

# You cannot have both – Two different ways of change implementation and their effects on adaptive performance and frustration

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## ABSTRACT

The dynamics and frequency of change in today's workplaces force organizations to address the question of how to create optimal conditions for facilitating adaptation to change. Identifying critical factors that affect performance and well-being in change situations can help answer this question. Given the need for applied research in this area, the aim of this paper is to investigate whether the way of change implementation has an impact on performance and well-being. Additionally, retentivity and specific self-efficacy as individual factors are exploratorily investigated. In an experimental study, seventy-one participants learned and trained specific manufacturing steps in a simulated production environment. Subsequently, they had to adapt the trained task execution as some of the previously learned manufacturing steps were subject to change. The changes were implemented a) either in a stepwise manner or b) all at once. The executed manufacturing steps were recorded, enabling the calculation of task execution time and classification of adaptation errors. The results of Mann-Whitney-U-tests showed that the stepwise introduction of changes led to significantly faster task execution time than the change introduction all at once. Additionally, descriptive statistics indicated fewer adaptation errors but higher frustration. Our exploratory analysis showed a significant negative relationship between retentivity and task execution time, as well as between specific self-efficacy and frustration. Stepwise change introduction seems to be beneficial for adaptation, even though emotional responses and individual factors must be considered.

## 1. Introduction

### 1.1. Challenges of a fast-changing working world

Technological advances, globalization, and flexible working models are just a few examples responsible for changing the nature of human work (Bentley et al., 2021). These have considerably affected the way how and where we work, as well as the roles humans play within the broader organizational system (Cascio and Montealegre, 2016). Socio-technical systems thinking matters more than ever, as human-technology-interaction and automation have significantly increased (Davis et al., 2014). Thus, the joint consideration of human and technology is an indispensable basis for comprehensive organization and work design (Parker and Grote, 2022). However, the dynamics and instabilities in the current times further increase complexity and

challenge organizations (Kim et al., 2021). Organizations are forced to react flexible and agile to maintain being competitive and up to date (Petermann and Zacher, 2020).

Human interactions with other components of socio-technical systems, as well as their well-being and performance in those complex environments, are subject of ergonomics and human factors research (Wilson, 2000). The goal is the optimization of socio-technical systems and the development of strategies to reach those (Karwowski and Zhang, 2021). In times of frequent organizational change, the continuous evaluation and reconsideration of processes, structures, and technology from a human-centered perspective are essential (Woods and Decker, 2000). There is a need for purposeful change management to sustain high performance in socio-technical systems (Nuutinen, 2005). This highlights the relevance of human factors and ergonomics in implementing system designs that support organizations and their members in

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these dynamic times (Bentley et al., 2021). This stream of research helps to find the best way to create optimal conditions for both organizations and their members.

Frequent changes in organizations increase the importance of human adaptability (Sony and Mekoth, 2022). Individuals must be capable of adapting to changes and adjusting their task execution to meet emerging demands and challenges (Schmitt and Chan, 2014). Task execution at the individual level must be appropriate to achieve the goal of agile and dynamic organizations and increase system performance in total (Park and Park, 2021). Therefore, organizations should facilitate adaptation to change and create a supportive environment by considering technology, individual, and higher-level factors (Parker and Grote, 2022). Ergonomics and human factors research helps to identify the factors being particularly relevant for enhancing performance and well-being (Wilson, 2000). Kadir and Broberg (2020) showed that performance and well-being tend to decrease during the implementation of new technologies and improve afterwards. Research on factors affecting these processes helps to find the best possible way to keep performance and well-being at a high level.

The aim of this article is to investigate how adaptation errors and frustration in change situations can be decreased. It is investigated which specific interventions should be implemented to reach productivity and well-being at the individual level. Our research contributes to answering this question with a simulation study conducted in a close-to-real Industry 4.0 setting. Applied human factors and ergonomics research on Industry 4.0 is particularly relevant, given the lack of empirical data on how to design work in those complex socio-technical systems (Kadir et al., 2019). Our study aims to derive implications for system design that help organizations support their members in change situations.

In the following chapters, the theoretical background on performance and well-being in change situations is outlined. The research gap is identified, and hypotheses and research questions are derived. Subsequently, the materials and methods used in the study conducted are described in detail, followed by the results. The final chapter includes a discussion of the results, limitations, practical and theoretical implications, as well as directions for future research and a conclusion.

## 1.2. Adaptive performance and its underlying processes

The performance-related outcomes of employees adapting to change is covered by the term *adaptive performance* (Park and Park, 2021). It describes whether people are capable of adapting to changes in task-relevant aspects (Jundt et al., 2015). However, adaptive performance visible at the performance level is the result of certain underlying processes: *detecting* a change, *diagnosing*, *strategizing*, *learning*, and *performing* (Jundt and Shoss, 2023). It becomes clear that acquiring and recalling appropriate knowledge is a central part of adaptation. Pulakos et al. (2000) even included learning activities as one dimension in their eight-dimensional taxonomy of adaptive performance. However, knowledge management in change situations does not only include learning but also voluntary forgetting (Mariano et al., 2020). Forgetting is an essential adaptive function, preventing the execution of obsolete and irrelevant work steps (Anderson, 2020). It creates capacities for new learning and can be an intended and goal-directed process in a change situation (Niessen et al., 2020). This is described by the concept of intentional forgetting, which is defined as “motivated attempt to limit the future recall of a defined memory element” (Kluge and Gronau, 2018, p. 6). Niessen and Lang (2021) showed that cognitive control strategies have an impact on adaptive performance, in terms of a directed forgetting instruction or the instruction to learn new things being beneficial for task adaptation compared to the instruction to remember the old things.

Learning and forgetting are required in every change situation, even when detecting, diagnosing, and strategizing are not needed due to clear instructions about the change and its consequences. The (un)successful

completion of all processes underlying adaptive performance becomes visible during task execution at the performance level. Therefore, adaptive performance can be operationalized through speed (time needed for task execution) and accuracy (number of errors) as common performance indicators (Vandierendonck, 2017). In the specific case of change situations, relapse errors to obsolete habits and routines can be used to quantify the success of adaptation (Betsch et al., 2004). If someone still behaves as required before the change, this clearly indicates poor adaptive performance.

## 1.3. Frustration as emotional reaction to change

Not only measurable performance indicators but also subjective perceptions and affect should be considered in change situations (Liu and Perrewé, 2005). Emotional responses to change can have far-reaching consequences, as they have an impact on work- and person-related outcomes (Khaw et al., 2023; Oreg et al., 2011). In a change situation, an emotion that often arises due to a mismatch between a wish and reality is frustration (Jeronimus and Laceulle, 2017). Complex task changes challenge employees, and a discrepancy between what employees want to do and are actually able to execute at the performance level might occur (Fasbender and Gerpott, 2023). When people cannot cope with changes and cannot reach a goal within the expected time, it is likely that they get frustrated (Jeronimus and Laceulle, 2017). Frustration may occur when individuals feel that they are unable to perform as desired, for example, caused by external hindrances such as new structures or policies (Liu and Perrewé, 2005). As frustration has negative consequences for organizations and impairs performance (Spector, 1978), its occurrence should be minimized.

## 1.4. Cognitive load in change situations

Affective reactions, as well as adaptive performance, can be influenced by different individual and situational factors (Fisher, 2002; Park and Park, 2019). These factors determine the amount of cognitive load someone experiences in a learning situation (Choi et al., 2014). High cognitive load implies that information processing becomes more difficult, and in turn, performance can be impaired (Sweller et al., 2011). There is empirical evidence that higher cognitive load negatively affects task performance (e.g., Biondi et al., 2021; Leyman et al., 2004). Cognitive load also affects aspects of well-being, such as frustration (Fasbender and Gerpott, 2023), and can be seen as risk factor for burnout if it comes to cognitive overload (Iskander, 2019).

In change situations, high cognitive load arises due to the redesign of work process, often accompanied by increased task complexity and the need to learn new ways of task execution (Fasbender and Gerpott, 2023; Tucker et al., 2014). However, the level of cognitive load in change situations depends on the change itself. In the literature, it is specifically distinguished between two different types: episodic and continuous change (Weick and Quinn, 1999). Episodic change implies that people must deal with a lot of information simultaneously, whereas continuous change describes a stepwise introduction of changes (Weick and Quinn, 1999). Stepwise introduction reduces complexity and facilitates information processing, as changes are introduced one after another. Job complexity and cognitive overload are positively related (Fasbender and Gerpott, 2023), indicating that episodic change leads to higher cognitive load than continuous change.

