Transfer-of-Training Research at NASA Ames Research Center

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Delft University of Technology, 06-04-2014
Outline

• Part I – Human Systems Integration Division
  – Research
  – Simulation Facilities (NASA SimLabs)

• Part II – Transfer-of-Training Research
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  – Study 2: Transfer of Stall Recovery Training (NASA Aeronautics Research Program)
  – Discussion
Part I
Human Systems Integration Division
The **Human Systems Integration Division** advances human-centered design and operations of complex aerospace systems through analysis, experimentation, and modeling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency, and mission success.

[http://humansystems.arc.nasa.gov](http://humansystems.arc.nasa.gov)
Research Overview

Flight Deck Display Research Laboratory
The FDDRL develops both prototypes and guidelines for advanced interfaces which integrate displays, decision support tools, and flight deck automation.

Operationally Based Vision Assessment
The primary objective of the OBVA program is to correlate clinical vision standards to aircrew operational performance using a high fidelity synthetic environment to simulate operational visual tasks.

Vibration Laboratory
The objective of the Human Vibration Laboratory is to assess whole-body vibration impacts on visual, cognitive, and manual performance, understand the mechanisms contributing to vibration-induced performance deficits.
Airspace Operations Lab
The Airspace Operations Lab evaluates ATM concepts and explores human-system interaction issues in a simulation environment designed to allow rapid prototyping of NextGen concepts.

Human Perception and Cognition Research
Advance the fundamental understanding of how people perceive and process visual, vestibular, and auditory information.

Automation Interaction Design Group
The development of methods and tools to support design and Human-Computer Interaction analysis of complex, safety-critical automated systems.
Simulation Facilities (SimLabs)

1. Vertical Motion Simulator (VMS)
2. Advanced Concepts Flight Simulator (ACFS)
3. B747-400 simulator
4. FutureFlight Central

http://simlabs.arc.nasa.gov
Part II
Transfer-of-Training Research
The problem:

1. There is still no consensus on the value of motion in pilot training

2. There are no objective motion cueing criteria
Why do simulators move?

1. Motions adds to pilot acceptance
2. Research shows a subjective preference for motion
3. Myriad of cue combinations leads regulators to adopt a conservative approach
Previous work to determine the value of motion in flight simulation:

1. Effects of motion on skill-based manual control behavior in tracking tasks
2. Transfer-of-training research:
   a) Task performance in realistic flight tasks
   b) Performance and control behavior in tracking tasks
Transfer-of-training research:

1. True transfer of training

2. Quasi transfer of training
Study 1
Transfer of training on the Vertical Motion Simulator

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Two research questions:

• Does objective evidence exist for the value of training with platform motion?

• Are recently proposed objective motion criteria effective in determining the value of motion for training?
Experiment design:

- **Independent variable:** 4 training motion groups (no mot., hex lo, hex hi, VMS)
- **Tasks:** 4 challenging flight tasks
- **Participants:** 61 pilots without commercial transport experience
- **Aircraft model:** enhanced for more representative aircraft response in the stall and overbank tasks
Experiment design (continued):

- **Training**: until proficient (minimum of 3, maximum of 6 runs)
- **Check run**: only 1 try
- **Evaluation**: instructor pilot in right seat and experiment observer in control room
- **Cockpit**: T-CAB with B777 PFD
Task 1: Approach and landing with sidestep:

1. Track the GS and LOC to SFO RWY 28R maintaining 141 KIAS
2. Perform sidestep to RWY 28L at ATC command
3. Continue visual to RWY 28L maintaining GS
4. Flare and touchdown 750 – 1,500 ft from the threshold
5. Task evaluation ends at touchdown
Task 2: High-altitude stall recovery at FL 410:
1. Retard throttle to idle
2. Roll left to a 15 deg bank angle
3. Pull up to decelerate at approximately 4 kt/s
4. Continue deceleration through stick shaker until a sink rate develops
5. Apply nose down pitch, roll as needed, power as needed to return to steady-state flight
Task 3: Overbank upset recovery at 5,000 ft:

1. Hands off controls as computer flies the aircraft to 120 deg left bank and 20 deg nose down pitch attitude

2. At the command “your airplane”, unload, roll wings level, and then apply nose-up pitch rate similar to a takeoff rotation rate to recover safely to level flight
Task 4: Engine out on takeoff:

1. Advance throttles to takeoff thrust (60% N1)
2. Maintain centerline
3. Rotate at \( V_r = 128 \) kts to a pitch attitude of 10 degs and establish speed of \( V_2 + 10 \)
4. Maintain heading and speed after single engine failure
## FAA Study Setup

### Motion conditions:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
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<tbody>
<tr>
<td>NOM</td>
<td>no-motion for all tasks</td>
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<tr>
<td>HLO</td>
<td>small hexapod motion for all tasks</td>
</tr>
<tr>
<td>HHI</td>
<td>large hexapod motion for all tasks</td>
</tr>
<tr>
<td>SIDE</td>
<td>VMS motion for sidestep task</td>
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<tr>
<td>HALT</td>
<td>VMS motion for stall task</td>
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<tr>
<td>OVER</td>
<td>VMS motion for overbank task</td>
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<tr>
<td>TOFF</td>
<td>VMS motion for takeoff task</td>
</tr>
</tbody>
</table>
Objective Motion Cueing Test:

FAA Study Setup

fidelity region
preliminary OMCT data
Approach and landing with sidestep:

**longitudinal deviation**

**lateral deviation**

[Graphs showing deviations for different training motions (NOM, HLO, HHI, SIDE).]
High-altitude stall recovery:

stick shakers
FAA Study Results

Overbank upset recovery:

**pilot rating**

<table>
<thead>
<tr>
<th>rating</th>
<th>NOM</th>
<th>HLO</th>
<th>HHI</th>
<th>OVER</th>
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<tr>
<td>7</td>
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<td>(8)</td>
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</tbody>
</table>

**load factor**

![Graph showing load factor vs training motion for NOM, HLO, HHI, OVER]
Engine out on takeoff:

**pilot rating**

- NOM: (4) (7)
- HLO: (6) (1)
- HHI: (5)
- TOFF: (3) (3) (1) (1)

**reaction time**

- NOM, HLO, HHI, TOFF: Graph showing reaction time with error bars.
We found objective measures that depend on the motion condition in training.

However, we found a limited number of significant effects:

- Results are from single runs
- Pilots not familiar with aircraft dynamics
- No familiarization with tasks
- Scripted nature of tasks
- Criteria not strict enough
- Task performance might not be the best measure
Objective motion cueing criteria show early promise

However, some improvements can be made to the OMCT and the newly proposed criteria:

• One-size-fits-all approach is not always appropriate
• Self checks should be introduced to validate results
• In some axes less sensitive compared to Sinacori Criteria
• Criteria not valid for more exotic motion filters

FAA Study Discussion
Two principal conclusions:

1. The study found objective measures that depend on the motion condition in training.

2. The new objective motion criteria may offer valid standardization benefits, as increases in the training motion fidelity, as predicted by the criteria, resulted in expected trends in pilot ratings and objective performance measures after transfer.
The objective of the next experiment (end 2014) is to refine the new motion criteria:

![Graph showing different levels of motion criteria]
Study 2
Transfer of Stall Recovery Training

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In early 2014, the FAA issued an update to AC 120-109, covering stall prevention and recovery training.

However, current flight simulators do not represent aircraft behavior in upset situations that take the aircraft out of its normal flight envelope.
Main focus of previous research:

• The development of useful post-stall aircraft model characteristics

• Increasing the realism of motion stimuli in upset recovery simulation
  – No focus on training
Importance of motion during an approach to and recovery from a stall:

- **Approach:** buffeting, reduced pitch and roll control effectiveness, reduced or negative roll stability, wing drop
- **Recovery:** sensitive pitch control (amount of back pressure is important)
Main objective:

• Optimize motion cueing for maximum transfer of stall recovery training using a cybernetic approach
Cybernetic approach:
Planning:

1. Preliminary experiments in a part task simulator to optimize our identification and modeling techniques (July/August)
2. VMS experiment on motion and visual cue integration in training (September/October)
3. VMS experiments on stall recovery training
Summary

Two approaches in transfer-of-training research:

1. Task performance in realistic flight tasks
   - Limited benefits of motion found
   - More relevant for authorities and training institutes

2. Skill-based behavior and performance in tracking tasks
   - Motion improves skill acquisition and performance after transfer
   - Less relevant for authorities and training institutes
Discussion and Questions

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