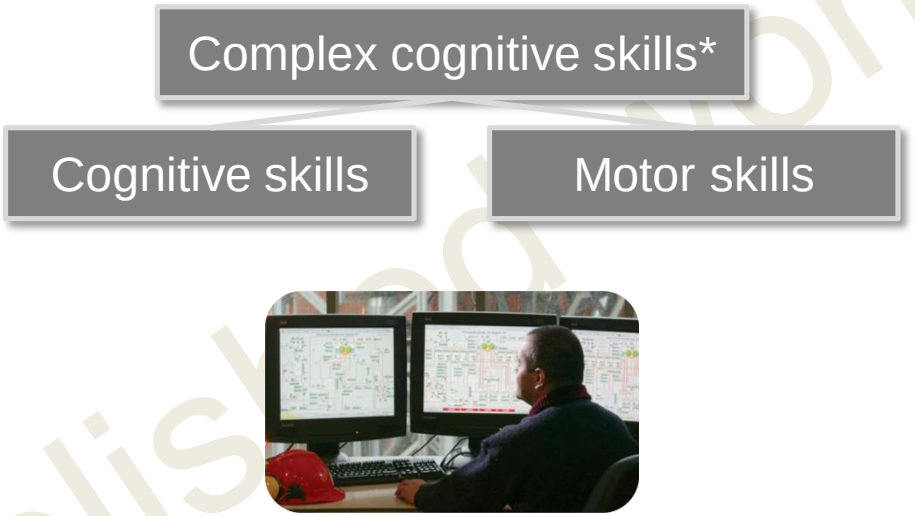
Is Test-Enhanced Learning Able to Support Complex Cognitive Skill Retention in Fixed Tasks, Dual Tasks and Decision-Making Tasks?

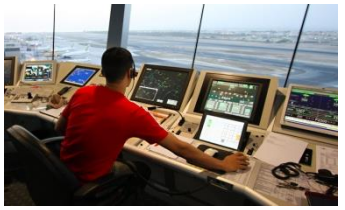
Barbara Frank
Merle Lau
Annette Kluge

BUSINESS-PSYCHOLOGY

DFG Number KL2207/3-3

Complex cognitive skills (Van Merriënboer, 1997)





- Complex cognitive skills can be learned based on standard operating procedures (SOP) (Wickens & Hollands, 2000)
- Such complex tasks in non-routine situations can consist of e.g. fixed, sequential tasks or parallel tasks:
  - In fixed, sequential tasks the operators need to figure out first what kind of task has to be executed (e.g. start-up of a plant or error management) and then execute the initial learned standard operating procedures sequentially (Kluge, 2014)

* synonyms: High performance skills, complex technical skills, industrial skills

Testing-effect and complex cognitive skills

Testing effect is explained by (Bjork & Bjork, 1992; Roediger & Karpicke, 2006)

1) the *intense retrieval* effort that learners have to invest in the testing situation to retrieve information from long-term memory
2) a *transfer enhancing processing* of information which is identical in the refresher situation and the later retention assessment (RA) situation

- Testing effect has been shown for simple task (e.g. word lists) (e.g., Carpenter et al., 2006; Carpenter et al., 2008; Karpicke & Roediger 2007, 2008)
- Little research for testing effect and complex tasks (Rawson, 2015; Kluge & Frank, 2014)
- Existing research is **inconsistent**

Testing is effective for complex material (e.g. Karpicke & Aue, 2015)

Testing is *not* effective for complex material (e.g. Leahy, Hanham & Sweller, 2015; van Gog & Sweller, 2015; van Gog, Kester, Dirks, Hoogerheide, Boerboom, & Verkoeijen, 2015)

Complex tasks

Complex tasks in non-routine situations can consist of e.g. fixed, sequential tasks or parallel tasks:

Fixed sequence task

- Operators first need … to be executed (e.g. start-up of a plant or error … execute the initially learned standard operating pr… , 2014)

$$S1 \rightarrow A \rightarrow B$$

Parallel sequence task

- Parallel-sequence tasks basically consist of two sequences which have to be synchronised in time (Proctor & Dutta, 1995; Wickens, & McCarley, 2008; Wickens, 2008). In these tasks e.g. the operato… executing a first task, and both tasks are ex… s, directed attention allocation and time-sl… ask (Schumacher et al., 2001) An example of such a task is when a pilot is controlling different instruments during take-off, and consequently has to divide his/her attention according to change frequency and how valuable and costly the attention is (Moray, 1986)

$$S1 \rightarrow A1 \text{ AND } A2 \rightarrow B$$

Contingent sequence task

- Dynamic decision making can be defined by multiple, interdependent and real-time decisions, occur… s independently and as a function of a sequenc… an environment, decisions under certainty take p… sible alternatives, consequences and th… A contingent-sequence task under certainty c… in which at a special point or under a special condition, the operator has to perform the next steps based on a correct gathering of information and interpretation of the situation.

$$S1 = X \rightarrow A_x \rightarrow B$$
$$\text{OR}$$
$$S1 = Y \rightarrow A_y \rightarrow B$$

Question

- Testing as a refresher intervention supports skill retention better than practice or no intervention for all three task-types