Although there exists a lot of research on cognitive load and its related factors in ergonomics and human factors research (e.g., De Bruyne et al., 2023; Lagomarsino et al., 2022), there is lack of applied research investigating the effects of different types of task complexity on performance and well-being in situations of organizational change. The present study aims to integrate cognitive psychology perspectives with research on change and adaptation, and empirically investigates the effects of different ways of change implementation on adaptive performance and frustration. With this research goal, our study contributes to

ergonomics and human factors research on the future of work and addresses the existing research gap (Bentley et al., 2021). Based on the assumption that a radical change introduction all at once leads to higher cognitive load and, in turn, to higher frustration and lower adaptive performance compared to a change introduction in a stepwise manner, the following hypotheses were derived.

**Hypothesis 1).** Participants confronted with a stepwise introduction of changes make fewer adaptation errors compared to participants confronted with an introduction of changes all at once.

**Hypothesis 2).** Participants confronted with a stepwise introduction of changes need less task execution time compared to participants confronted with an introduction of changes all at once.

**Hypothesis 3).** Participants confronted with a stepwise introduction of changes indicate less frustration compared to participants confronted with an introduction of changes all at once.

### 1.5. Individual factors as predictors for adaptive performance

The amount of cognitive load is influenced by task and environmental characteristics as well as by individual factors (Choi et al., 2014). Whenever learning is required, retentivity becomes an essential cognitive ability (Kluge et al., 2019). Retentivity is an individual variable that is closely connected to memory and defined as people's ability to memorize and reproduce previously learned memory items (Kersting et al., 2008). The meta-analysis by Salgado et al. (2003) revealed that memory is a good predictor for job performance. In the context of adaptive performance, retentivity also appeared as being beneficial (Kluge et al., 2024). Our preliminary study indicated that participants with huge adaptation problems have a particularly low level of retentivity (Roling et al., 2024). However, there are also counterintuitive results indicating that people with high general mental ability show more performance decrease in change situations compared to people with low general mental ability (Lang and Bliese, 2009).

Self-efficacy is another individual factor with relevance for adaptive performance (Yang et al., 2022). It is defined as one's perception about the own capability to reach a performance goal (Bandura, 1997). With its motivational impact, self-efficacy enhances performance at work (Stajkovic and Luthans, 1998) and well-being (X. W. Chan et al., 2017). It seems to be positive in the context of frustration, as people with high self-efficacy tend to engage in problem-solving in case of failure (Peterson and Arnn, 2005). However, there are also contradictory assumptions, proposing that failure particularly leads to frustration if people put high value in their goals and are confident to achieve those (Lazar et al., 2006). If failure is caused by environmental factors, people with high work-related self-efficacy also tend to get more frustrated (Fida et al., 2015).

Based on these results, we incorporate the exploratory analysis of retentivity, specific self-efficacy, adaptive performance, and frustration.

**Research Question:** Are retentivity and specific self-efficacy related to a) the number of adaptation errors, b) task execution time, and c) frustration in a change situation?

## 2. Methods

To test the hypotheses and address the research question, we analyzed data of 71 participants (28 male, 42 female, 1 diverse;  $M_{age} = 23.90$ ,  $SD_{age} = 4.58$ ) collected between September 2021 and December 2022. The study was conducted in the Research and Application Center Industry 4.0 at Ruhr University Bochum, enabling us to simulate a change process in the workplace. The Research and Application Center Industry 4.0 depicts a manufacturing setting where participants learned the execution of specific manufacturing steps. Later, some of these initially learned manufacturing steps were subject to change, and the participants were required to adapt their task execution. The changes

were implemented either in a stepwise manner or all at once, serving as the experimental manipulation in our study. Each participant signed an informed consent at the beginning and received a financial reward or study credits for complete study participation. The study received approval from the Ethics Committee of the Faculty of Psychology at Ruhr University Bochum (Vote No. 243).

### 2.1. The experimental setting: The Research and Application Center Industry 4.0

The Research and Application Center Industry 4.0 is a special-purpose setting, integrating a simulated manufacturing environment with a standardized laboratory to leverage the advantages of both lab and field experiments (Gronau et al., 2023; Stone-Romero, 2011). The laboratory is equipped with hardware (e.g., a transportation system and robotic arm) and software components to simulate a manufacturing setting, providing the opportunity to display a close-to-real manufacturing process (Gronau et al., 2023). Large cubes with computers represent machines with interfaces for starting and monitoring the manufacturing process, while small cubes with computers represent the workpieces. The digital work plan is shown on a tablet (see Fig. 1). To simulate work on the assembly line, the Research and Application Center Industry 4.0 consists of two different work positions. The participant at the first work position starts the processing of the workpiece and is responsible for milling and grinding. The workpiece is forwarded to the second work position, where another participant is responsible for lasering and polishing the workpiece. Although participants engage in sequential teamwork, the tasks of the two participants remain independent. When one of the participants makes an error, this does not affect the work steps of the other participant. Each interaction with machines and workpieces is accompanied by audible or visual effects, or the activation of a physical component (e.g., of a robotic arm). Upon completion of each workpiece processing cycle at each work position, participants receive feedback on the quality of the processed workpiece (categorized as good or bad) through images on the workpiece interfaces. The importance of manufacturing steps varies, as some actions are critical for achieving high-quality workpieces while others are not.

### 2.2. Participants and procedure

The study consisted of two measurement points in the Research and Application Center Industry 4.0 and an online training program the participants should use in between (see Fig. 2). The participants took part in teams of two people. At the first measurement point, the participants learned and trained the simulated manufacturing of artificial knee joints in the Research and Application Center Industry 4.0. First, they were introduced to the study and filled out questionnaires, measuring general self-efficacy (Schwarzer and Jerusalem, 1999), conscientiousness (Körner et al., 2008), disposition to trust technology (McKnight et al., 2011; as adapted and translated by Thielsch et al., 2018), technology competence (Neyer et al., 2012), and prior knowledge (self-developed by the project team). In the following, only the questionnaires relevant for the present analysis are explained in detail. After questionnaire completion, the participants were randomly assigned to one of the two work positions. In a first learning phase, each participant processed three workpieces with the help of printed instructions. Then, the participants processed additional nine workpieces without any help. At the end of the first measurement point, the participants again filled out several questionnaires, measuring presence (Frank, 2015), specific self-efficacy (Kluge, 2004), and demographics.

The participants were introduced to further practice the manufacturing steps on their specific work positions with an online training program. The online training program mirrored the laboratory setup and enabled interactive training of the manufacturing steps. The participants were told to train at least 10 min per day. Seven days after

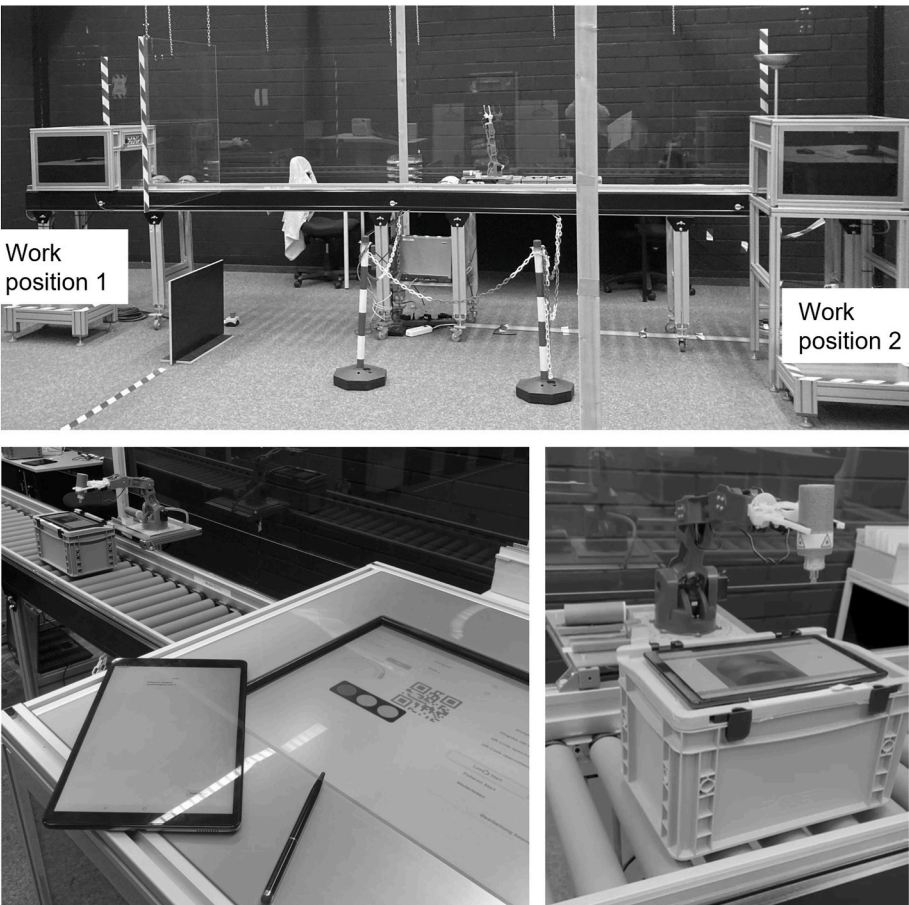


**Fig. 1.** The Research and Application Center Industry 4.0 at Ruhr University Bochum.  
*Note.* The small cubes simulate the workpieces, and the large cubes simulate the machines. The digital work plan is displayed on the tablet.

