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Evaluating Scenarios That Can Startle and Surprise Pilots

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Rahim D. Agha, Andrew R. Dattel, & Jennifer E. Thropp

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Purpose

- Identify scenarios that can startle and surprise pilots
- Determine the effect startle and surprise has on pilots while flying different aircraft
- Evaluate pilot performance during startle and surprise events
- Evaluate pilot workload during startle and surprise events



Startle

- An uncontrollable, automatic muscle reflex, raised heart rate, blood pressure, elicited by exposure to a sudden, intense event that violates a pilot's expectations

Surprise

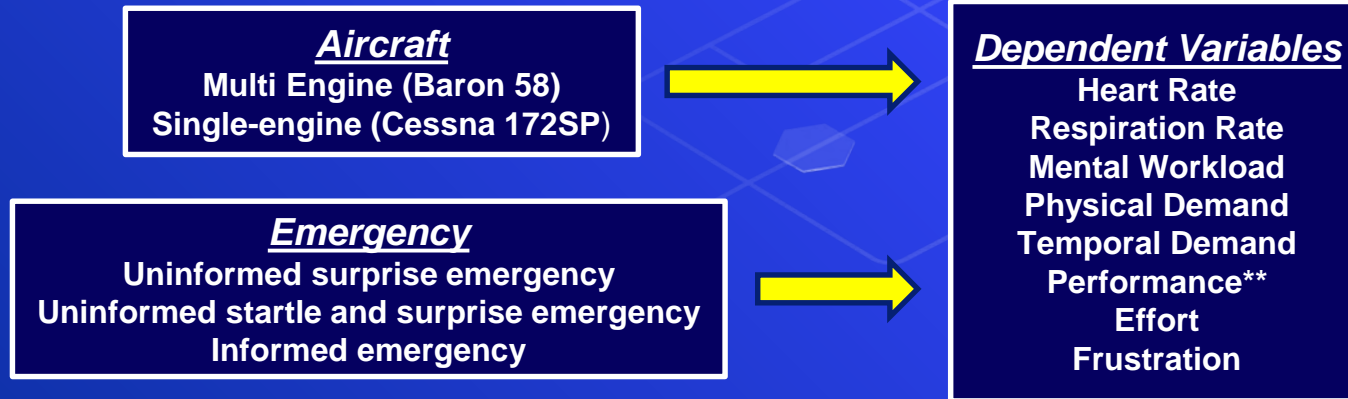
- An unexpected event that violates a pilot's expectations and can affect the mental processes used to respond to the event

Why Startle and Surprise

- Contributing factor in multiple airline accidents
 - Air France 447
 - Colgan Air 3407
 - Turkish Airlines 1951

Research Design

- Experimental design
 - 2 x 3 within subject design
 - 8 dependent variables
- Performance* measured separately for each aircraft



* Evaluated using data obtained from X-Plane

** Self assessed by each participant

Method

■ Sample

- Fifteen commercial pilots (multi-engine and single-engine rated)
- Recruited using convenience sampling
- Paid 20 USD for participation

■ Apparatus

- Six scenarios were created on Elite PI-135 flight simulator using X-Plane 11 software
- Nexus 10 was used to record heart rate and respiration rate
- NASA-TLX* was used to assess pilot workload



Cessna 172SP

<u>Scenario</u>	<u>Scenario Parameters</u>	<u>Scenario Description</u>
Uninformed Surprise Emergency	10 nm** ILS ^a approach to 25R DAB ^c	Engine failure at 1500 feet with cloud layer set at 1000 feet
Uninformed Surprise and Startle Emergency*	10 nm ILS approach to 25R DAB	Engine failure at 1500 feet and engine fire at 1000 feet. A loud bang or thunder noise at different altitudes
Informed Emergency	10 nm ILS approach to 25R DAB	Engine failure at 1500 feet with cloud layer set at 1000 feet

* Half participants heard loud bang and the other half thunder noise with lightning

** Nautical miles

^a Instrument Landing System

^b Daytona Beach International Airport

Baron 58

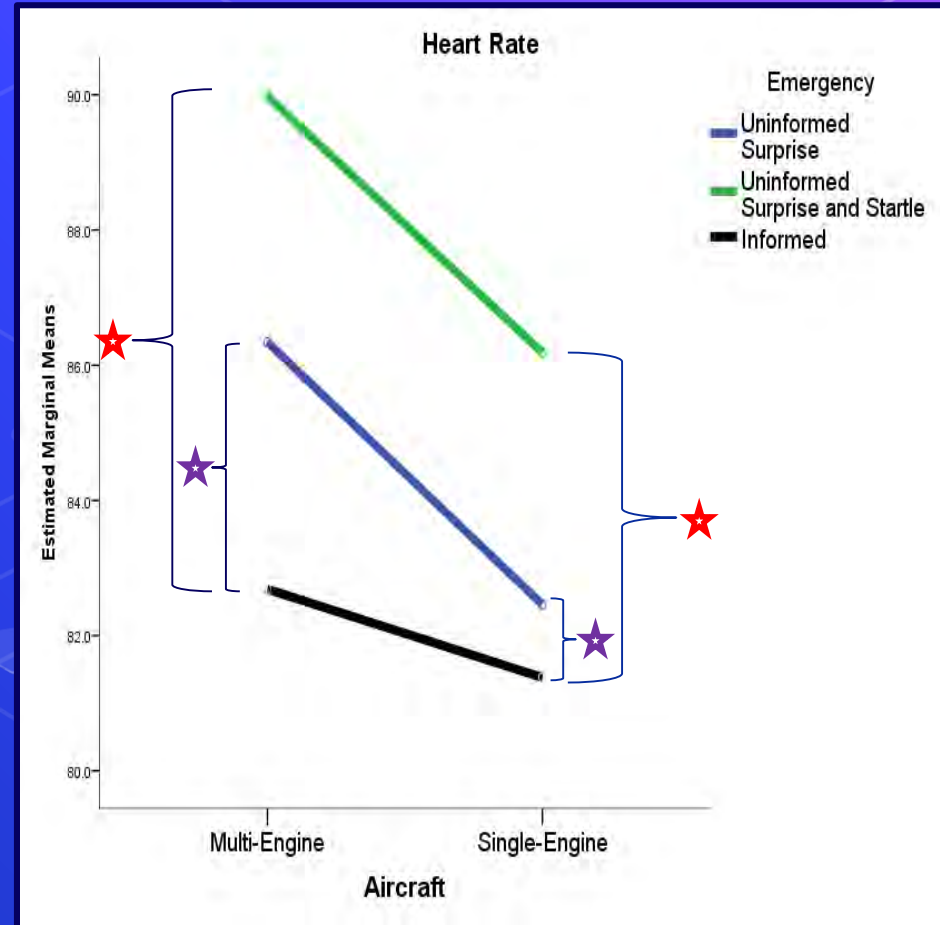
<u>Scenario</u>	<u>Scenario Parameters</u>	<u>Scenario Description</u>
Uninformed Surprise Emergency	3 nm ILS approach to 25R DAB	Left engine failure at 450 feet with cloud layer set at 100 feet
Uninformed Surprise and Startle Emergency*	3 nm ILS approach to 25R DAB	Left engine failure at 450 feet and cloud layer set at 100 feet. A loud bang or thunder noise at different altitudes
Informed Emergency	3 nm ILS approach to 25R DAB	Left engine failure at 450 feet with a cloud layer set at 100 feet

