The influence of level of automation, adaptive automation and practice on performance and well-being

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1 INTRODUCTION

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Today's industrial production work is characterized by a high degree of automation. Besides positive consequences for the workers, such as relief by reducing workload [1], it can also reveal negative consequences such as mental underload. Kaber and Endsley [2] argued that various criteria determine the best level of automation (LoA) and that adaptive automation should address context as well as user status. The Factory2Fit research project aims at developing automation solutions that match work and task requirements to the experience and the preferences of the workers in order to increase satisfaction and productivity. The effects of adaptive automation in the factory context have hardly been studied. Gombolay et al. [3] showed that addressing preferences in terms of LoA results in better user evaluation, but performance and subjective workload were not investigated. The aim of this experiment is to **test if subjects' subjective workload and performance correlate with their preference for specific LoAs**. Furthermore, it is of interest **if people feel less stressed (H1)** and **perform better (H2)** when the process has a **higher LoA**. Furthermore, it is of interest **if training effects changes with higher LoAs**, so that there is an interaction effect between LoA and training.

2 METHOD

- Factory-like laboratory environment
- 23 subjects (M_{age} = 23 years, SD_{age} = 3.8; $range_{age}$: 19–34; 12 man) worked on 3D printer tasks
- 3 (LoA) x 2 (training) mixed design:
  - LoA (manual vs. partly automated vs. fully automated),
  - Training (simple instruction, no training vs. instructed training),
- Preference as quasi-experimental manipulation (preference met vs. not met), before and after experiment for each LoA
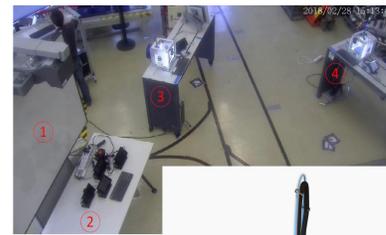- Dependent variables: subjective workload (NASA TLX [1]), performance (time to set system)

Figure 1. Factory-like lab environment (upper picture) and 3D-printer [4].

3 RESULTS (preliminary)

Preferences (*n* pre | post)

- Manual (2|9) < partly automated (13|5) < fully automated (8|8)
- Training reduces preference for partly automated process towards manual task
- No significant correlation between pre and post

Subjective Workload (NASA TLX-Score, [1])

- Relatively low in all conditions
- ANOVA for repeated measures
  - ✓ Significant **effect of LoA,** $F(2,24)$ = 6.20, p = .004, η^2_p = .23 → **contrary to hypothesis H1**: higher workload in partly automated condition compared to manual (p = .008)
  - ✓ **No significant effect of training**
  - ✓ **No significant interaction** between LoA x Training

Figure 2. Results of subjective workload (mean) for all conditions (*n* = 23).

3 RESULTS (preliminary, continued)

Performance (time to set system):

- Relatively low in all conditions
- ANOVA for repeated measures with z-scores showed
  - ✓ **No significant effect of LoA**
  - ✓ Significant **effect of Training** ($F(1,12)$ = 12.02, p = .005, η^2_p = .50) → **supports H2**: higher performance after instructed training in each condition,
  - ✓ **No significant interaction** between LoA x Training

Preference and Workload / Performance

- Preference did not significantly correlate with subjective workload or performance
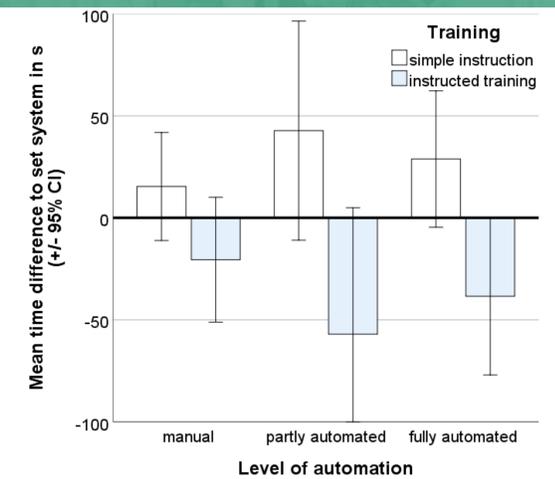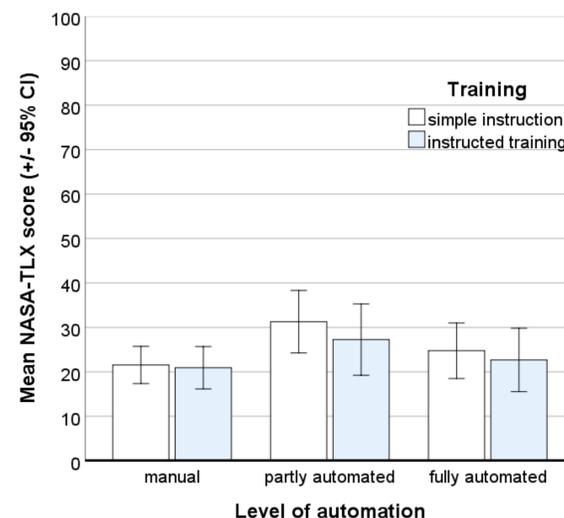

Figure 3. Relative time to set system compared to average time for all conditions (*n* = 14).

4 SUMMARY

- Study could not show that the preference for a task goes along with higher performance and lower workload
- Training is important for performance, but not for workload when the general workload is low for the task
- Higher LoAs do not always reduce workload, LoA has to be selected carefully [2] and other well-being measures should be investigated
- Although **adaption automation to preferences** might not increase productivity, it **has high potential to increase workers' satisfaction** [3]

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