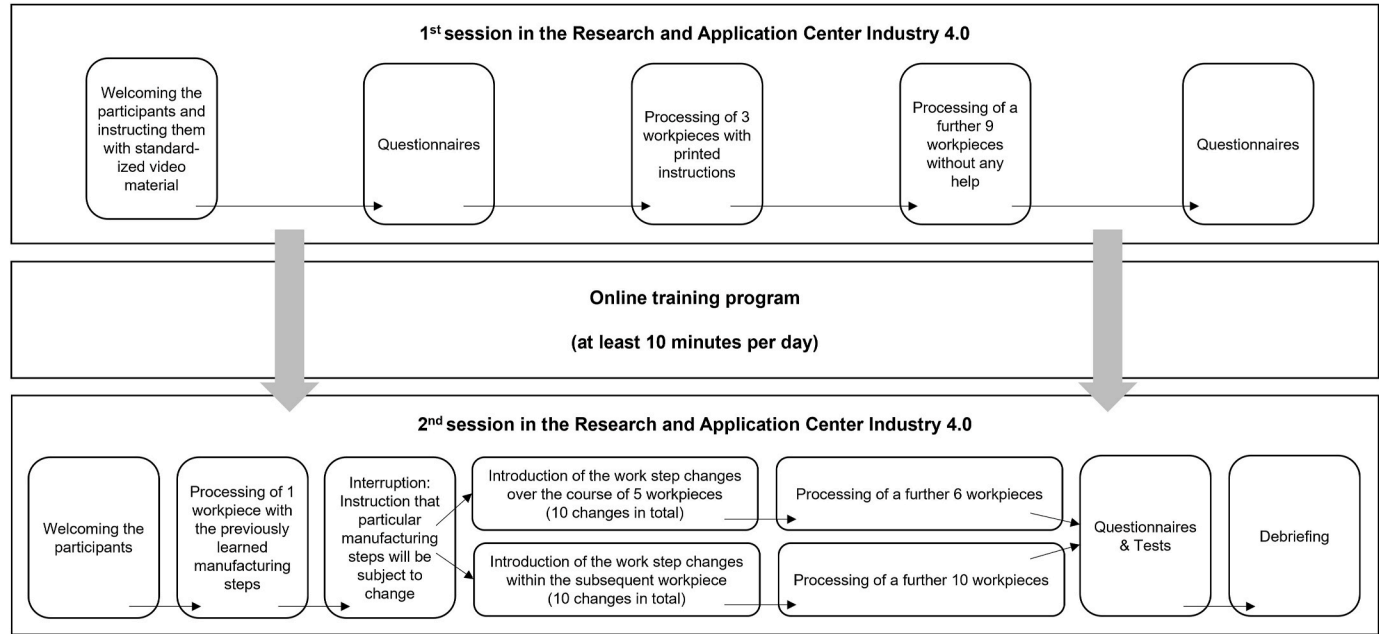


**Fig. 2.** Overview of the procedure.

the first measurement point, the participants returned to the Research and Application Center Industry 4.0 expecting to perform the manufacturing steps they had trained before. Each participant processed

one workpiece with their initially trained manufacturing steps. This enabled us to observe how well the participants were able to execute the initial manufacturing steps. Then, the participants were interrupted and

told that the manufacturing company has an important message for them. This message revealed that specific work steps will be subject to change. Depending on the experimental condition, either a stepwise change introduction or an introduction all at once was announced. In both conditions, the participants were asked to again fill out the questionnaire measuring specific self-efficacy (Kluge, 2004). The implementation of changes and additional processing of certain workpieces followed. Again, the participants received feedback on the quality of the processed workpiece (good or bad) through the image on the workpiece interface. At the end of the second laboratory session, the participants again filled out some questionnaires, measuring presence (Frank, 2015), frustration (adapted from NASA Task Load Index; Hart and Staveland, 1988), perceived behavioral control (adapted from the questionnaire of the Unified Theory of Acceptance and Use of Technology; Venkatesh et al., 2003), situational trust (Thielsch et al., 2018), creativity (Berlin Test of Intelligence Structure (Form 4); Jäger et al., 1997), subjective switching costs (self-developed by the project team), and retentivity (Wilde Intelligence Test 2; Kersting et al., 2008). Additionally, the participants were asked for any comments regarding the experiment. The session was closed with a debriefing of participants. A visualization of the procedure can be found in Fig. 2.

### 2.3. Experimental manipulation

In the condition of *change introduction all at once*, the message informed the participants that the system has received a single software update causing changes of specific manufacturing steps. Ten work step changes were introduced during the subsequent workpiece (see Figs. 2 and 3). The information about the specific changes were implemented through notes on the digital work plan.

In the condition of *change introduction in a stepwise manner*, the changes of specific manufacturing steps were explained with a new operating system. The participants were told that the operating system and the quality control department continuously improve the manufacturing steps. The ten work step changes were introduced over the course of five workpieces (workpieces 2 to 6; see Figs. 2 and 3). Two work step changes per workpiece were introduced and implemented through notes on the digital work plan.

### 2.4. Dependent variables

#### 2.4.1. Operationalization of adaptive performance

**2.4.1.1. Adaptation errors.** Throughout data collection, every interaction with machines, workpieces and tablets was logged. The comparison of the recorded logfile data with the ideal manufacturing steps allowed us to categorize the task execution as correct or incorrect. Participants were also equipped with mobile helmet cameras to record body movements and voice. If the logfile data led to any uncertainty (e.g., due to technical problems), the video recordings could be used for verification. The video recordings were also used to screen for any abnormalities during the experimental procedure.

Implemented changes included three types of change content (see Figs. 3 and 4).

- 1) An action that was part of the initial manufacturing steps should be executed in a changed manner (e.g., the unit in which the workpiece should be measured changed from centimeters to inches),
- 2) An action that was part of the initial manufacturing steps should be omitted (e.g., to not enable the machine/robot),
- 3) A new action was added (e.g., to calibrate the machine/robot).

Adaptation errors were counted when participants executed the initial, not the changed manufacturing steps. Other types of errors were ignored. A detailed overview is depicted in Fig. 4. The analysis focused on the first six workpieces after all the changes were introduced. Due to the two different modes of change introduction, this meant workpieces 3 to 8 in the condition of change introduction all at once, and workpieces 7 to 12 in the condition of change introduction in a stepwise manner. The sum of adaptation errors within those six workpieces was the dependent variable.