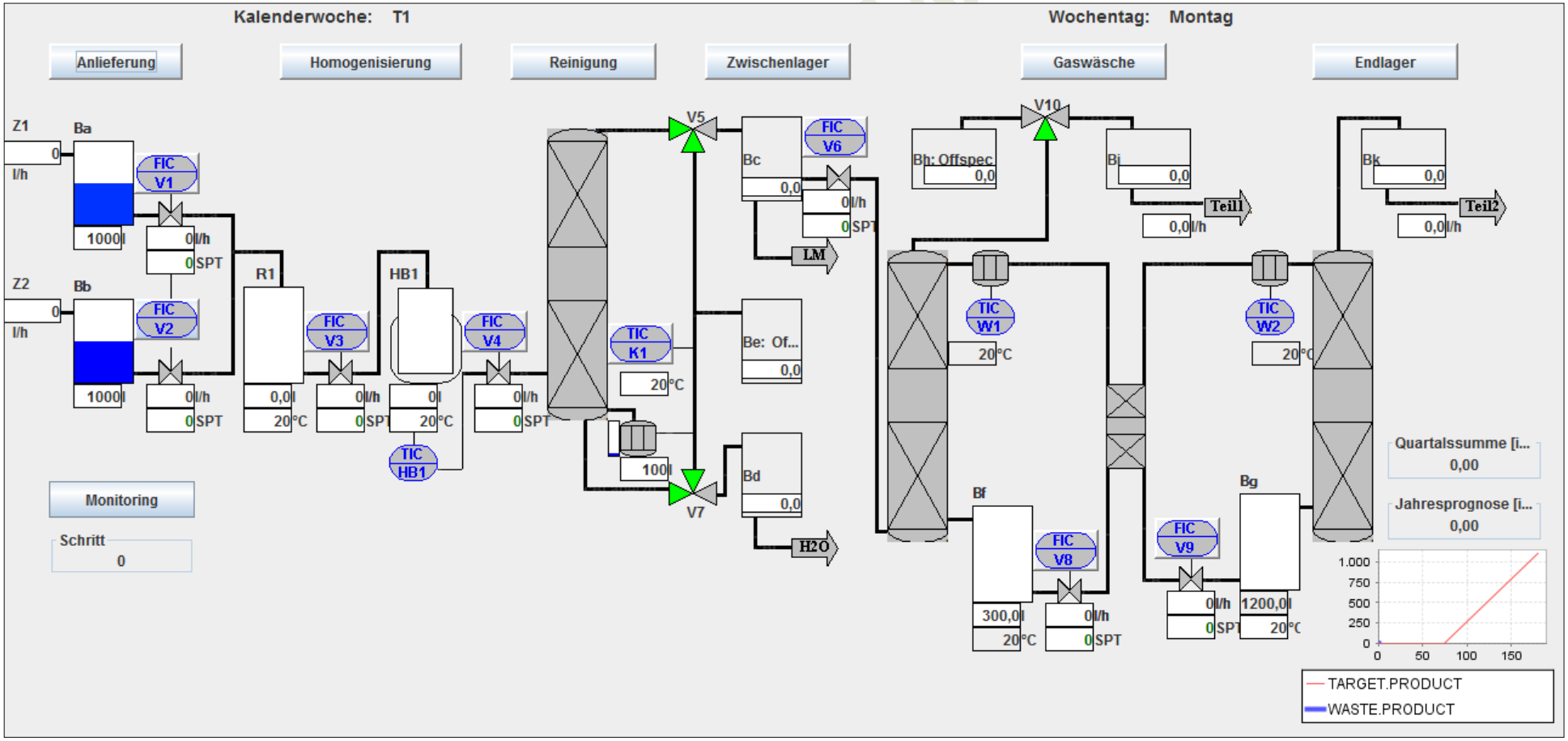
Hypothesis for Experiment 1, 2 & 3

H1 Testing supports performance better than no intervention

H2 Testing supports performance better than a practice (relearning) refresher intervention

