Overview

- Levels of Automation
- Cognitive Ability
- Task Performance
  - Automation groups: preliminary data
- Ability Battery
  - Ability factors: preliminary data
- Continuing work
• What is automation?
  
  "a device or system that accomplishes (partially or fully) a function that was previously carried out (partially or fully) by a human operator."

(Wickens, Mavor, Parasuraman, & McGee, 1998)
Automation

- Ever increasing introduction of automation
  - Improved performance & safety
  - Efficiency (fewer people doing more jobs)
  - Support of the person
Change in Emphasis

• Previous issue – technical capabilities of automation
• Often overlooked issue – human capabilities in interacting with automation
Automation

- Automation need not be an all or none thing
- Variety of types of automation
  - Concept of Levels of Automation
    - Sheridan & Verplank (1978)
10. The computer decides everything and acts autonomously, ignoring the human.
9. informs the human only if it, the computer, decides to
8. informs the human only if asked, or
7. executes automatically, then necessarily informs the human, and
6. allows the human a restricted time to veto before automatic execution, or
5. executes that suggestion if the human approves, or
4. suggests one alternative, and
3. narrows the selection down to a few, or
2. The computer offers a complete set of decision/action alternatives, or
1. The computer offers no assistance: the human must take all decisions and actions.
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<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>LOW</td>
<td>1. The computer offers no assistance: the human must take all decisions and actions.</td>
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</table>
| MID   | 2. The computer offers a complete set of decision/action alternatives, or
|       | 3. Narrows the selection down to a few, or
|       | 4. Suggests one alternative, and
|       | 5. Suggestion of one action, and executes if the human approves, or
|       | 6. Allows the human a restricted time to veto before automatic execution, or
|       | 7. Executes automatically, then necessarily informs the human, and
|       | 8. Informs the human only if asked, or
|       | 9. Informs the human only if it, the computer, decides to |
|       | 10. The computer decides everything and acts autonomously, ignoring the human. |
| HIGH  | 6. Computer suggests one action, and executes automatically but allows the human a restricted time to veto before automatic execution. |
1. The computer offers no assistance: the human must take all decisions and actions.

2. The computer offers a complete set of decision/action alternatives, or

3. Narrows the selection down to a few, or

4. Suggests one alternative, and

5. Suggestion of one action, and executes if the human approves

6. Allows the human a restricted time to veto before automatic execution, or

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9. Informs the human only if it, the computer, decides to

10. Expects the human to accept autonomously, ignoring the human.
Training

- Automation during training
  - Naturally present in the system
  - Guide learning
  - Better performance from novices
Negative consequences

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

- Simulated Orange Juice Pasteurizing Plant
  - Interaction of 3 subsystems
  - Presence of competing goals
  - Dynamics incorporate time lags
Method

- 3 conditions
  - No automation
  - User-initiated automation
  - Auto-initiated automation (with veto option)
- Two sessions of training
  - 10 trials per session for 2 days
- Final test without automation
Preliminary Data

![Graph showing units of good juice produced vs. session. The graph compares manual, user-activated, and auto-activated methods. The manual method shows a steady increase, the user-activated method shows a slight increase, and the auto-activated method shows a more significant increase.]
Preliminary Findings

• Very early data...
• Evidence that automation changes learning and performance
• Operator-initiated version linked to superior performance
  ▪ No evidence this is linked to superior knowledge of the system
Contribution

One ongoing issue in our research:

• How should automation fit into the MURI training x task matrix?
Second Strand
Individual Differences

- Standardized training is not equally effective for everyone
  - Skill acquisition
  - Transfer of training
Phases of Learning

• Long-standing idea that complex task learning progresses through 3 phases
  ▪ Declarative knowledge
  ▪ Knowledge compilation
  ▪ Procedural

Anderson 1982; Fitts & Posner, 1967; Schneider & Shiffrin, 1977;
Shiffrin & Schneider, 1977
Cognitive Abilities

Ackerman (1988)

• Distinct cognitive ability dimensions related to performance of learners in each of 3 phases
  ▪ General cognitive ability = declarative knowledge
  ▪ Perceptual speed abilities = knowledge compilation
  ▪ Psychomotor abilities = procedural
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

*Educational Testing Service’s Kit of Factor-Referenced Cognitive Tests*
ASVAB

• Abilities included in our test are similar to abilities assessed in the ASVAB
Perceptual Speed

• Data at this point are VERY preliminary
• Some hint of a relationship of transfer performance to perceptual speed ability
Preliminary Ability Data

Interaction of Sheridan Level and Perceptual Speed on Performance

Performance on No Automation Trial

-0.6 -0.4 -0.2 0 0.2 0.4 0.6

low high

Perceptual Speed Ability

- Manual
- User activated
- Auto activated
Perceptual Speed

• Beyond initial declarative stage?
  ▪ Task has limited demands on declarative knowledge (when g is most predictive)

• Potential link to knowledge compilation stage

• Pasteurizer requires operators scan visual environment, react to observed changes, discover contingencies
  ▪ Natural relationship to perceptual speed ability
Next Steps

• Further data collection
• Multiple performance measures to examine, plus frequency of automation use, trust and self-confidence ratings
• Variance in training performance accounted for by individual differences
• Effects of the combination of levels of automation and cognitive abilities
  ▪ Goal of matching automation to the learner
1) Review of literature relevant to dimensions of individual differences that might contribute to the MURI training matrix
2) Review of literature relevant to levels of automation that might contribute to the MURI training matrix
3) Development of Cognitive Ability Battery
4) Refined Levels of Automation task
5) Developed CSU Study I: Aptitude, levels of automation and the effectiveness of training
6) Commenced data collection on Study I
   - Running complete for 199 subjects with 1 hour cognitive ability battery plus 2 sessions x 1.5 hours computer-based micro-simulation training