**2.4.1.2. Task execution time.** Task execution time was operationalized through the time between machine authorization and indicating the workpiece quality. This action window was chosen because it depicted the main part of workpiece processing. At the beginning and end of each workpiece processing, it might have happened that participants had waiting times due to a slower team member. With the use of the described action window, those waiting times were excluded from the time score. Additionally, the running times of milling and grinding or

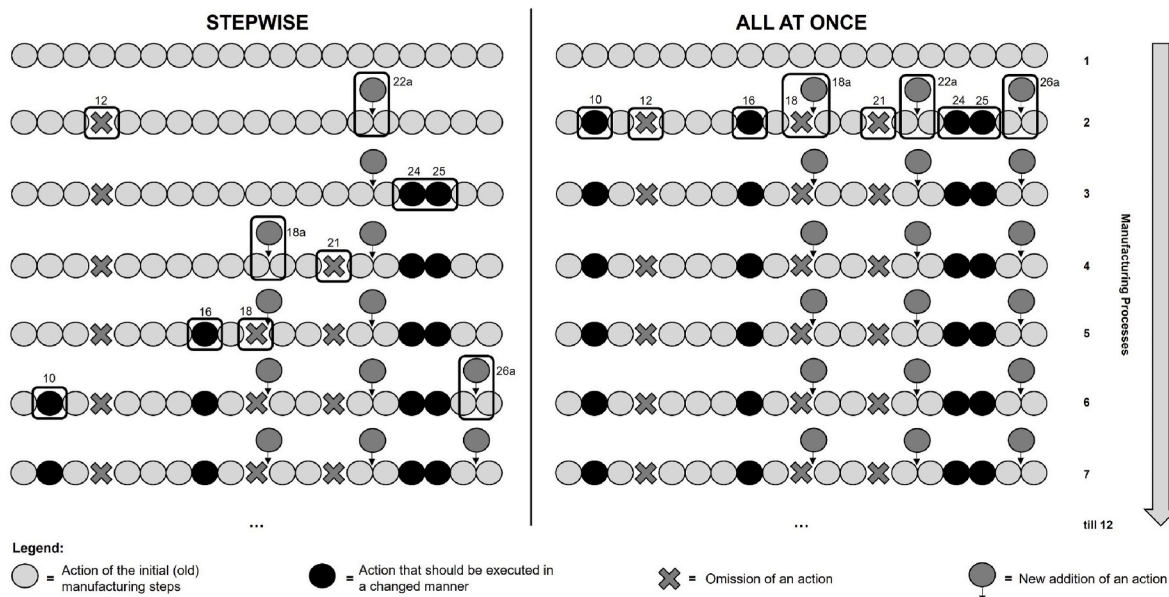


Fig. 3. Overview of the introduction of changes.

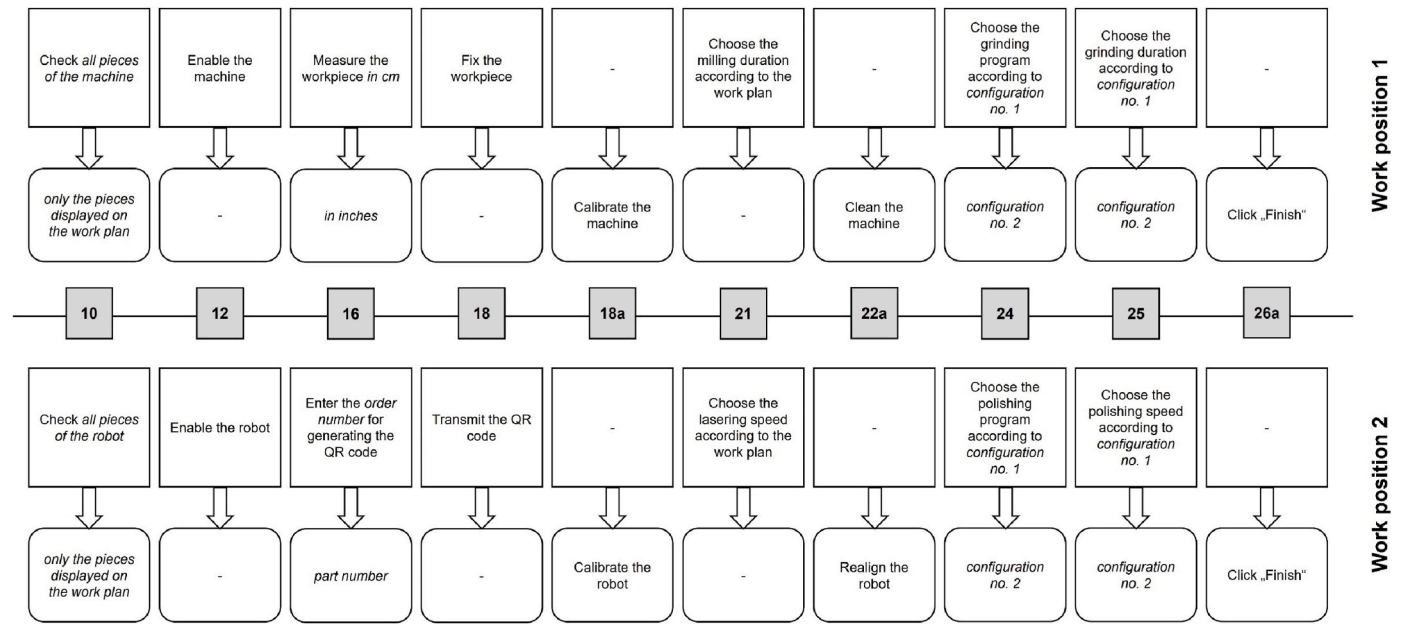


Fig. 4. Comparison of the initial and changed manufacturing steps.

lasering and polishing were subtracted. To exclude individual outliers, the median of the task execution times within the six workpieces was considered.

#### 2.4.2. Frustration

Frustration was measured with 6 items at the end of the second laboratory session. The items were adapted from the frustration-level subscale of the NASA Task Load Index (NASA-TLX; Hart and Staveland, 1988). The participants had to indicate their amount of insecurity, discouragement, irritation, stress, annoyance, and frustration on a Likert-scale, ranging from 1 (completely disagree) to 5 (completely agree). Cronbach's alpha in our sample was  $\alpha = .88$ .

### 2.5. Person-related variables

#### 2.5.1. Retentivity

Retentivity was measured at the end of the second laboratory session. Participants completed the retentivity-subscale of the Wilde Intelligence Test 2 (WIT-2; Kersting et al., 2008). A text provided verbally, numerically, and figuratively coded information that had to be memorized during a 4-min learning phase. Then, the participants had to deal with other questionnaires for approximately 17 min (disruption phase). After this, the participants had to work on 21 items, which tested the recognition of the formerly learned information. The participants had to decide between six response options. They had three and a half minutes to answer all the items. The total number of correct answers built the score of the retentivity-subscale (ranging from 0 to 21). When the answers of certain items were missing, those were counted as incorrect.

#### 2.5.2. Specific self-efficacy

Specific self-efficacy was measured at the end of the first laboratory session and again at the second laboratory session after the participants were introduced that certain changes will occur. For the present analysis, the latter one was used as the specific self-efficacy regarding adaptation to change was of interest. The participants had to complete 4 items, adapted from Kluge (2004). They had to indicate their confidence to solve the task on a Likert-scale, ranging from 1 (completely disagree) to 6 (completely agree). Cronbach's alpha in our sample was  $\alpha = .91$ .

### 2.6. Participants

In total, data of 86 participants were collected. Unfortunately, the data of 15 participants had to be excluded from analysis due to technical problems and missing data ( $n = 5$ ), too few workpieces processed at the second measurement point ( $n = 4$ ), or when participants clearly stated during data collection that they had misunderstood the task or miscommunicated with the investigator ( $n = 6$ ). The study participants were mostly students from various faculties (e.g., law, engineering, language, or psychology). They were recruited via social media, postings in Internet forums, and flyers handed out on the campus. Participants were not allowed to take part when they had already participated in previous studies of the research project.

### 2.7. Statistical analysis

Statistical analyses were conducted with IBM SPSS Statistics (Version 29). Visual inspection revealed that the data were not normally distributed and contained some outliers which is why non-parametric Mann-Whitney-U-tests were calculated for hypothesis testing (one-tailed; using the exact sampling distribution of  $U$  by Dinneen and Blakesley, 1973). The exploratory analysis of retentivity and specific self-efficacy was made with a correlational analysis (Spearman correlations). Additionally, we had a look at the pre-change performance since the participants sometimes already executed the manufacturing steps in the way it should be done after the changes even when those have not yet been introduced. We counted the number of these specific pre-change errors that were executed during the processing of the first workpiece at the second measurement point in the Research and Application Center Industry 4.0 and correlated them with the number of adaptation errors. The results were not significant (change introduction in a stepwise manner:  $r_s = -.034$ ,  $p = .842$ ; change introduction all at once:  $r_s = .101$ ,  $p = .562$ ) which is why the pre-change errors were neglected for hypothesis testing.

## 3. Results

Descriptive results are integrated in Table 1.