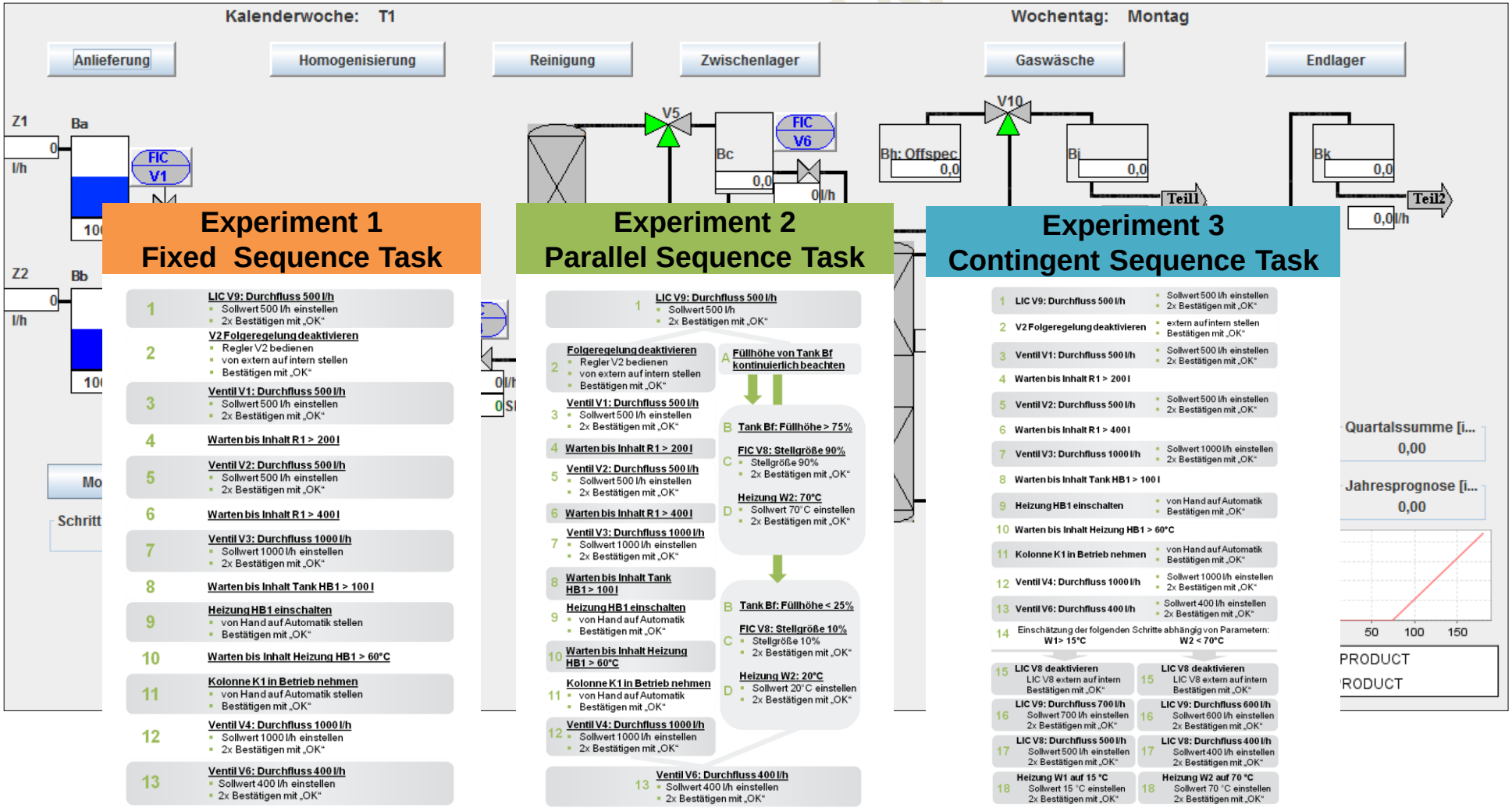
Method: Waste Water Treatment Simulation

