Training to Reduce Metacognitive Inaccuracy and its Effects on Performance Variables for Air Traffic Controllers

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Introduction:

- To achieve safe and efficient operations, ATCos need to have manageable levels of workload and high levels of situation awareness (SA; Durso and Dattel, 2004).
- However, they also need accurate subjective assessments of their workload and SA, as it is these meta-cognitive judgments that affect much of their decision-making (Roske-Hofstrand and Murphy, 1998).
  - E.g., inaccurate assessments of workload may cause a controller to not ask for assistance when he/she requires it, and over-confidence in their SA may cause a controller to not take steps to ensure that their understanding of a situation is accurate.
- This study examines the consequences of inaccuracies in metacognitive judgments of workload and SA in ATCo performance.
- We assumed that accuracy of metacognitive judgments of workload and SA can be assessed by the difference between an operator's subjective estimate of workload and SA and a more objective measure, response latency.
- We also examined whether type of ATCo training affects the accuracy of these metacognitive judgments.
- This study is a secondary analysis of Kiken et al. (2011), which compared two methods (part-whole vs. whole task) for teaching ATCo trainees how to use manual, voice-based tools, and NextGen tools.

Research Questions:

- Does Workload Metacognitive Inaccuracy (WMI) affect ATCo performance?
- Does Situation Awareness Metacognitive Inaccuracy (SMI) affect ATCo performance?
- How does training, skill level and equipage affect WMI?
- How does training, skill level and equipage affect SMI?

Methods:

Participants:

13 students training for a career in Air Traffic Control (ATCo) received hands-on radar simulation training with voice-based tools, and NextGen tools (i.e. conflict alerting, controller-pilot Data-Link and a trail planner with conflict probes).

Training						
Week	**1**	**2-7**	**8**	**Midterm**	**9-14**	**Final**
Part-Whole	Intro Voice	Voice	Voice & NextGen	Midterm Test	Voice & NextGen	Final Test
Whole	Intro Voice & NextGen	Voice & NextGen	Voice & NextGen	Midterm Test	Voice & NextGen	Final Test

Design:

Workload Metacognitive Inaccuracy: Z-scores of WL subjective measures (TLX) were subtracted from Z-scores of WL objective measures (SPAM Ready Latency). The absolute value of this difference was used to calculate WL Metacognitive Inaccuracy.

Situation Awareness Metacognitive Inaccuracy: Z-scores of SA subjective measures (SART) were subtracted from Z-scores of SA objective measures (SPAM Accuracy & Question Latency). The absolute value of this difference was used to calculate SA Metacognitive Inaccuracy.

Correlation between WMI and SMI: r =.082 p=.772

Median Split of Z-scores for High & Low WMI and SMI			
	Low	**High**	***p*-value**
SMI	M = .17	M = 1.27	p = .009
WMI	M = .33	M = 1.02	p = .003

Non-Journeyman = not proficient in using four skill sets* by midterm.
Journeyman = proficient in using four skill sets* by midterm.

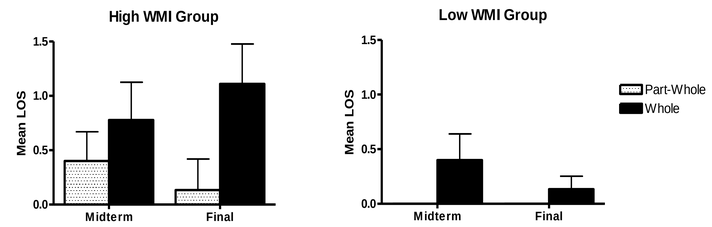
* passing methods, altitude, speed, heading and structure

Results:

PERFORMANCE ANALYSIS

Workload Metacognitive Inaccuracy (WMI)

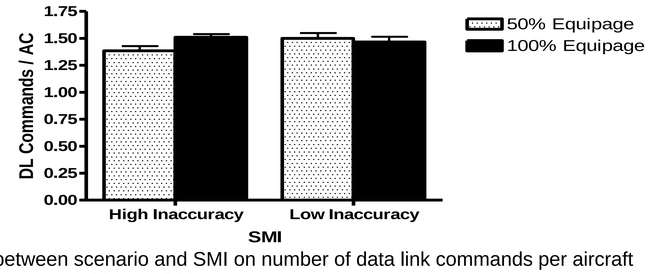
The Effect of WL Metacognitive Inaccuracy, Training and Test Session on Mean LOS



- There was a marginal interaction between metacognitive inaccuracy, test session and training type on mean LOS, $F(1,11) = 4.433$, $p=.06$.
- For those with high WMI there was a marginally significant interaction between test session and training type on mean LOS ($p=.09$). For those with low WMI there was a non-significant interaction between test session and training type on mean LOS ($p=.37$).