**Table 1**

Descriptive statistics and Spearman correlations of relevant study variables (Upper diagonal: Stepwise; Lower diagonal: All at once).

|                                | Stepwise |           |            |            | All at once |           |            |            | 1    | 2                 | 3                 | 4                 | 5                 | 6                 |
|--------------------------------|----------|-----------|------------|------------|-------------|-----------|------------|------------|------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                                | <i>M</i> | <i>SD</i> | <i>Min</i> | <i>Max</i> | <i>M</i>    | <i>SD</i> | <i>Min</i> | <i>Max</i> |      |                   |                   |                   |                   |                   |
| 1. Number of adaptation errors | 1.92     | 3.67      | .00        | 14.00      | 2.54        | 3.91      | .00        | 12.00      | 1    | -.08              | .23               | -.09              | -.26              | .03               |
| 2. Task execution time         | 67.87    | 18.18     | 39.00      | 121.00     | 75.50       | 17.55     | 37.50      | 115.00     | -.16 | 1                 | .14               | -.47 <sup>b</sup> | -.11              | .01               |
| 3. Frustration                 | 2.05     | .85       | 1.00       | 4.50       | 1.79        | .68       | 1.00       | 4.50       | -.06 | .10               | 1                 | .01               | -.35 <sup>a</sup> | .05               |
| 4. Retentivity                 | 14.11    | 1.86      | 10.00      | 17.00      | 13.66       | 3.61      | 7.00       | 20.00      | -.10 | -.46 <sup>b</sup> | -.13              | 1                 | .10               | -.07              |
| 5. Specific self-efficacy      | 4.50     | 1.33      | 1.00       | 6.00       | 4.64        | 1.16      | 1.75       | 6.00       | -.27 | -.20              | -.37 <sup>a</sup> | .27               | 1                 | -.46 <sup>b</sup> |
| 6. Pre-change errors           | .97      | 1.10      | .00        | 5.00       | .83         | 1.18      | .00        | 4.00       | .10  | .27               | -.00              | -.17              | -.28              | 1                 |

Note. Maximum possible number of adaptation errors: 60; Likert-scale measuring frustration: 1–5; Maximum possible number of correct answers to the retentivity-test: 21; Likert-scale measuring specific self-efficacy: 1–6; Maximum possible number of pre-change errors: 10; Stepwise:  $n \geq 35$ ; All at once:  $n = 35$ .

<sup>a</sup>  $p < .05$  (two-tailed).

<sup>b</sup>  $p < .01$  (two-tailed).

### 3.1. Hypothesis testing

**Hypothesis 1.** The descriptive results indicated that the number of adaptation errors was lower when changes were introduced in a stepwise manner compared to an introduction all at once (see Table 1). The Mann-Whitney-U-Test revealed a marginally significant difference between the two groups (see Table 2). Based on the significance level of .05, Hypothesis 1 was not supported.

**Hypothesis 2.** The descriptive results indicated that task execution time was lower when changes were introduced in a stepwise manner compared to an introduction all at once (see Table 1). The Mann-Whitney-U-Test revealed a significant difference between the two groups, supporting Hypothesis 2 (see Table 2).

**Hypothesis 3.** The descriptive results indicated that frustration was higher when changes were introduced in a stepwise manner compared to an introduction all at once (see Table 1). As this is not the hypothesized direction, Hypothesis 3 was not supported (see Table 2).

### 3.2. Exploratory results

To answer our research question whether retentivity and specific self-efficacy are related to the number of adaptation errors, task execution time, and frustration, the correlations between these variables were analyzed (see Table 1). In both experimental conditions, there was a significant negative relationship between retentivity and task execution time, indicating that higher retentivity was related to lower task execution time. According to Cohen (1988), the effect size was medium.

Additionally, there was a significant negative relationship between specific self-efficacy and frustration, indicating that higher specific self-efficacy was related to lower frustration. Again, the effect size was medium (Cohen, 1988).

In the condition of stepwise change introduction, there was a

significant negative relationship between the number of pre-change errors and specific self-efficacy, indicating that fewer pre-change errors were related to higher specific self-efficacy. The effect size was medium as well (Cohen, 1988).

## 4. Discussion

The results of our simulation study showed that a stepwise introduction of changes led to marginally significantly fewer adaptation errors and significantly lower task execution time compared to an introduction of changes all at once. At the descriptive level, frustration was higher in the condition of stepwise changes. Furthermore, retentivity was significantly negatively correlated with task execution time, whereas specific self-efficacy was significantly negatively correlated with frustration. Only in the condition of stepwise change introduction, specific self-efficacy was significantly negatively correlated with the number of pre-change errors.

The fact that a stepwise introduction of changes led to less task execution time and (at the descriptive level) fewer adaptation errors indicates better adaptive performance compared to the introduction of changes all at once. The stepwise introduction of changes goes along with less information that must be processed simultaneously and, compared to an introduction all at once, a lower level of cognitive load (Sweller, 1994). From a long-term perspective, the stepwise introduction seems to be beneficial for adaptive performance, even though it takes more time until all changes are implemented. This implies that organizations should not wait until the necessity for change has accumulated and should rather focus on continuous and small adjustments. These empirical results support the theoretical perspective of Weick and Quinn (1999), who stated that an ideal organization is capable of continuously adapting, and that radical change only becomes necessary when continuous adaptation has failed.

However, there was no significant difference in the level of frustration between the two groups. At the descriptive level, our results showed higher frustration when the changes were introduced in a stepwise manner compared to the introduction all at once. This is contradictory to our assumptions and not in line with the findings of Fasbender and Gerpott (2023), who outlined a positive relationship between cognitive load and frustration. An explanation for this finding might be that the stepwise introduction of changes meant that the participants were constantly interrupted in their work and had to balance consistent work steps and adaptive demands (Turner and Rindova, 2012). This might cause the feeling of never coming to an end of restructuring. In contrast, the participants who were faced with a change introduction all at once only had one interruption. Past research outlined that frequency of changes was indirectly negatively related to satisfaction (Rafferty and Griffin, 2006), which might be another explanation for increased frustration.

Not only the way of change implementation but also individual factors seem to be relevant in change situations. Higher retentivity led to faster task execution time, which underlines the beneficial effect of

**Table 2**

Results of hypothesis testing (one-tailed).

| Variable                    | Group       | Mean rank | U       | Z      | p    |
|-----------------------------|-------------|-----------|---------|--------|------|
| Number of adaptation errors | Stepwise    | 33.24     | 530.500 | -1.300 | .098 |
|                             | All at once | 38.84     |         |        |      |
| Task execution time         | Stepwise    | 31.15     | 455.500 | -2.007 | .022 |
|                             | All at once | 40.99     |         |        |      |
| Frustration                 | Stepwise    | 39.10     | 518.500 | -1.288 | .100 |
|                             | All at once | 32.81     |         |        |      |

Note. Maximum possible number of adaptation errors: 60; Likert-scale measuring frustration: 1–5; Likert-scale measuring specific self-efficacy: 1–6; Maximum possible number of pre-change errors: 10; Stepwise:  $n = 36$ ; All at once:  $n = 35$ .

retentivity in change situations. Retentivity facilitates skill retention (Kluge et al., 2016), which in turn has the positive effect that participants can quickly recall and execute their tasks. They do not have to spend a long time with thinking about what comes next and have a faster task execution time. However, there was no significant relation with the number of adaptation errors. This is in line with our previous findings that adaptation errors might result from errors in different processes of adaptive performance (Roling et al., 2024). Only if adaptation errors result from huge adaptation struggles and not only from single attentional or memory failures or misunderstood instructions, is there a relation to low retentivity. This would explain why there is no linear relationship between the number of adaptation errors and retentivity. However, it must be considered that the present dataset was partly overlapping with the dataset used for that analysis. Additionally, our present study identified that higher specific self-efficacy was related to less frustration. This finding is in line with previous research, emphasizing that people with high self-efficacy tend to engage in problem solving when confronted with failures (Peterson and Arnn, 2005). This solution-oriented behavior might be an explanation why people with high self-efficacy have less tendency to get upset in difficult situations. In the condition of stepwise introduced changes, the number of pre-change errors was negatively related to specific self-efficacy, indicating that participants who came with a better baseline performance were more confident to deal with the changes. This was not visible in the condition of radical change all at once, which indicates that those participants do not take their self-efficacy from pre-change performance. Since there can be different sources of self-efficacy (Gale et al., 2021), the participants in the condition of change introduction all at once might have assessed another one as appropriate.

