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Effects of Lighting and Noise on Performance and Situation Awareness in an Air Traffic Control Task

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By Saralee Pruksaritanon

Overview

- Significance of the Study and Existing Problems
- Background Information
- Research Question and Hypotheses
- Method
- Results
- Discussion & Recommendation

Significance and Problems

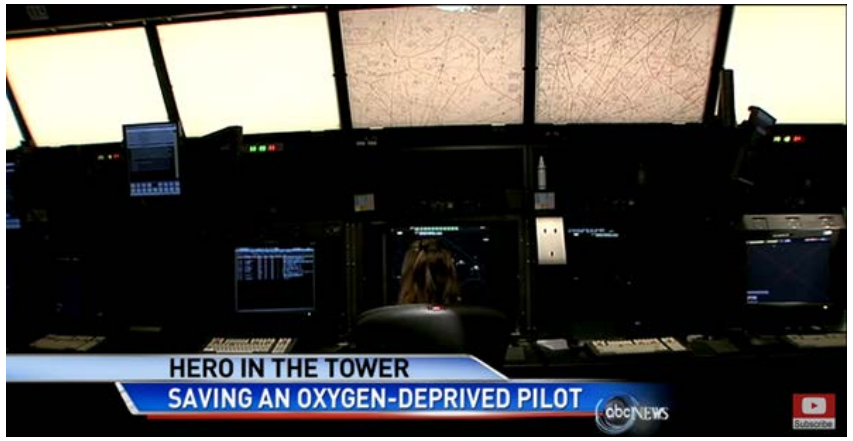
- **Significance of the Study**
  - To understand the impact of lighting and noise on performance and SA in ATC tasks.
  - The results of the study are useful for those involved in the design of ATC workplace environment such as ATC training academies, aviation regulators and air navigation service providers (ANSPs).
- **Problems**
  - Since the introduction of radar displays, ATC rooms at Air Route Traffic Control Center (ARTCC) and Terminal Radar Approach Control (TRACON) have been kept in the dark to minimize undesirable effects (i.e. reflections and glares) caused by light sources (Kopala, 1977).
  - Technology Advance: Air Traffic Situation Display, Strip Printer
  - Is keeping the ATC room dark still necessary? Would performing ATC tasks under normal office lighting result in any change in human performance and SA?

Background Information

- Work environment influences an individual's performance and situation awareness (SA).
- International Civil Aviation Organization (ICAO) identifies ambient light and noise as parts of the internal workplace environment that all sectors of the aviation system must assess and consider (ICAO, 2012).
- Without sufficient lighting, it is more difficult for individuals to maintain high visual acuity (Hawes, Brunye, Mahoney, Sullivan, & Aall, 2012).
- Effective radio communication between controllers and pilots is recognized as a significant contribution to aviation safety. Distractions and barriers to communication can result in miscommunications, errors or accidents (Barshi & Farris, 2016).

Lighting in ATC rooms

America



Fort Worth Air Route Traffic Control Center (2013)

https://www.youtube.com/watch?v=aButLTPDA10
1:26 (TRACON), 2:03 (ARTCC)

Europe

An air traffic controller monitors a display at Eurocontrol's Maastricht Upper Area Control Center (2014).

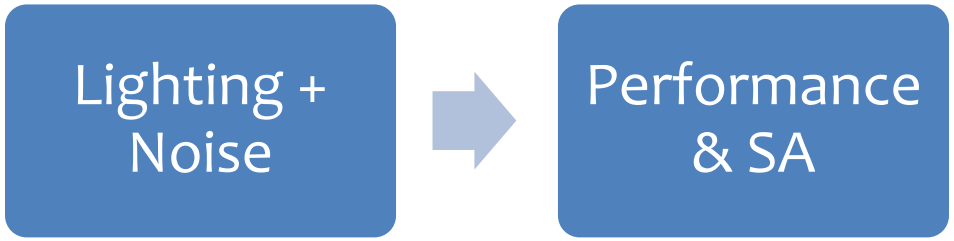
https://www.youtube.com/watch?v=iUrEexcEsKQ 0:45

