Automation and Training

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Overview

• Automation and training
  ▪ Background

• What automation does to training
  ▪ Previous studies
    • Review plus new (individual differences)
  ▪ Current studies
    • Teams
    • Transition of previous findings
  ▪ Future work
Future warfighters will interact with a variety of new forms of technology…
...which will place new demands on the warfighter
Goal is often to simply have automation support the operator...
Might have an idea about “bad” automation
• But it can also bring a certain:
  Je ne sais quoi…
• But it can also bring a certain:
  Je ne sais quoi…
• But it can also bring a certain: Je ne sais quoi…

Wireless networks detected

One or more of your preferred networks are in range. To see the list and connect to a network, click this message.
Wireless networks detected

One or more of your preferred networks are in range. To see the list and connect to a network, click this message.
But it can also bring a certain: Je ne sais quoi…

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Wireless networks detected
One or more of your preferred networks are in range. To see the list and connect to a network, click this message

Professor Healy is looking somewhat concerned that you are not yet showing everyone any data!

OK

One or more of your preferred networks are in range. To see the list and connect to a network, click this message
Negative consequences

• Automation in training might:
  ▪ Mask operator shortcomings
  ▪ Restrict exposure to certain system states
  ▪ Reduce learning (“Out of the loop”)
  ▪ Add to workload (remember to engage automation)
Initial Research Task

• Simulated Orange Juice Pasteurizing Plant
Study 1

• Central issue: Does automation improve learning in training?
Method

3 conditions

• Manual Control
  ▪ No automation

• Automatically-initiated automation
  ▪ Automation adopts control of subsystem unless vetoed

• User-initiated automation
  ▪ Operator can choose to relinquish control
Results:
Across training

![Graph showing units of good juice across different block levels for manual control, user activated auto, and auto activated auto.]
Results: Across training

Units of Good Juice
Results:
Across training

Automation improves initial performance

Units of Good Juice
0 200 400 600 800 1000
Block 1 Block 2 Block 3 Block 4

- Manual Control
- User Activated Auto
- Auto Activated Auto
Results: Across training

Both levels of automation look the same
Results:
Across training
By end of training, no differences
Quick Summary

• Suggests benefits from automation
  ▪ Novice operators do better at first
• No difference between the type of automation

Next look at performance when automation is removed
Removing Automation

![Graph showing the comparison between Manual Control, User Activated, and Auto Activated in terms of Units of Good Juice](image)
Removing automation

No significant cost of removing user activated automation

![Bar chart showing units of good juice for manual control, user activated, and auto activated settings. The chart indicates no significant difference in units of good juice among the three settings.]
Removing automation

Evidence of operator dependence on automation
Summary of Findings

• Evidence that automation changes learning and performance
  • Type of automation matters
Individual Differences

• Standardized training is not equally effective for everyone
  ▪ Skill acquisition
  ▪ Transfer of training
Cognitive Ability Battery

• Two tests for specific ability dimensions
  ▪ Reasoning Ability
  ▪ Quantitative Ability
  ▪ Verbal Ability
  ▪ Visual Scanning Ability
  ▪ Perceptual Speed Ability

• General cognitive ability (g)
  ▪ Factor scores from the first, unrotated principle factor (perceptual speed not included)

*Educational Testing Service’s Kit of Factor-Referenced Cognitive Tests*
<table>
<thead>
<tr>
<th>Our Battery</th>
<th>ASVAB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantitative</strong></td>
<td></td>
</tr>
<tr>
<td>Arithmetic Attitude</td>
<td>Arithmetic Reasoning*</td>
</tr>
<tr>
<td>Necessary Arith. Operations</td>
<td>Math Knowledge*</td>
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<tr>
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<tr>
<td>Vocabulary Test I</td>
<td>Word Knowledge*</td>
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<tr>
<td>Vocabulary Test II</td>
<td>Paragraph Comprehension*</td>
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<td>Paper Folding Test</td>
<td>Assembling objects</td>
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<td>Card Rotations Test</td>
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Battery also includes 2 tests for perceptual speed, 2 tests of general reasoning

