Designing effective training
Transfer of skills and refresher training

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Challenge: Skill retention and transfer

How can effective training for complex, technical tasks be designed?
What kind of training can support transfer of acquired skills for longer durations?

- For complex and not regularly performed tasks
  (Lindburg & Dar-EI, 2000)
- Rare opportunities
- Automation: Risk of skill decay
- Skill decay of cognitive skills
  (Wickens, Hollands, Banbury, & Parasuraman, 2013)
### Designing training for temporal and adaptive transfer

<table>
<thead>
<tr>
<th>Transfer type</th>
<th>Description and Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal transfer</td>
<td>Application of skills and knowledge after a period of non-use</td>
</tr>
<tr>
<td>Adaptive transfer</td>
<td>Need to adapt acquired skills to novel situation</td>
</tr>
</tbody>
</table>


### Comparison of training methods

<table>
<thead>
<tr>
<th></th>
<th>Emphasis Shift Training</th>
<th>Situation Awareness (SA) Training</th>
<th>Drill and practice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rationale</strong></td>
<td>Priority changes on subcomponents of a whole task</td>
<td>Randomized &quot;freezing&quot; of a task with SA questions &amp; debriefing</td>
<td>Rehearsal, repetition and practice of a task</td>
</tr>
<tr>
<td><strong>Empirical findings</strong></td>
<td>Enhancing attention-management strategies, transfer to novel situations</td>
<td>Useful for individual SA and performance, but few empirical studies on effects of SA training</td>
<td>Useful for procedural tasks and longer retention intervals for familiar situations</td>
</tr>
<tr>
<td><strong>Explanations for effectiveness</strong></td>
<td>Reducing load allowing to invest more resources in learning other tasks</td>
<td>Improving competence to make decisions and project events in the future</td>
<td>Reducing load on working memory</td>
</tr>
<tr>
<td><strong>Usefulness assumed for</strong></td>
<td>System control performance Diagnostic performance of novel faults</td>
<td>System control performance Diagnostic performance of novel faults</td>
<td>Diagnostic performance of practiced faults</td>
</tr>
</tbody>
</table>

Burkholder, Kluge, Sizer, & Ritzmann (2010)
Simulated process control task

- Cabin air management system
- System control performance
- Diagnostic performance

Experimental design

Training of 5 system faults

- Drill and practice
- Emphasis shift training (EST)
- EST and Situation Awareness (EST/SA)

Testing sessions with practiced and novel system faults

Test immediate $\rightarrow$ Test 2 weeks $\rightarrow$ Test 3 weeks
Training method

System fault 1: Leak in oxygen valve

Training of system control

CAMS exercise: T3

Description of system fault:
Oxygen leaks from the valve to the patients of the oxygen outlet. This results in reduced oxygen uptake in the patients.

Symptoms:
The oxygen concentration in the air decreases, and the patients show symptoms of hypoxia.

Intervention:
1. Increase oxygen in the automatic controller of the oxygen settings from "default" to "high".
2. Monitor the parameters of the oxygen settings in the automatic controller.
3. Monitor the parameters:
   - Pay attention that the values are in normal range.

Results: System control performance

System control performance:
Mean deviation from normal range in %, SD in brackets

- Test immediate: D&P 20.4, (8.9); EST 24.6, (9.2); EST/SA 25.9, (10.1)
- Test 2 weeks: D&P 16.1, (8.4); EST 14.3, (8.9); EST/SA 17.3, (9.7)
- Test 6 weeks: D&P 10.6, (7.0); EST 10.1, (7.3); EST/SA 17.0, (9.0)

Bunkhorst, Kluge, Sauer, & Ritzmann (2010)
Results: Temporal transfer

Diagnostic accuracy (practiced faults): Mean incorrect fault diagnoses in %, SD in brackets

Results: Adaptive transfer

Diagnostic accuracy (novel faults): Mean incorrect fault diagnoses in %, SD in brackets
Summary of results

<table>
<thead>
<tr>
<th>Training method</th>
<th>Temporal transfer</th>
<th>Adaptive transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drill and practice</td>
<td>✓ Diagnosis</td>
<td></td>
</tr>
<tr>
<td>EST/Situation awareness</td>
<td></td>
<td>✓ Diagnosis</td>
</tr>
<tr>
<td>Emphasis shift training (EST)</td>
<td>Performance not as well as expected for system control</td>
<td></td>
</tr>
</tbody>
</table>

Burckholz, Kluge, Sauer, & Ritzmann (2010)

Refresher training

- Prevalent/required in high-risk environments
  (O'Connor et al., 2008)

- However: Little research on design and methods
  (Deasy & Sinclair, 1990)

Burckholz & Kluge, 2011; Kluge, Burckholz & Frank, 2012

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Hypothesis 2

Burkholder & Kluge, 2011; Kluge, Burkholder & Frank, 2017
Waste Water Treatment Simulation (WaTr Sim)

Experimental design

<table>
<thead>
<tr>
<th></th>
<th>60 min</th>
<th>10 min</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EG 1</strong></td>
<td>Practice</td>
<td>Initial Training</td>
</tr>
<tr>
<td><strong>EG 2</strong></td>
<td>Symbolic Rehearsal</td>
<td>Initial Training</td>
</tr>
<tr>
<td><strong>CG</strong></td>
<td></td>
<td>Initial Training</td>
</tr>
</tbody>
</table>

Bürkholder, Kluge, German, & Graul (2009)
Bürkholder & Kluge, 2011; Kluge, Bürkholder & Frank, 2012
Experimental design

EG 1
Practice

Initial Training 60 min Test 1 10 min

EG 2
Symbolic Rehearsal

Initial Training 60 min Test 1 10 min

1 week Practice 20 min 1 week

CG

Initial Training 60 min Test 1 10 min

2 weeks Test 2 15 min

Results: Temporal transfer

Temporal transfer: Start-up procedure

\[ M = 1083.3, SD = 139.1 \]
\[ M = 850.3, SD = 294.1 \]
\[ M = 719.3, SD = 418.7 \]
Results: Temporal transfer

Results: Adaptive transfer

Output

Adaptive transfer: Non-routine situation

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Burkholder & Kluge, 2011; Kluge, Burkholder & Frank, 2012
Summary and conclusion

- Refresher training effective and efficient for skill retention
- Refresher training: For temporal transfer not adaptive transfer
- Drill and practice for temporal transfer

Specific training methods for temporal transfer AND for adaptive transfer

Determine task characteristics and requirements thoroughly

Assess training outcomes in multi-faceted way

References


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Thank you very much for your attention!

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