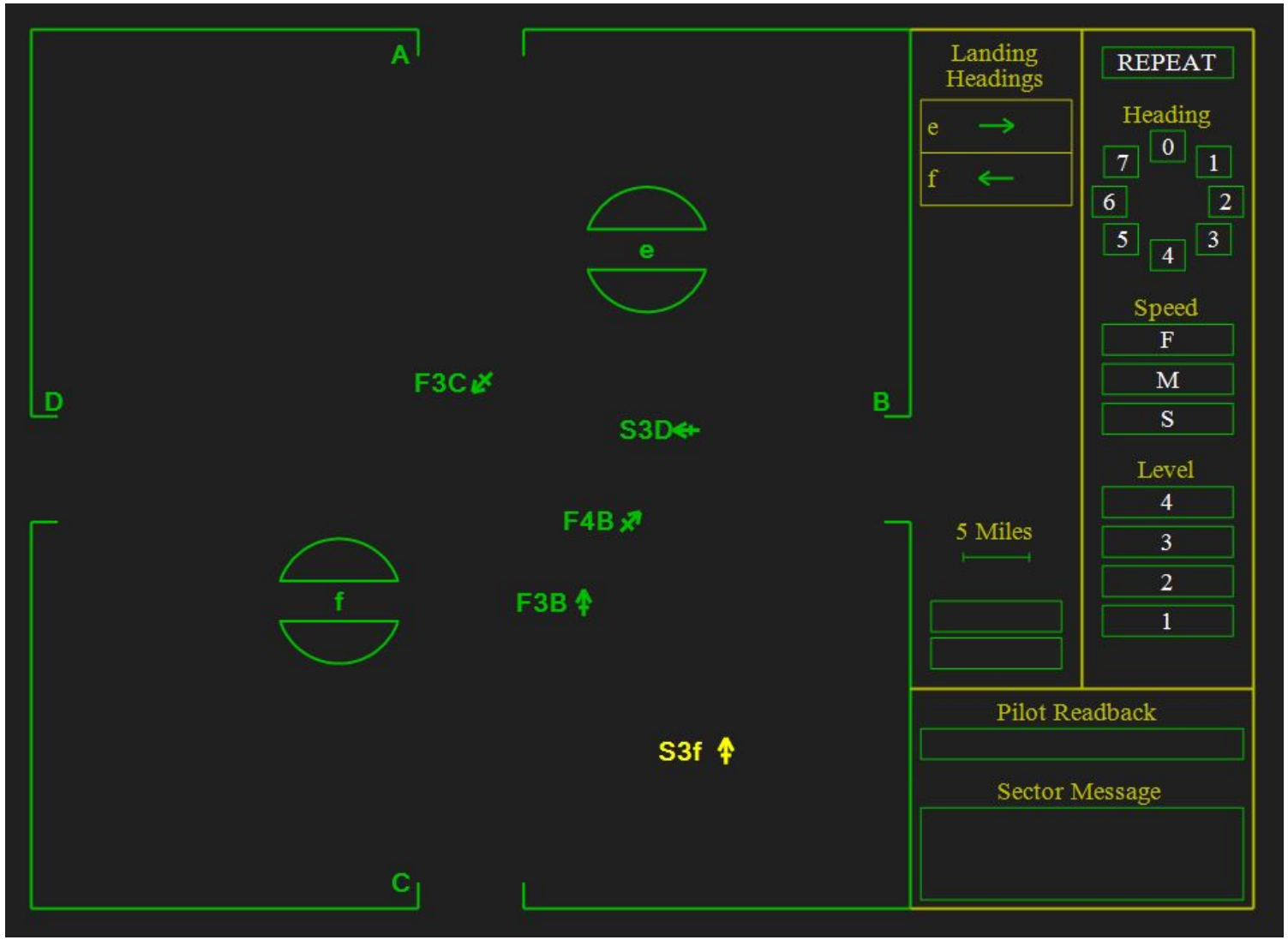
Research Question and Hypothesis

- **Research Question**
  - Is there a significant effect of lighting and noise on performance and situation awareness when performing ATC tasks?
- **Hypotheses**
  - H1: There is no significant difference in performance between a group working under low lighting and a group working under normal lighting.
  - H2: There is no significant difference in performance between a group working in a noisy environment and a group working in a quiet environment.
  - H3: There is no significant interaction effect between lighting and noise in terms of performance.
  - H4: There is no significant difference in SA between a group working under low lighting and a group working under normal lighting.
  - H5: There is no significant difference in SA between a group working in a noisy environment and a group working in a quiet environment.
  - H6: There is no significant interaction effect between lighting and noise in terms of SA.