Process control task: Separate waste water into water and gas



Method: Waste Water Treatment Simulation

Process control task: Separate waste water into water and gas

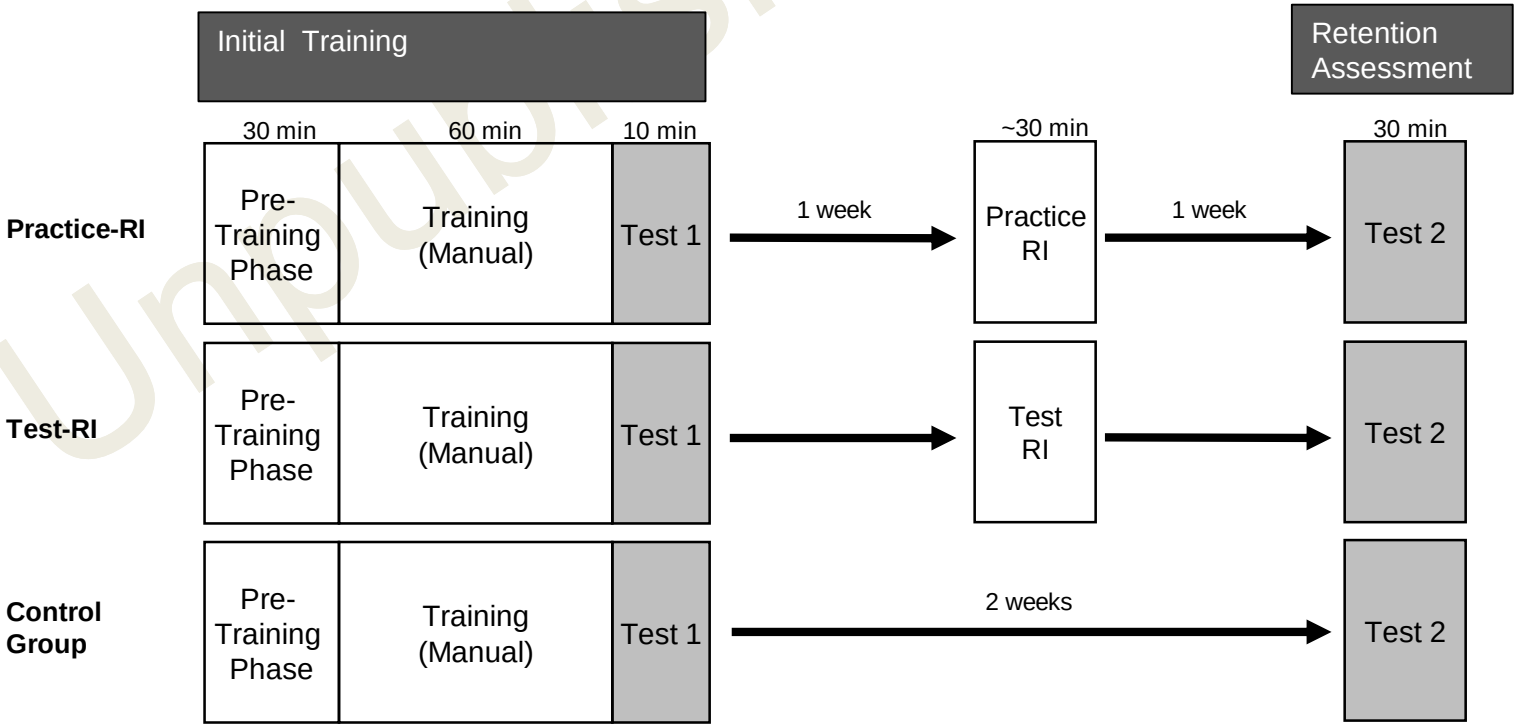


Method Exp. 1-3: Participants & Procedure

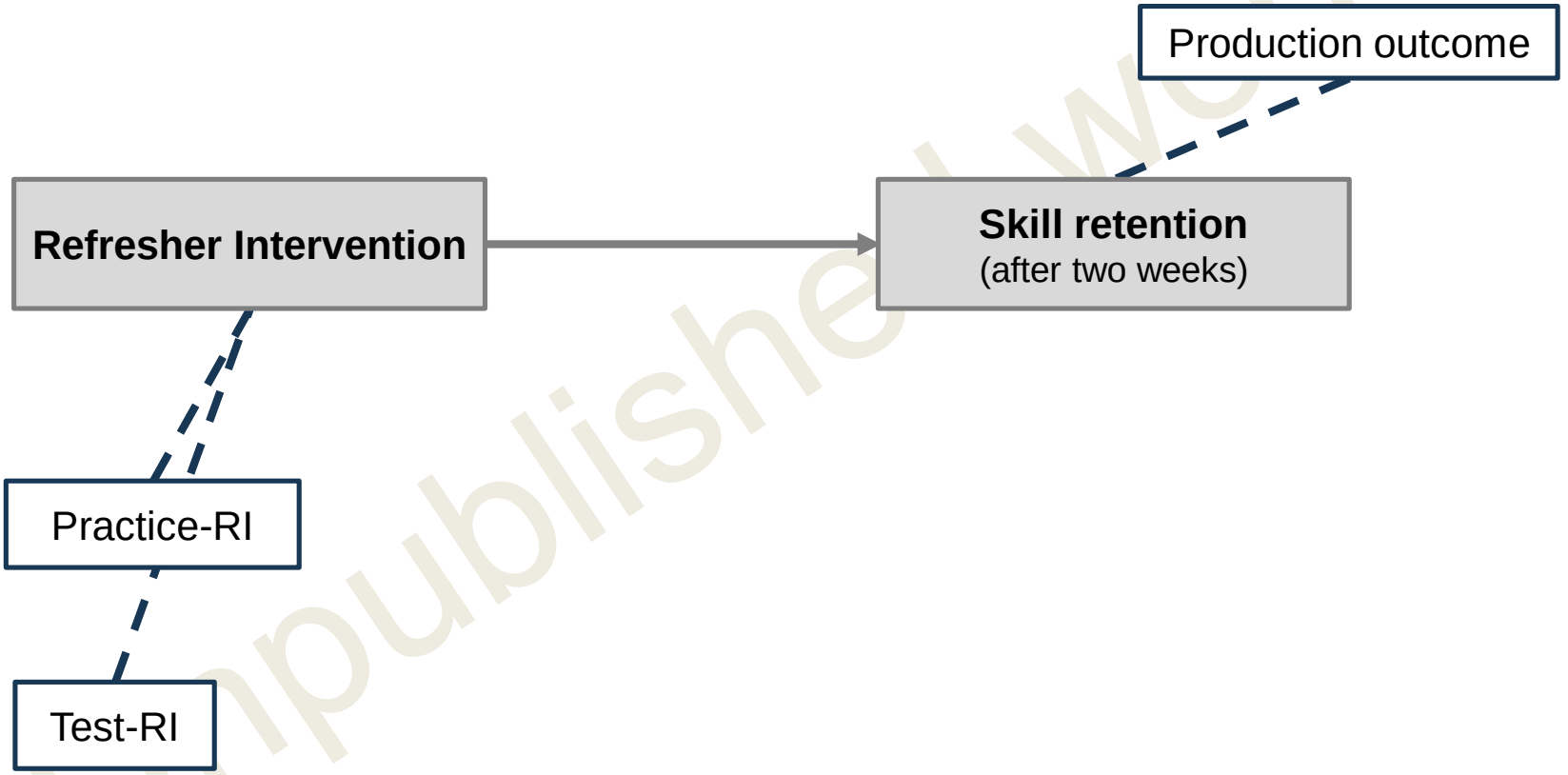
Participants

Experiment 1: Fix	Experiment 2: Parallel	Experiment 3: Contingent
N=57 (18 female)	*N*=60 (16 female)	*N*=58 (22 female)
Age: 21.88 (3.14, 18-31)	Age: 23.45 (3.57, 19-36)	Age: 22.76 (3.11, 17-32)