Situation Awareness Metacognitive Inaccuracy (SMI)

The Effect of SA Metacognitive Inaccuracy and Equipage on Data-Link Commands per Aircraft

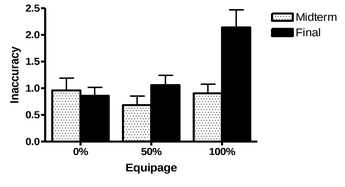


- An interaction between scenario and SMI on number of data link commands per aircraft was found, $F(1, 11) = 11.324$, $p=.006$.
- There was a significant effect for scenario in high SMI ($p=.021$), but a non-significant effect for low SMI ($p=.298$); those with high SMI recorded fewer DL commands per aircraft in the 50% equipage than in the 100% equipage scenario.

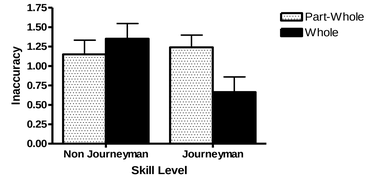
TRAINING ANALYSIS

Workload Metacognitive Inaccuracy (WMI)

Effect of Test Session and Equipage on WL Metacognitive Inaccuracy



Effect of Training and Skill Level on WL MetaCognitive Inaccuracy



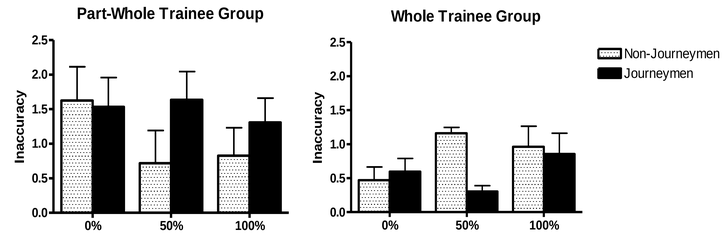
- There was an interaction between scenario and test session on WMI, $F(2,22) = 5.197$, $p=.014$. For midterm, there was no effect of scenario on WMI ($p=.59$). For final, the interaction between scenario and test session was significant ($p=.003$).
- *Post hoc* tests reveal that for the final, WMI was significantly greater in the 100% equipage scenario than any other scenario. WMI was also greater in the 50% equipage scenario than the 0% scenario.

- There was a marginal interaction for training type and journeyman status, $F(1,11) = 4.342$, $p=.061$. Journeymen in Part-Whole Training had higher WMI than those in Whole-training ($p=.024$). Training for Non-Journeymen did not effect their WMI ($p=.577$).

Results (cont.)

Situation Awareness Metacognitive Inaccuracy (SMI)

The Effect of Training, Equipage and Skill Level on SA Metacognitive Inaccuracy



- There was an interaction between scenario, training type, and Journeyman status, $F(2, 22) = 7.120$, $p=.004$.
- There was an interaction between Scenario and Journeymen status for Part-Whole Training for SMI, (p=.008), but a marginal interaction for Whole-Training ($p=.067$).
  - For Journeymen SMI was not affected by scenario. For Non-Journeymen SMI was lowest at 50 and 100% equipage.

Discussion:

PERFORMANCE ANALYSIS

Workload Metacognitive Inaccuracy (WMI):
- LOS was the only performance factor found to be affected by WMI
- Low WMI results in fewer LOS than High WMI at least for Part-Whole Training.

Situation Awareness Metacognitive Inaccuracy (SMI):
- DL/AC was the only performance factor found to be affected by SMI
- Low SMI resulted in fewer DL/AC in mixed-equipage scenarios.
- However controversy exists surrounding the desired amount DL/AC.

- WMI has a bigger impact on performance than SMI.

TRAINING ANALYSIS

Workload Metacognitive Inaccuracy (WMI):
- 100% equipage significantly increased WMI in the Final test session.
- Whole-Training significantly reduced WMI for Journeymen.

Situation Awareness Metacognitive Inaccuracy (SMI):
- Whole-Training reduces SMI for Journeymen.

- Whole-Training reduces Metacognitive Inaccuracy for both Workload and Situation Awareness for Journeymen.

References:

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