Method

- A quantitative research design using a within-subject research model to determine the differences in performance and SA when ATC tasks were performed under four different working conditions.
- The Air Traffic Scenario Test (ATST) was employed to simulate ATC tasks and to measure the performance of participants.
- The Situation Awareness Global Assessment Technique (SAGAT) was modified and adopted as a tool to measure SA of participants.
- Experimental Study
  - 16 ATM students in 2nd, 3rd, and 4th year
  - Cognitive Engineering Research in transportation Systems (CERTS Lab)
- Using a simulation software, Air Traffic Scenario Test (ATST)

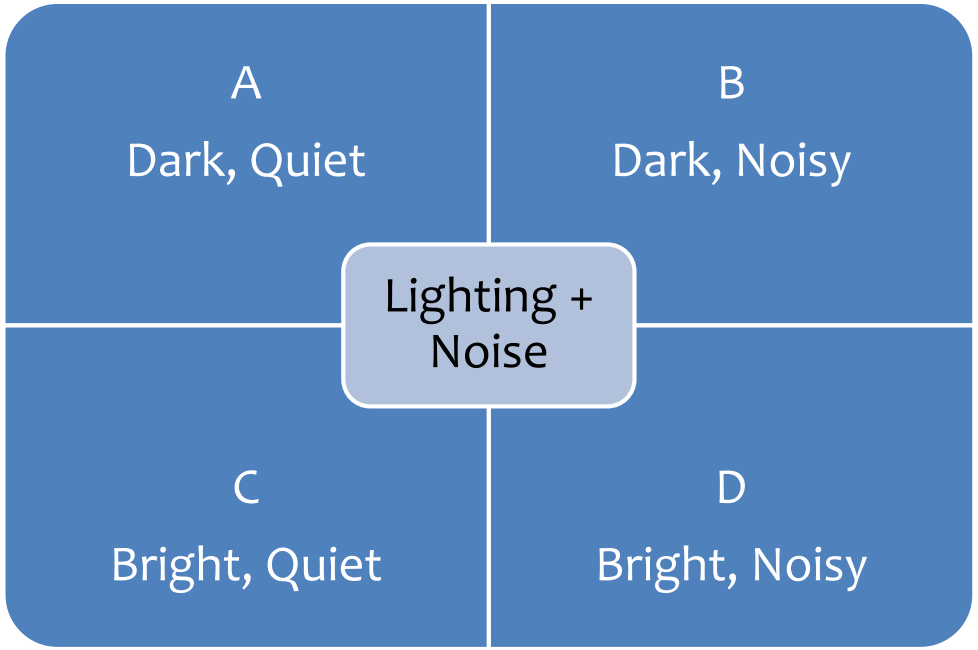




Air Traffic Scenario Test (ATST)

Design and Procedures

- Participants: ATM students
- Independent Variables (IVs)
  - Lighting
    - Dark: 100 lux
    - Bright: 250 lux
  - Noise
    - Quiet: approx. 40 dB
    - Noisy: 60-70 dB
- Dependent variable (DVs)
  - Performance
  - SA