#### 4.1. Practical and theoretical implications

Our study contributes to empirical research on change and adaptation and enhances knowledge on how to effectively design change processes. The close-to-real study setting enables the derivation of concrete implications for organizational practice. First, our results emphasize that organizations should implement changes in a stepwise rather than a radical manner to improve adaptive performance. Information processing seemed to be easier, and people needed less time to execute their tasks when changes were implemented in a stepwise manner. However, this stepwise implementation of changes tended to evoke higher levels of frustration. Therefore, organizations should focus on good communication and coordination strategies to minimize the occurrence of frustration (see Fig. 5). It is crucial to consider employee's needs and well-being to prevent the occurrence of negative emotions and their consequences. In this context, one crucial aspect could be the time between change implementations. Time intervals should not be too short, as frequent interruptions might increase the occurrence of frustration. Additionally, retentivity and specific self-efficacy unfolded as beneficial factors in change situations. Organizations should take this into account and develop strategies on how to buffer a low level of these individual factors. Individuals with low retentivity could benefit from

checklists, specific retrieval cues, or trainings. Those with low self-efficacy could be supported through regular feedback and empowerment.

In addition to practical implications, our results also provide empirical support on existing theories in ergonomics and human factors research. The important role of task-related aspects is outlined, as the amount of information that must be processed simultaneously seems to have an impact on adaptive performance in change situations. The way how task changes are introduced is one of the relevant factors for adaptive performance. Not only individual and environmental factors, but also detailed task-related factors are of interest in change situations. The assumption that cognitive load has an impact on performance could be supported with empirical data, focusing on the adaptive facet of performance. This extends prior research on cognitive load and performance, emphasizing that this relationship is relevant in different situations and contexts. Furthermore, our results outlined that performance and well-being must be considered in a differentiated way. Interventions that enhance performance do not necessarily lead to high well-being as well.

#### 4.2. Limitations and directions for future research

Nevertheless, when interpreting the results of our study, limitations must be considered. Due to the study setting, the time window between the stepwise introduced changes in our experiment was very short. This might have overwhelmed the participants and particularly have encouraged frustration. Unfortunately, we were not able to operationalize the stepwise introduction over a longer time period, which is a limitation of our study and not comparable to reality. In general, it must be considered that our study has not been conducted in a real organization with workers who must adapt work steps they have had internalized for years. Nevertheless, even though external validity is limited, the simulation environment provides a close-to-real and standardized setting. However, it should be mentioned that it was impossible to completely standardize data collection, since technical problems as well as interactions between the team members might have had an impact. Furthermore, we should consider that the changes occurred for different types of actions with different contents. A closer look on the quality and plausibility of the actions and their position and relevance for the whole manufacturing process would be necessary. These aspects, as well as the feedback the participants receive during the manufacturing process, might have an impact on the success of adaptation and possible learning from adaptation errors. It also should be considered that the manufacturing steps on the two work positions differ from each other, although we aimed to standardize the manufacturing steps as much as possible.

These methodological limitations should be considered in future research. Similar studies would benefit from incorporating these aspects to further refine their methodological design. In addition, the empirical results themselves provide a valuable starting point for future research on change and adaptation. More empirical research is needed to shed light on the interactions of task-related and individual factors that

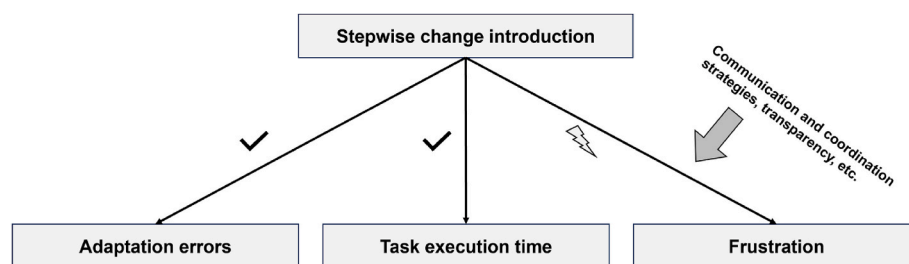


Fig. 5. Stepwise change introduction and its consequences  
Note. This figure does not display any statistical significances.

influence performance and well-being. Further applied research is necessary to develop a comprehensive understanding of these processes. Moreover, future research should empirically investigate the role of cognitive load. It must be considered that we did not explicitly measure cognitive load in our study.

#### 4.3. Conclusion

In sum, our study sheds light on the consequences different ways of change implementation have. Stepwise introduction of changes led to a better adaptive performance compared to change introduction all at once. However, the stepwise introduction did not lead to reduced frustration. At the descriptive level, frustration was even higher compared to the change introduction all at once. These results outline the advantages of continuous change and adaptation but also emphasize the necessity of thoughtful change management to prevent the occurrence of frustration. Additionally, the impact of person-related variables should not be neglected. The way how changes are implemented can have far reaching consequences for performance and well-being.

#### 5. Relevance to industry

Adaptation to change is central for coping with today's fast-changing working world. Our results point out that changes should be implemented in a stepwise manner to increase human adaptive performance. Interventions to minimize frustration and buffer low levels of retentivity and specific self-efficacy should be considered for organizational change management.

#### CRediT authorship contribution statement

**Wiebke M. Roling:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Marcus Grum:** Writing – review & editing, Software. **Norbert Gronau:** Writing – review & editing, Supervision, Software, Funding acquisition. **Annette Kluge:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

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#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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#### Data availability

Data will be made available on request.