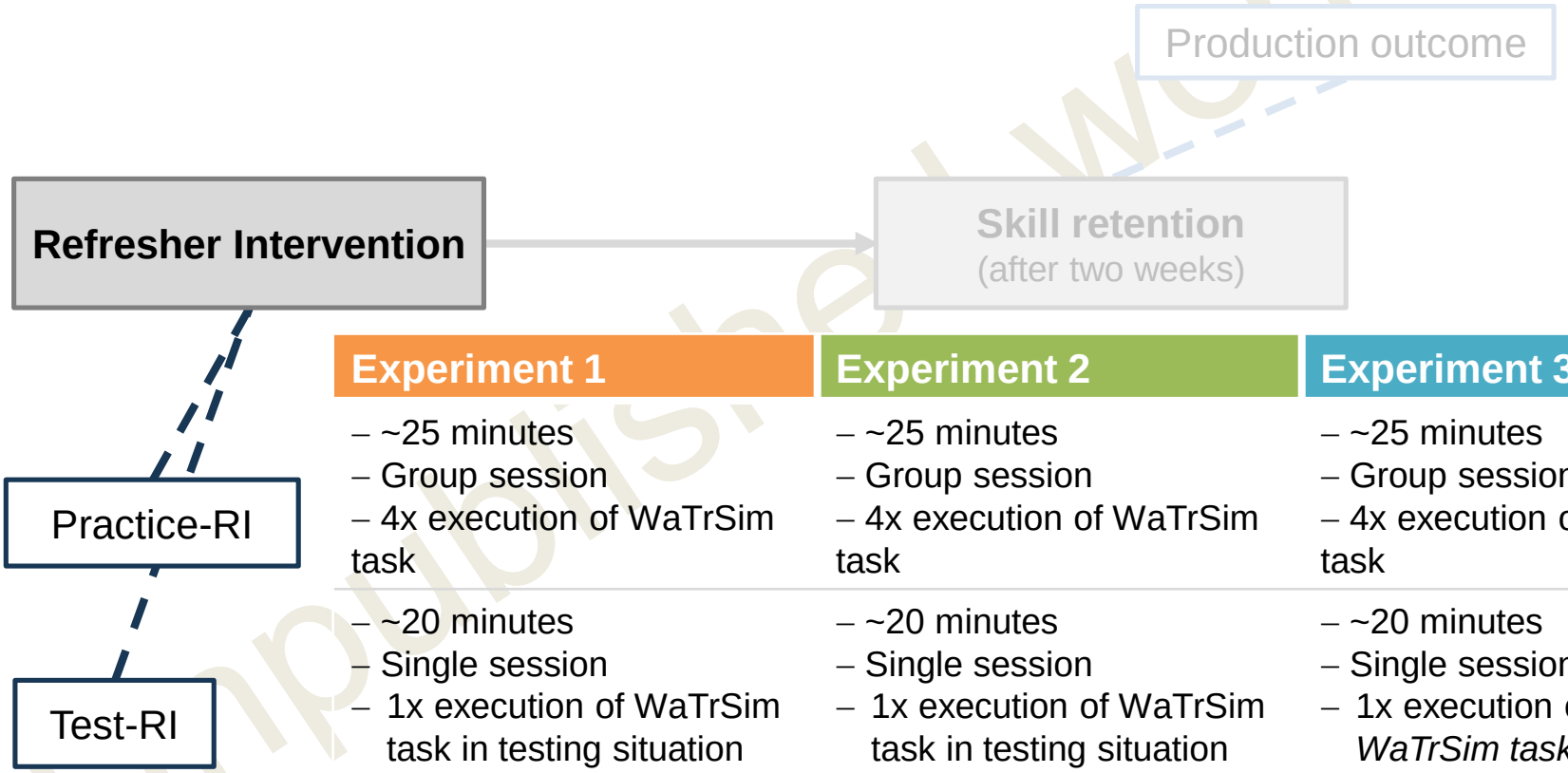
Procedure (Exp. 1-3)



Method Exp. 1-3: Variables



Method Exp. 1-3: Variables



	Experiment 1	Experiment 2	Experiment 3
Practice-RI	– ~25 minutes – Group session – 4x execution of WaTrSim task	– ~25 minutes – Group session – 4x execution of WaTrSim task	– ~25 minutes – Group session – 4x execution of WaTrSim task
Test-RI	– ~20 minutes – Single session – 1x execution of WaTrSim task in testing situation – Coverstory	– ~20 minutes – Single session – 1x execution of WaTrSim task in testing situation – Coverstory	– ~20 minutes – Single session – 1x execution of *each WaTrSim task conditions* in testing situation – Coverstory

Coverstory

A small town called 'Feldkirchen' needs the participants' help. The participant was told that she/he is responsible to start-up the plant and produced as much water as possible to save the water supply. In addition, the participant was asked explicitly to concentrate and focus all attention on the task. It is emphasised that she/he has only one chance to start-up the procedure correctly.

Method Exp. 1-3: Variables

Production outcome

Refresher Intervention

Skill retention
(after two weeks)