Results

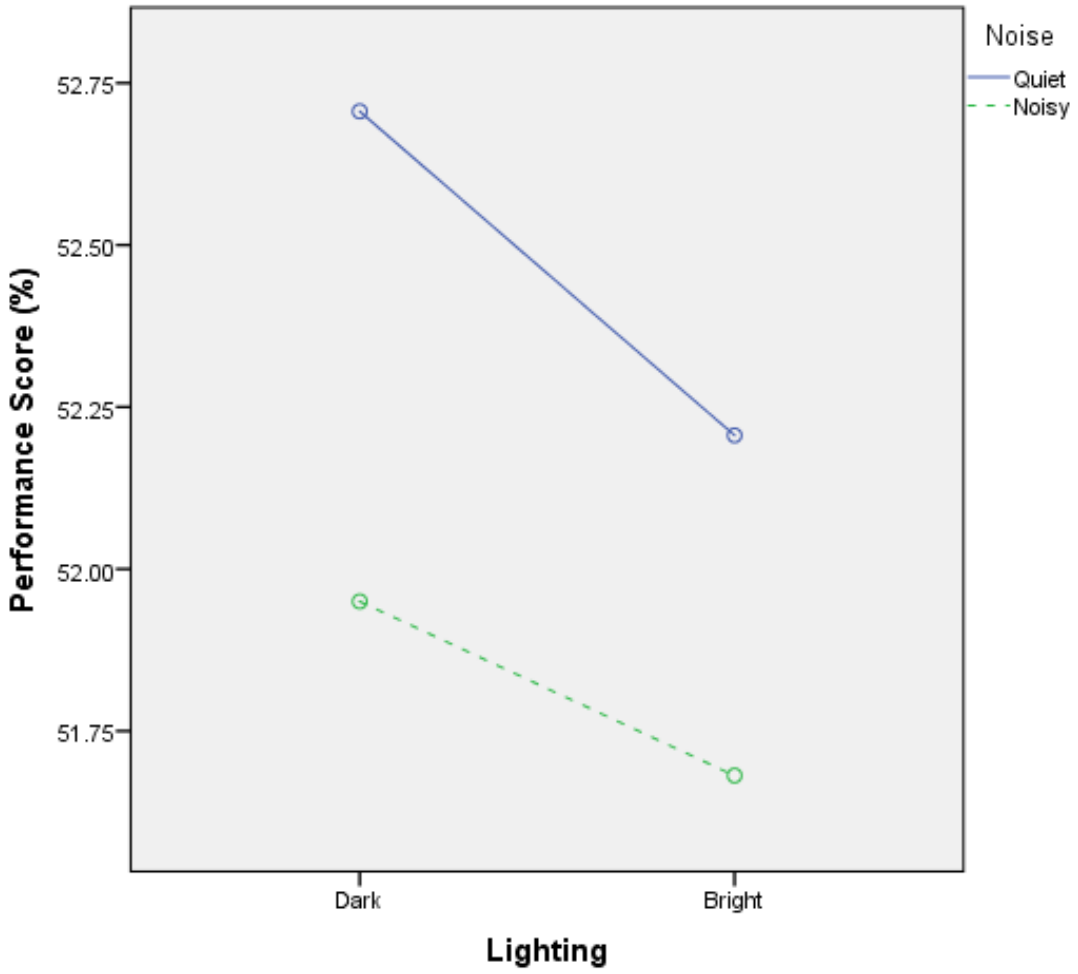
Hypothesis Testing on Performance Means (1/2)

Means and Standard Deviations of Performance for Each Factor and the Results for Hypothesis Testing

Factor	*M*	*SD*	*F*	*p*
Lighting			1.272	.277
Dark	52.33	.32		
Bright	51.94	.34		
Noise			5.447	.034
Quiet	52.46	.32		
Noisy	51.82	.31		
Lighting x Noise			.103	.753
PMDarkQuiet	52.71	1.54		
PMDarkNoisy	51.95	1.27		
PMBrightQuiet	52.21	1.79		
PMBrightNoisy	51.68	1.69		

Note. PMDarkQuiet = Performance measured from the dark and quiet condition; PMDarkNoisy = Performance measured from the dark and noisy condition; PMBrightQuiet = Performance measured from the bright and quiet condition; PMBrightNoisy = Performance measured from the bright and noisy condition.

Hypothesis Testing on Performance Means (2/2)



