity condition

3 RESULTS (continued)

- **Stress score:** effect of LoA, $F(3,57) = 8.09$, $p < .001$, $\eta^2 = .10$
  > In general, lower stress level compared to pre-assessment
  > contrary to hypotheses: higher stress in semi-automatic condition compared to automatic ($p = .046$), no difference in activity level

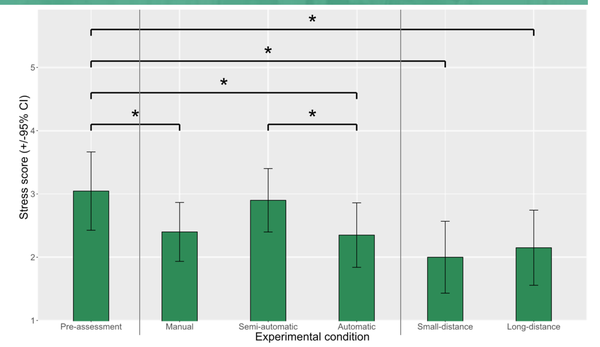

Figure 4. Results of stress score for all conditions.

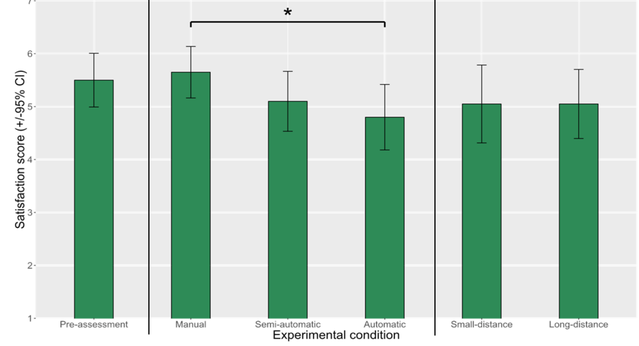

*Figure 5. S*atisfaction level in all conditions.

- **Satisfaction:** effect of LoA, $F(3,57) = 5.60$, $p = .002$, $\eta^2 = .07$
  > contrary to hypotheses: lower satisfaction with increasing LoA
  > highest satisfaction in manual condition, lowest in automatic ($p = .01$), no difference in activity level

4 SUMMARY

- Higher LoAs do not always reduce workload, reduced workload does not necessarily increase satisfaction
- To increase satisfaction, tasks should be planned individually for optimal workload
- Short queries presented on a smartwatch serve as easy, quick and location-independent method for individual online assessment

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