* Indicates test is a component of AFQT. Battery also includes science/technical tests
Abilities & Automation

- Examined relationship between ability and performance for automation conditions
### Results: Initial Performance

Correlations between ability and Block 1 Performance by condition

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Values in **RED** are statistically significantly different from zero.
# Results: Initial Performance

Correlations between ability and Block 1 Performance by condition

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### Results: End of Training

Correlations between ability and Block 4 Performance by condition

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<td>Quant</td>
<td>.29</td>
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<td>Verbal</td>
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<td>Spatial</td>
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<td>.05</td>
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<td>Perceptual Speed</td>
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<td>.00</td>
<td>-.04</td>
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<tr>
<td>g</td>
<td>.30</td>
<td>.05</td>
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Importance of Aptitude plus Automation

• Look in more detail at g
Results:

Initial Performance

Regression of Block 1 performance on $g$, condition, and interaction
Results:
Initial Performance
Regression of Block 1 performance on $g$, condition, and interaction

Low $g <$ High $g$
Results:
Initial Performance

Regression of Block 1 performance on $g$, condition, and interaction

Automation improves initial performance for learners with lower $g$
Results: Initial Performance
Regression of Block 1 performance on $g$, condition, and interaction

Not really so for learners with higher $g$
Results:
End of Training

Regression of Block 4 performance on $g$, condition, and interaction
Results:
End of Training
Regression of Block 4 performance on $g$, condition, and interaction

Low $g <$ High $g$
Results:

End of Training

Regression of Block 4 performance on $g$, condition, and interaction

Reduced effect of $g$ for user activated automation
Conclusions

*If the system inherently includes automation*
- Automation present in training can produce superior performance earlier in practice
- But it may mask differences between operators

*If automation is only being used as a training aid*
- Later removal of automation can harm performance
IMPRINT: Current approach

• Cognitive ability in IMPRINT
  ▪ Knowing something about the trainees is part of modeling expected outcomes
  ▪ Adjust cognitive ability test cutoff score
    • “If our trainees are this smart, what is the outcome”

This needs to be based on some known relationship between cognitive ability and the performance outcome
Implications of our findings

• The relationship between cognitive ability and outcomes changes if training changes
Potential usefulness

• Knowing how the relationship changes allows for modeling more complex decisions, and new types of training technology
  ▪ “Given a type of trainee and a type of training, what is the outcome?”
  ▪ Might also lead to ideas for assigning different types of training to trainees with different characteristics
Taxons

• Individual differences could be best added to the taxonomic analysis as an additional dimension
• Starting to show some indications of which abilities might matter and why
Study 2

• Central issue: Should automation vary or reduce across training?
Method

3 conditions

• Manual Control
  ▪ No automation

• Varying selection of automation
  ▪ Part-task training, different subsystems controlled by automation

• Decreasing automation
  ▪ Operator adopts greater control with increasing experience
Results: Across Training

![Graph showing units of good juice across training blocks for different conditions.]

- **Manual Control**
- **Random Automation**
- **Decreasing Automation**

Units of Good Juice

Block 1 | Block 2 | Block 3 | Block 4
Results: Across Training

Manual control similar to Study 1
Results: Across Training

Observation of automation only
Results: Across Training

Observation less effective than part-task training (random auto > decreasing auto)
Results: Across Training

Both automation conditions less effective training than Manual Control
Aptitude

- Analyses of individual differences effects
## Results

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Conclusions

- Show potential costs of using automation to manage the exposure of individuals during learning
- Also illustrates how minor changes to nature of the automation change the influence of the abilities on performance
Summary Previous Studies

• Identified training effects of automation
• Begun to map on variations with individual differences
Current studies

• Teams and automation in training
• Extending our previous findings to operationally-relevant tasks
Teams, automation, and training

• Does automation have different effects on training in a team-based situation?
Networked Fire Chief (NFC)

• NFC (Networked Fire Chief)
  ▪ Omodei&Wearing (1998)