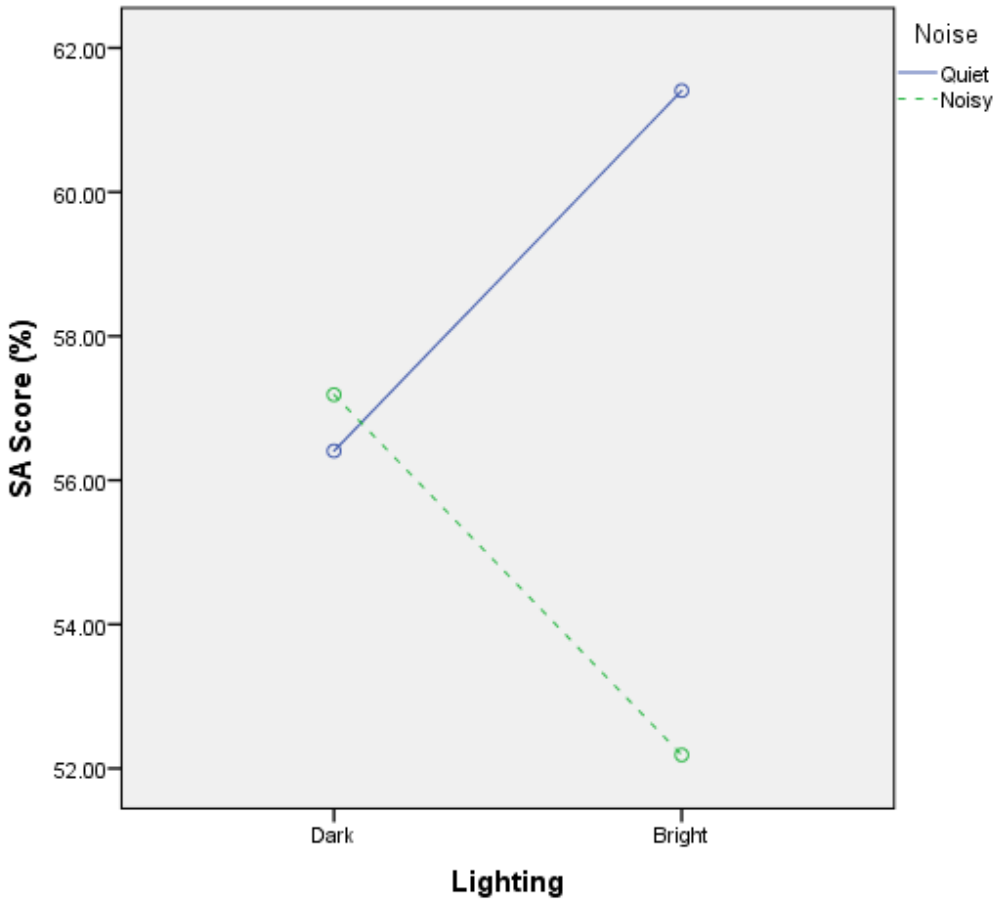
Hypothesis Testing on SA Means (1/2)

Means and Standard Deviations of SA for Each Factor and the Results for Hypothesis Testing

Factor	*M*	*SD*	*F*	*p*
Lighting			0.000	1.000
Dark	56.80	2.48		
Bright	56.80	2.61		
Noise			1.820	.197
Quiet	58.91	2.45		
Noisy	54.69	2.74		
Lighting x Noise			1.959	.182
SADarkQuiet	56.41	3.15		
SADarkNoisy	57.19	3.34		
SABrightQuiet	61.41	2.85		
SABrightNoisy	52.19	4.39		

Note. SADarkQuiet = SA measured from the dark and quiet condition; SADarkNoisy = SA from the dark and noisy condition; SABrightQuiet = SA measured from the bright and quiet condition; SABrightNoisy = SA measured from the bright and noisy condition.

Hypothesis Testing on SA Means (2/2)



Discussion (1/2)

- Hypothesis testing on Performance
  - Performance decreased when the continuous sound of strip printer was present.
  - Reduction in performance can be explained by the interference of noise with the communication between controllers and pilots.
  - Bell, Roer, Dentale, and Buchner (2012) claim that noise can impair the locus of attention by diverting the attention away from visual information and relocating it to the sound which causes interruption to the task.
  - Working in a bright room and being able to see things around do not affect controllers' attention because of the nature of ATC task that requires high attention.

Discussion (2/2)

- Hypothesis Testing on SA
  - No significant difference of SA scores in any working conditions
  - For lighting treatment, the result of SA is correspond to the result of performance.
  - Participants do not rely on their auditory perceptions, but primarily use their visual perception to create SA and understanding of traffic situation.

Recommendation

- Lighting condition in ARTCCs can be adjusted as long as glares and reflections do not cause problems to the operators.
- The noise level in the control room should not go beyond 60 dB
- For further research
  - Add difficulty as one of the IVs
  - Actual controllers
  - Team SA
  - Field experiment

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