Practice-RI

Test-RI

Experiment 1

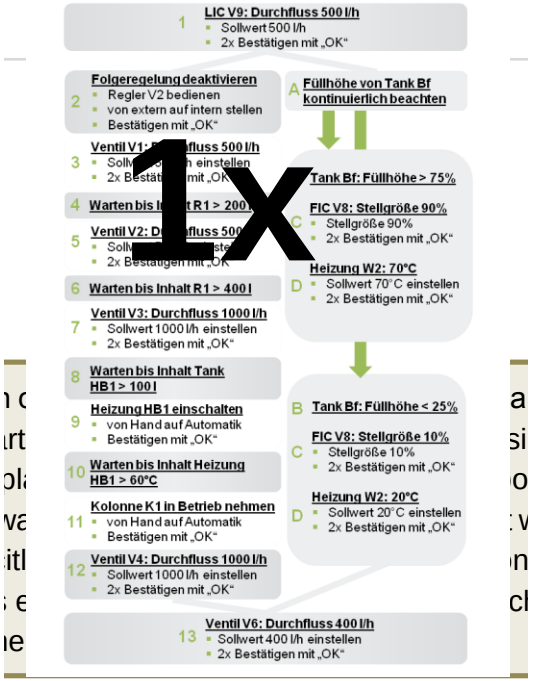
Experiment 2

Experiment 3

Experiment 1
Fixed Sequence Task

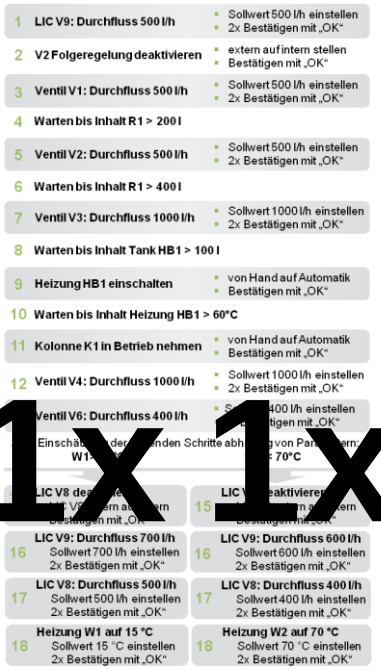
1x

Experiment 2
Parallel Sequence Task



1x

Experiment 3
Contingent Sequence Task



1x 1x

Experiment 1: Fixed sequence task

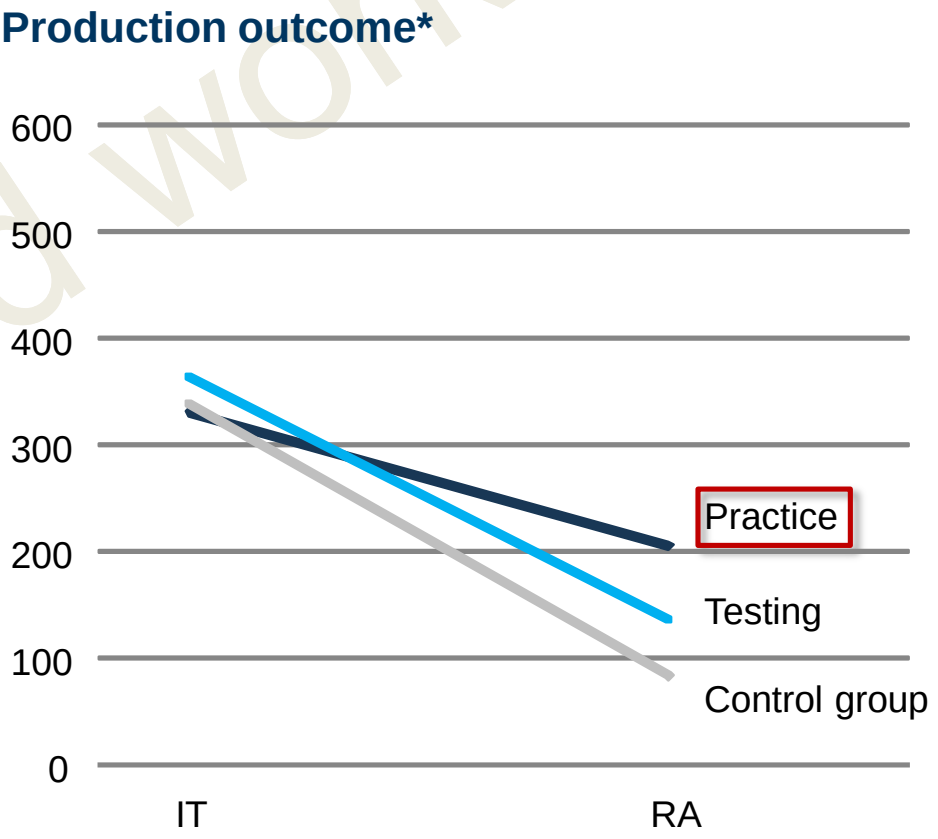
Results

Hypothesis 1
Testing > No intervention

- Effect of time
  ($F(1,36)=125.74$; $p<.001$; $n^2_p=.777$)
- Effect of group
  ($F(1,36)=2.98$; $p=.093$; $n^2_p=.076$)
- Interaction
  ($F(1,36)=0.38$, $p=.544$; $n^2_p=.010$)

Hypothesis 2
Testing > Practice Refresher Intervention

- Effect of time
  ($F(1,37)=57.83$; $p<.001$; $n^2_p=.610$)
- Effect of group
  ($F(1,37)=0.56$; $p=.458$; $n^2_p=.015$)
- **Interaction**
  ($F(1,37)=5.21$; $p=.028$; $n^2_p=.124$)