• Microworld simulation for command and control decision making
  ▪ Both for individual and team training
Task basics

• Participants utilize appliances (fire trucks and helicopters) to extinguish fires

• Lakes are used to refill water in appliances

• Navigation map enables participants to travel to different locations on the map.
Procedure

Practice sessions:
• 2 sessions each with 4 separate maps
• 4 training conditions (2 x 2 design)
  ▪ Automated / Non-automated appliances
  ▪ Individual / 2 person team
Training Performance

Percentage Saved

Day 1

Day 2

Auto - Team

Auto - Individual

Manual - Team

Manual - Individual
Training Performance

Percentage Saved

- Auto - Team
- Auto - Individual
- Manual - Team
- Manual - Individual

Percentage of objects NOT burned

Day 1
Day 2
Training Performance

Automation plus teams most effective performance

Auto - Team
Auto - Individual
Manual - Team
Manual - Individual

Day 1
Day 2
Percentage Saved
Also shows automation is effective at aiding performance.

Training Performance

- Auto - Team
- Auto - Individual
- Manual - Team
- Manual - Individual

Percentage Saved

Day 1

Day 2
Test trial

How do the previous training conditions impact learning?

Now have:

• No automation
• Everyone performs on their own
Preliminary data

Previous Training Type

Percentage Performance

Auto Team
Manual Team
Auto Individual
Manual Individual
Preliminary data

Percentage Performance

Previous Training Type

Auto Team
Manual Team
Auto Individual
Manual Individual
Implication

Important preliminary finding:
• Situation in which automation seems beneficial
Extending our previous findings

• “A realistic Predator” uninhabited air vehicle (UAV) synthetic task environment (STE)
  ▪ Air Force Research Laboratory’s Warfighter Training Research Division sponsored and designed platform
UAV work

- Predator UAV STE
  - Complex, unforgiving aircraft control paradigm
Design

- Procedure
  - Training Session 1
    - Basic Maneuvering (BM) tutorial, 20 trials BM task 1
  - Training Session 2
    - 20 trials BM task 2, 20 trials BM task 3
  - Test Session
    - Landing Task (LT) tutorial, Test: 10 trials Landing Task
Conditions

Manual Group:
• No treatment / learn with “full” stick input

Automation Group:
• 2/3 control inputs (airspeed and altitude) provided by computer during Basic Maneuvering task 2
Preliminary results

Control Error (Average RMSE)

Automation
Manual

GndTrk Approach
GndTrk Final
Glide Slope
Preliminary results

Control Error

- Automation
- Manual

GndTrk Approach
GndTrk Final
Glide Slope
Preliminary results

Control Error (Average RMSE)

- Automation
- Manual

GndTrk Approach
GndTrk Final
Glide Slope
Future work

• Extending MURI findings
  ▪ Information fusion
  ▪ Training with other mappings
Information fusion

• Training debiasing
  ▪ Do we see biases with more complex information integration tasks?
    • Switch to using a micro-UAV simulator for the information fusion task
Simulated HUD

Another study in my lab, we started looking at…

• How best to present directional information?
Task

- Respond to the direction of the arrow, unless there is a potential hazard in the photo
Congruent arrow placement

Incongruent (consistent location) arrow placement
Proportion of hazards correctly identified

Location of display arrows

Left and Right

Right only
Correctly identifying a hazard in the scene

Proportion of hazards correctly identified

Location of display arrows
Left and Right
Right only
Better performance for congruent location rather than consistent location.
…but RT varied with their “preference”
Training of mapping

• Proctor & Yamaguchi shown how training with incompatible responses mediates the Simon effect
Examination of MURI principle

• Currently setting up experiments to test whether incompatible training can impact:
  ▪ Current (photo) version of the task
  ▪ Driving simulator version
Summary of Current and Future Work

• Teams and automation
  ▪ In progress experiment
• Transition
  ▪ Operationally-relevant simulations
    • Also collecting individual differences in here
    • Connecting to MURI team findings and approaches
Questions?