#### References

- Anderson, M.C., 2020. Motivated forgetting. In: Baddeley, A., Eysenck, M.W., Anderson, M.C. (Eds.), *Memory*, third ed. Routledge, pp. 315–349. <https://doi.org/10.4324/9780429449642-10>.
- Bandura, A., 1997. *Self-efficacy: the Exercise of Control*. W. H. Freeman and Company.
- Bentley, T., Green, N., Tappin, D., Haslam, R., 2021. State of science: the future of work - ergonomics and human factors contributions to the field. *Ergonomics* 64 (4), 427–439. <https://doi.org/10.1080/00140139.2020.1841308>.
- Betsch, T., Haberstroth, S., Molter, B., Glöckner, A., 2004. Oops, I did it again - relapse errors in routinized decision making. *Organ. Behav. Hum. Decis. Process.* 93 (1), 62–74. <https://doi.org/10.1016/j.obhdp.2003.09.002>.
- Biondi, F.N., Cacanindin, A., Douglas, C., Cort, J., 2021. Overloaded and at work: investigating the effect of cognitive workload on assembly task performance. *Hum. Factors* 63 (5), 813–820. <https://doi.org/10.1177/0018720820929928>.
- Cascio, W.F., Montealegre, R., 2016. How technology is changing work and organizations. *Annual Review of Organizational Psychology and Organizational Behavior* 3, 349–375. <https://doi.org/10.1146/annurev-orgpsych-041015-062352>.
- Chan, X.W., Kalliath, T., Brough, P., O'Driscoll, M., Siu, O.-L., Timms, C., 2017. Self-efficacy and work engagement: test of a chain model. *Int. J. Manpow.* 38 (6), 819–834. <https://doi.org/10.1108/IJM-11-2015-0189>.
- Choi, H.-H., van Merriënboer, J.J.G., Paas, F., 2014. Effects of the physical environment on cognitive load and learning: towards a new model of cognitive load. *Educ. Psychol. Rev.* 26 (2), 225–244. <https://doi.org/10.1007/s10648-014-9262-6>.
- Cohen, J., 1988. *Statistical Power Analysis for the Behavioral Sciences*, second ed. Routledge. <https://doi.org/10.4324/9780203771587>.
- Davis, M.C., Challenger, R., Jayewardene, D.N.W., Clegg, C.W., 2014. Advancing socio-technical systems thinking: a call for bravery. *Appl. Ergon.* 45 (2), 171–180. <https://doi.org/10.1016/j.apergo.2013.02.009>.
- De Bruyne, J., Joundi, J., Morton, J., Zheleva, A., van Kets, N., van Wallendael, G., Talsma, D., Saldien, J., Marez, L. de, Durme, W., Bombeke, K., 2023. I spy with my AI: the effects of AI-based visual cueing on human operators' performance and cognitive load in CCTV control rooms. *Int. J. Ind. Ergon.* 95. <https://doi.org/10.1016/j.ergon.2023.103444>. Article 103444.
- Dinneen, L.C., Blakesley, B.C., 1973. Algorithm AS 62: a generator for the sampling distribution of the Mann-Whitney U Statistic. *Journal of the Royal Statistical Society. Series C (Applied Statistics)* 22 (2), 269–275. <https://doi.org/10.2307/2346934>.
- Fasbender, U., Gerpott, F.H., 2023. Designing work for change and its unintended side effects. *J. Vocat. Behav.* 145. <https://doi.org/10.1016/j.jvb.2023.103913>. Article 103913.
- Fida, R., Paciello, M., Tramontano, C., Barbaranelli, C., Farnese, M.L., 2015. "Yes, I can": the protective role of personal self-efficacy in hindering counterproductive work behavior under stressful conditions. *Hist. Philos. Logic* 28 (5), 479–499. <https://doi.org/10.1080/10615806.2014.969718>.
- Fisher, C.D., 2002. Antecedents and consequences of real-time affective reactions at work. *Motiv. Emot.* 26 (1), 3–30. <https://doi.org/10.1023/A:1015190007468>.
- Frank, B., 2015. Presence messen in laborbasierter Forschung mit Mikrowelten - Entwicklung und erste Validierung eines Fragebogens zur Messung von Presence [Measuring presence in lab-based research with microworlds - Development and initial validation of a questionnaire to measure presence]. Springer. <https://doi.org/10.1007/978-3-658-08148-5>.
- Gale, J., Alemdar, M., Cappelli, C., Morris, D., 2021. A mixed methods study of self-efficacy, the sources of self-efficacy, and teaching experience. *Frontiers in Education* 6. <https://doi.org/10.3389/feedu.2021.750599>. Article 750599.
- Gronau, N., Kluge, A., Haase, J., Thim, C., 2021. Experiential learning factories: Bridging the gap between lab and field experiments. <https://doi.org/10.2139/ssrn.4469819>.
- Hart, S.G., Staveland, L.E., 1988. Development of NASA-TLX (Task Load Index): results of empirical and theoretical research. In: Hancock, P.A., Meshkati, N. (Eds.), *Advances in Psychology: Vol. 52. Human Mental Workload*. North Holland, pp. 139–183. [https://doi.org/10.1016/S0166-4115\(08\)62386-9](https://doi.org/10.1016/S0166-4115(08)62386-9).
- Iskander, M., 2019. Burnout, cognitive overload, and metacognition in medicine. *Medical Science Educator* 29 (1), 325–328. <https://doi.org/10.1007/s40670-018-00654-5>.
- Jäger, A.O., Süß, H.-M., Beauducel, A., 1997. *Berliner Intelligenzstruktur-Test (Form 4; BIS-4) [Berlin Test of Intelligence Structure (Form 4; BIS-4)]*. Hogrefe.
- Jeronimus, B.F., Laceulle, O.M., 2017. Frustration. In: Zeigler-Hill, V., Shackelford, T.K. (Eds.), *Encyclopedia of Personality and Individual Differences*. Springer. [https://doi.org/10.1007/978-3-319-28099-8\\_815-1](https://doi.org/10.1007/978-3-319-28099-8_815-1).
- Jundt, D.K., Shoss, M.K., 2023. A process perspective on adaptive performance: research insights and new directions. *Group Organ. Manag.* 48 (2), 405–435. <https://doi.org/10.1177/10596011231161404>.
- Jundt, D.K., Shoss, M.K., Huang, J.L., 2015. Individual adaptive performance in organizations: a review. *J. Organ. Behav.* 36 (S1), S53–S71. <https://doi.org/10.1002/job.1955>.
- Kadir, B.A., Broberg, O., 2020. Human well-being and system performance in the transition to Industry 4.0. *Int. J. Ind. Ergon.* 76. <https://doi.org/10.1016/j.ergon.2020.102936>. Article 102936.
- Kadir, B.A., Broberg, O., Da Conceição, C.S., 2019. Current research and future perspectives on human factors and ergonomics in Industry 4.0. *Comput. Ind. Eng.* 137. <https://doi.org/10.1016/j.cie.2019.106004>. Article 106004.
- Karwowski, W., Zhang, W., 2021. The discipline of human factors and ergonomics. In: Salvendy, G., Karwowski, W. (Eds.), *Handbook of Human Factors and Ergonomics*, fifth ed. Wiley, pp. 3–37. <https://doi.org/10.1002/9781119636113.ch1>.
- Kersting, M., Althoff, K., Jäger, A.O., 2008. *Wilde-Intelligenz-Test 2 (WIT-2) [Wilde Intelligence Test 2 (WIT-2)]*. Hogrefe.