* Amount of produced production outcome depends on task

Experiment 2: Parallel sequence task

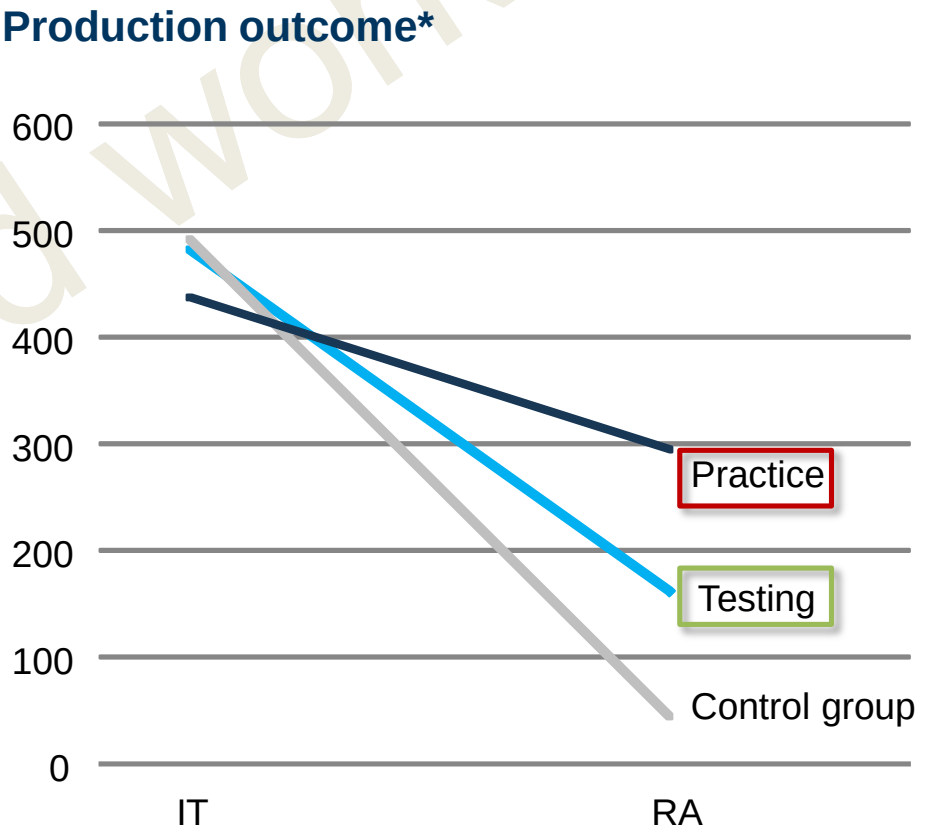
Results

Hypothesis 1
Testing > No intervention

- Effect of time
  ($F(1,38)=400.67$; $p<.001$; $n^2_p=.913$)
- Effect of group
  ($F(1,38)=3.83$; $p=.058$ $n^2_p=.091$)
- **Interaction**
  ($F(1,38)=10.53$, $p=.002$; $n^2_p=.217$)

Hypothesis 2
Testing > Practice Refresher Intervention

- Effect of time
  ($F(1,38)=83.80$; $p<.001$; $n^2_p=.688$)
- Effect of group
  ($F(1,38)=1.32$; $p=.258$; $n^2_p=.034$)
- **Interaction**
  ($F(1,38)=12.68$; $p=.001$; $n^2_p=.250$)



* Amount of produced production outcome depends on task

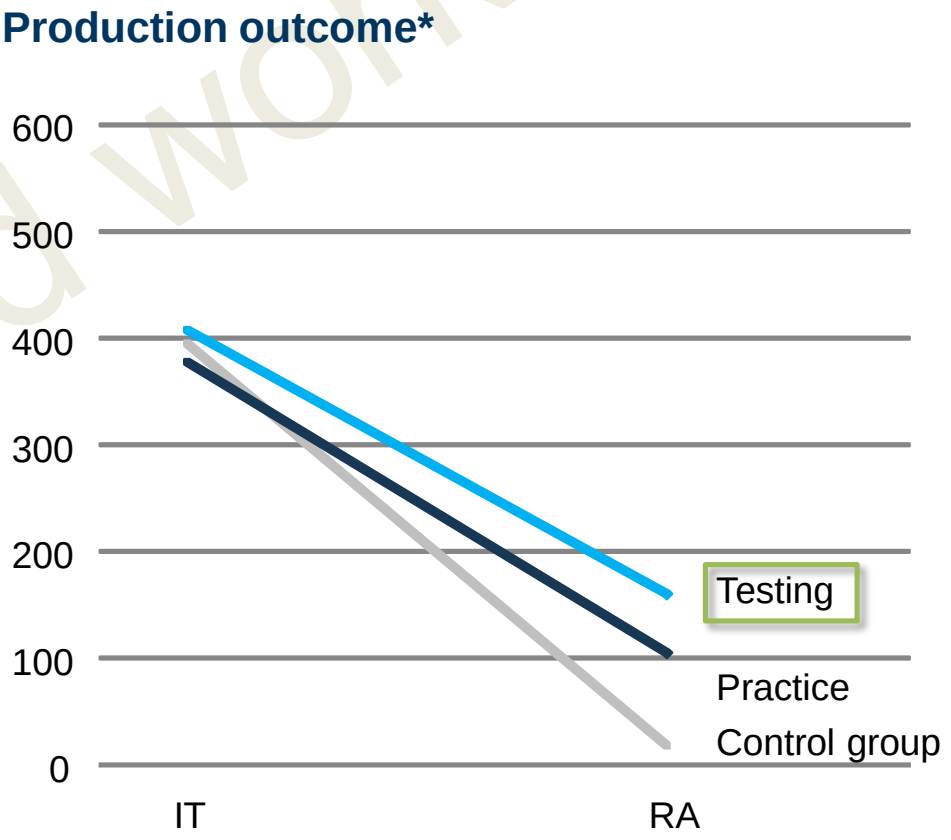
Results

Hypothesis 1
Testing > No intervention

- Effect of time
  ($F(1,36)=100.80$; $p<.001$; $n^2_p=.737$)
- Effect of group
  ($F(1,36)=4.85$; $p=.034$; $n^2_p=.119$)
- **Interaction**
  ($F(1,36)=4.36$; $p=.044$; $n^2_p=.108$)

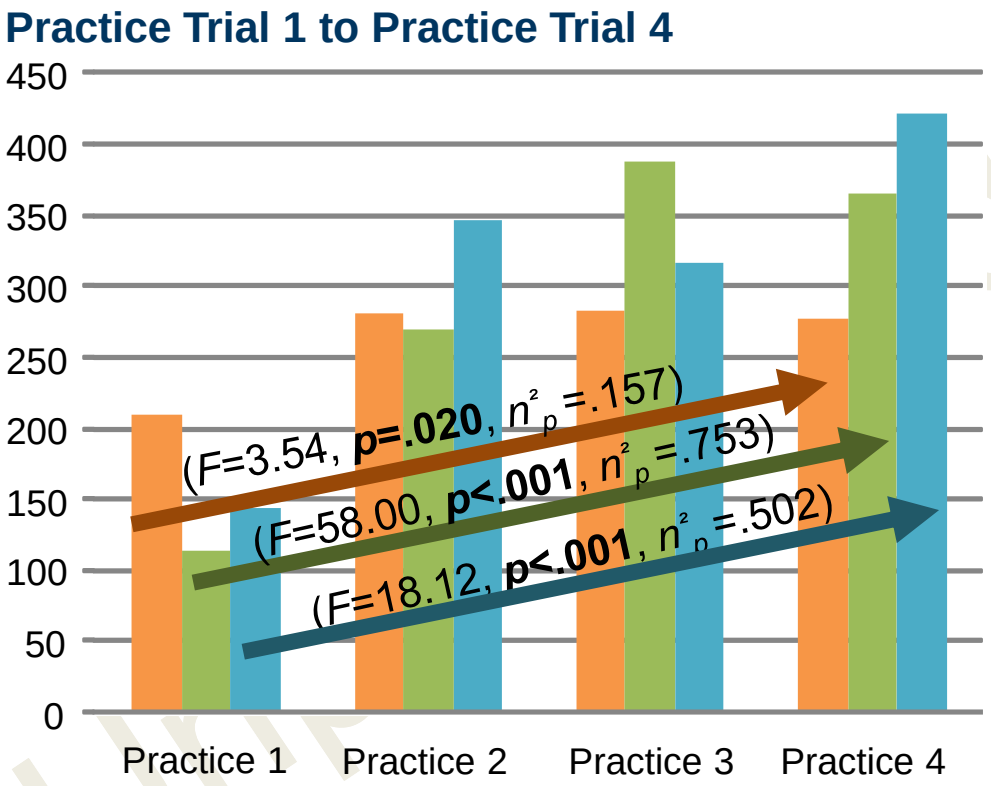
Hypothesis 2
Testing > Practice Refresher Intervention

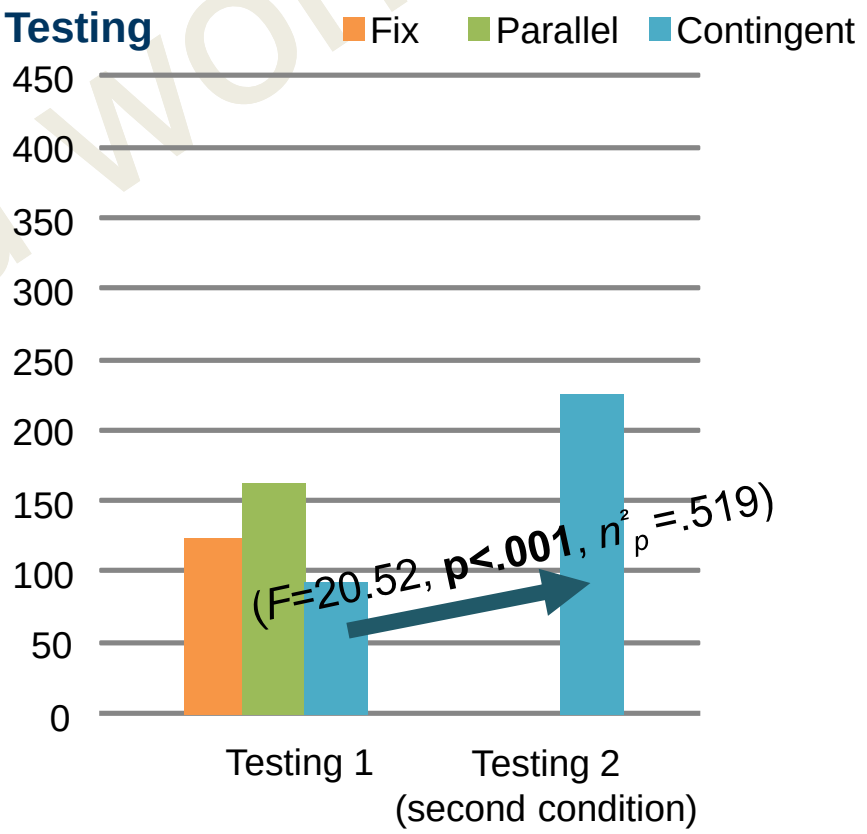
- Effect of time
  ($F(1,37)=76.54$; $p<.001$; $n^2_p=.674$)
- Effect of group
  ($F(1,37)=1.19$; $p=.283$; $n^2_p=.031$)
- Interaction
  ($F(1,37)=0.18$; $p=.677$; $n^2_p=.005$)



* Amount of produced production outcome depends on task

Post-hoc: What is the benefit of Practice?





- Rehearsal Practice supports learning
- Testing of two different conditions supports also learning

Discussion

- Testing effect for complex cognitive skills was not shown
  - Fixed sequence task: Practice > Testing
  - Parallel sequence task: Practice > Testing
  - Contingent sequence task: Practice = Testing
- Testing was not able to support skill retention of the complex tasks
- Rehearsal practice supports learning and understanding of complex tasks that require a precise execution in a predefined time
- Two testings in a row support also learning
  - Testing trials that differ in difficulty might induce an added value (Brown, Roediger, & McDaniel, 2014)
- Two consecutive testings have a similar effect as Practice

Practice > Testing

Thank you for your attention ☺

merle.lau@rub.de

barbara.frank@rub.de

annette.kluge@rub.de