- Khaw, K.W., Alnoor, A., Al-Abrow, H., Tiberius, V., Ganesan, Y., Atshan, N.A., 2023. Reactions towards organizational change: a systematic literature review. *Curr. Psychol.* 42, 19137–19160. <https://doi.org/10.1007/s12144-022-03070-6>.
- Kim, S., Wang, Y., Boon, C., 2021. Sixty years of research on technology and human resource management: looking back and looking forward. *Hum. Resour. Manag.* 60 (1), 229–247. <https://doi.org/10.1002/hrm.22049>.
- Kluge, A. (2004). *Wissenserwerb für das Steuern komplexer Systeme [Knowledge acquisition for the control of complex systems]*. Pabst.
- Kluge, A., Frank, B., Maafi, S., Kuzmanovska, A., 2016. Does skill retention benefit from retentivity and symbolic rehearsal? – Two studies with a simulated process control task. *Ergonomics* 59 (5), 641–656. <https://doi.org/10.1080/00140139.2015.1101167>.
- Kluge, A., Gronau, N., 2018. Intentional forgetting in organizations: the importance of eliminating retrieval cues for implementing new routines. *Front. Psychol.* 9. <https://doi.org/10.3389/fpsyg.2018.00051>. Article 51.
- Kluge, A., Schöffler, A.S., Thim, C., Gronau, N., 2024. Facilitating and hindering factors for routine adaptations in manufacturing and effects on human performance - unexpected insights from three experimental studies in a special purpose setting. *Ergonomics* 1–19. <https://doi.org/10.1080/00140139.2024.2369706>.
- Kluge, A., Silbert, M., Wiemers, U.S., Frank, B., Wolf, O.T., 2019. Retention of a standard operating procedure under the influence of social stress and refresher training in a simulated process control task. *Ergonomics* 62 (3), 361–375. <https://doi.org/10.1080/00140139.2018.1542036>.
- Körner, A., Geyer, M., Roth, M., Drapeau, M., Schmutzer, G., Albani, C., Schumann, S., Brähler, E., 2008. Persönlichkeitsdiagnostik mit dem NEO-Fünf-Faktoren-Inventar: Die 30-Item-Kurzversion (NEO-FFI-30) [Personality assessment with the NEO-Five-Factor Inventory: The 30-Item-Short-Version (NEO-FFI-30)]. *Psychother. Psychosom. Med. Psychol.* 58 (6), 238–245. <https://doi.org/10.1055/s-2007-986199>.
- Lagomarsino, M., Lorenzini, M., Momi, E. de, Ajoudani, A., 2022. An online framework for cognitive load assessment in industrial tasks. *Robot. Comput. Integrated Manuf.* 78. <https://doi.org/10.1016/j.rcim.2022.102380>. Article 102380.
- Lang, J.W.B., Bliese, P.D., 2009. General mental ability and two types of adaptation to unforeseen change: applying discontinuous growth models to the task-change paradigm. *J. Appl. Psychol.* 94 (2), 411–428. <https://doi.org/10.1037/a0013803>.
- Lazar, J., Jones, A., Shneiderman, B., 2006. Workplace user frustration with computers: an exploratory investigation of the causes and severity. *Behav. Inf. Technol.* 25 (3), 239–251. <https://doi.org/10.1080/01449290500196963>.
- Leyman, E., Mirka, G., Kaber, D., Sommerich, C., 2004. Cervicobrachial muscle response to cognitive load in a dual-task scenario. *Ergonomics* 47 (6), 625–645. <https://doi.org/10.1080/00140130310001629766>.
- Liu, Y., Perrewé, P.L., 2005. Another look at the role of emotion in the organizational change: a process model. *Hum. Resour. Manag. Rev.* 15 (4), 263–280. <https://doi.org/10.1016/j.hrmr.2005.12.001>.
- Mariano, S., Casey, A., Olivera, F., 2020. Organizational forgetting part I: a review of the literature and future research directions. *Learn. Organ.* 27 (3), 185–209. <https://doi.org/10.1108/TLO-12-2019-0182>.
- McKnight, D.H., Carter, M., Thatcher, J.B., Clay, P.F., 2011. Trust in a specific technology: an investigation of its components and measures. *ACM Transactions on Management Information Systems* 2 (2). <https://doi.org/10.1145/1985347.1985353>. Article 12.
- Neyer, F.J., Felber, J., Gebhardt, C., 2012. Entwicklung und Validierung einer Kurzskaala zur Erfassung von Technikbereitschaft [Development and validation of a brief measure of technology commitment]. *Diagnostica* 58 (2), 87–99. <https://doi.org/10.1026/0012-1924/a000067>.
- Niessen, C., Göbel, K., Siebers, M., Schmid, U., 2020. Time to forget: intentional forgetting in the digital world of work. *Z. Arbeits- Organisationspsychol.* 64 (1), 30–45. <https://doi.org/10.1026/0932-4089/a000308>.
- Niessen, C., Lang, J.W.B., 2021. Cognitive control strategies and adaptive performance in a complex work task. *J. Appl. Psychol.* 106 (10), 1586–1599. <https://doi.org/10.1037/apl0000830>.
- Nuutinen, M., 2005. Contextual assessment of working practices in changing work. *Int. J. Ind. Ergon.* 35 (10), 905–930. <https://doi.org/10.1016/j.ergon.2005.04.001>.
- Oreg, S., Vakola, M., Armenakis, A., 2011. Change recipients' reactions to organizational change. *J. Appl. Behav. Sci.* 47 (4), 461–524. <https://doi.org/10.1177/0021886310396550>.
- Park, S Sohee, Park, S Sunyoung, 2019. Employee adaptive performance and its antecedents: review and synthesis. *Hum. Resour. Dev. Rev.* 18 (3), 294–324. <https://doi.org/10.1177/1534484319836315>.
- Park, S Sohee, Park, S Sunyoung, 2021. How can employees adapt to change? Clarifying the adaptive performance concepts. *Hum. Resour. Dev. Q.* 32 (1), E1–E15. <https://doi.org/10.1002/hrdq.21411>.
- Parker, S.K., Grote, G., 2022. Automation, algorithms, and beyond: why work design matters more than ever in a digital world. *Appl. Psychol.* 71 (4), 1171–1204. <https://doi.org/10.1111/apps.12241>.
- Petermann, M.K.H., Zacher, H., 2020. Agility in the workplace: conceptual analysis, contributing factors, and practical examples. *Industrial and Organizational Psychology* 13 (4), 599–609. <https://doi.org/10.1017/iop.2020.106>.
- Peterson, T.O., Amn, R.B., 2005. Self-efficacy: the foundation of human performance. *Perform. Improv. Q.* 18 (2), 5–18. <https://doi.org/10.1111/j.1937-8327.2005.tb00330.x>.
- Pulakos, E.D., Arad, S., Donovan, M.A., Plamondon, K.E., 2000. Adaptability in the workplace: development of a taxonomy of adaptive performance. *J. Appl. Psychol.* 85 (4), 612–624. <https://doi.org/10.1037//0021-9010.85.4.612>.
- Rafferty, A.E., Griffin, M.A., 2006. Perceptions of organizational change: a stress and coping perspective. *J. Appl. Psychol.* 91 (5), 1154–1162. <https://doi.org/10.1037/0021-9010.91.5.1154>.
- Roling, W.M., Grum, M., Gronau, N., Kluge, A., 2024. The roots of errors in adaptive performance: Clustering behavioral patterns after the introduction of a change. *J. Workplace Learn.* 36 (4), 267–281. <https://doi.org/10.1108/JWL-10-2023-0168>.
- Salgado, J.F., Anderson, N., Moscoso, S., Bertua, C., De Fruyt, F., 2003. International validity generalization of GMA and cognitive abilities: a European community meta-analysis. *Person. Psychol.* 56 (3), 573–605. <https://doi.org/10.1111/j.1744-6570.2003.tb00751.x>.
- Schmitt, N., Chan, D., 2014. Adapting to rapid changes at work. In: Chan, D. (Ed.), *Individual Adaptability to Changes at Work: New Directions in Research*, first ed. Routledge, pp. 3–17.
- Schwarzer, R., Jerusalem, M., 1999. Skalen zur Erfassung von Lehrer- und Schülermerkmalen. Dokumentation der psychometrischen Verfahren im Rahmen der Skalen zur Erfassung von Lehrer- und Schülermerkmalen. Dokumentation der psychometrischen Verfahren im Rahmen der Wissenschaftlichen Begleitung des Modellversuchs Selbstwirksame Schulen [Scales for measuring teacher and pupil characteristics. Documentation of the psychometric procedures in the context of the scales for measuring teacher and pupil characteristics. Documentation of the Psychometric Procedures as Part of the Scientific Monitoring of the Self-Effective Schools Pilot Project].
- Sony, M., Mekoth, N., 2022. Employee adaptability skills for Industry 4.0 success: a road map. *Production & Manufacturing Research* 10 (1), 24–41. <https://doi.org/10.1080/21693277.2022.2035281>.
- Spector, P.E., 1978. Organizational frustration: a model and review of the literature. *Person. Psychol.* 31 (4), 815–829. <https://doi.org/10.1111/j.1744-6570.1978.tb02125.x>.
- Stajkovic, A.D., Luthans, F., 1998. Self-efficacy and work-related performance: a meta-analysis. *Psychol. Bull.* 124 (2), 240–261. <https://doi.org/10.1037/0033-2909.124.2.240>.
- Stone-Romero, E.F., 2011. Research strategies in industrial and organizational psychology: nonexperimental, quasi-experimental, and randomized experimental research in special purpose and nonspecial purpose settings. In: Zedeck, S. (Ed.), *APA Handbook of Industrial and Organizational Psychology*, vol. 1. American Psychological Association, pp. 37–72. <https://doi.org/10.1037/12169-002>. *Building and developing the organization*.
- Sweller, J., 1994. Cognitive load theory, learning difficulty, and instructional design. *Learn. Instruct.* 4 (4), 295–312. [https://doi.org/10.1016/0959-4752\(94\)90003-5](https://doi.org/10.1016/0959-4752(94)90003-5).
- Sweller, J., Ayres, P., Kalyuga, S., 2011. *Cognitive Load Theory*. Springer. <https://doi.org/10.1007/978-1-4419-8126-4>.
- Thielsch, M.M., Meelen, S.M., Hertel, G., 2018. Trust and distrust in information systems at the workplace. *PeerJ* 6. <https://doi.org/10.7717/peerj.5483>. Article e5483.
- Tucker, D.A., Hendy, J., Barlow, J., 2014. When infrastructure transition and work practice redesign collide. *J. Organ. Change Manag.* 27 (6), 955–972. <https://doi.org/10.1108/JOCM-09-2013-0173>.
- Turner, S.F., Rindova, V., 2012. A balancing act: how organizations pursue consistency in routine functioning in the face of ongoing change. *Organ. Sci.* 23 (1), 24–46. <https://doi.org/10.1287/orsc.1110.0653>.
- Vandierendondck, A., 2017. A comparison of methods to combine speed and accuracy measures of performance: a rejoinder on the binning procedure. *Behav. Res. Methods* 49 (2), 653–673. <https://doi.org/10.3758/s13428-016-0721-5>.
- Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D., 2003. User acceptance of information technology: toward a unified view. *MIS Q.* 27 (3), 425–478. <https://doi.org/10.2307/30036540>.
- Weick, K.E., Quinn, R.E., 1999. Organizational change and development. *Annu. Rev. Psychol.* 50, 361–386. <https://doi.org/10.1146/annurev.psych.50.1.361>.
- Wilson, J.R., 2000. Fundamentals of ergonomics in theory and practice. *Appl. Ergon.* 31 (6), 557–567. [https://doi.org/10.1016/S0003-6870\(00\)00034-X](https://doi.org/10.1016/S0003-6870(00)00034-X).
- Woods, D., Decker, S., 2000. Anticipating the effects of technological change: a new era of dynamics for human factors. *Theor. Issues Ergon. Sci.* 1 (3), 272–282. <https://doi.org/10.1080/14639220110037452>.
- Yang, H., Weng, Q., Li, J., Wu, S., 2022. Exploring the relationship between trait emotional intelligence and adaptive performance: the role of situational strength and self-efficacy. *Pers. Individ. Differ.* 196. <https://doi.org/10.1016/j.paid.2022.111711>. Article 111711.