* Half participants heard loud bang and the other half thunder noise with lightning

Significant Findings

■ Heart Rate

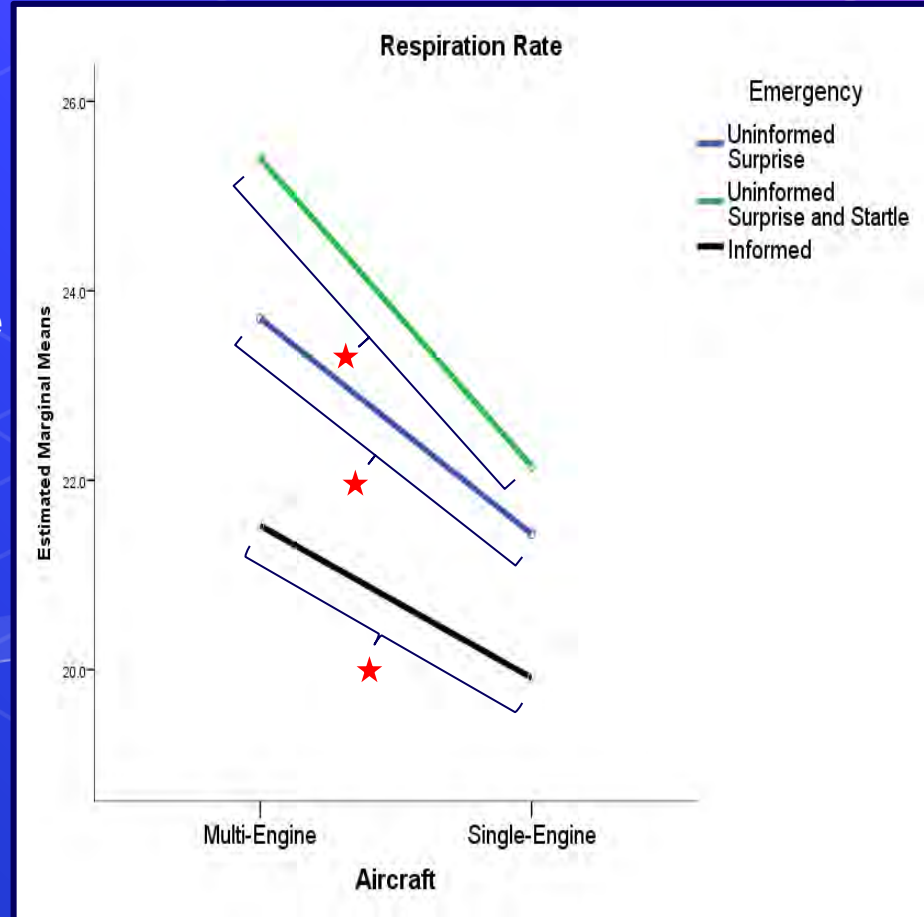
- Significant interaction between aircraft and emergency
- No significant differences for informed emergency between the aircrafts
- Difference between uninformed surprise and informed emergency is significantly higher in the multi-engine aircraft



Significant Findings

■ Respiration Rate

- No significant interaction
- Significant main effects
- Respiration rate was highest in the uninformed surprise and startle condition and lowest in the informed condition



Significant Findings

■ NASA-TLX

- All six factors were significantly higher for the uninformed surprise and startle condition
- Physical and temporal demand, effort, and frustration was higher for the multi-engine aircraft

Variable	Main Effect(Aircraft)	Main Effect (Scenario)	Interaction (Aircraft*Scenario)
Mental Demand	$p > .05^{ns}$	$p < .001^{**}$	$p > .05^{ns}$
Physical Demand	$p = .046^*$	$p = .007^*$	$p > .05^{ns}$
Temporal Demand	$p = .016^*$	$p < .001^{**}$	$p = .013^*$
Performance	$p > .05^{ns}$	$p < .001^{**}$	$p > .05^{ns}$
Effort	$p = .004^*$	$p = .003^*$	$p > .05^{ns}$
Frustration	$p = .001^{**}$	$p < .001^{**}$	$p > .05^{ns}$

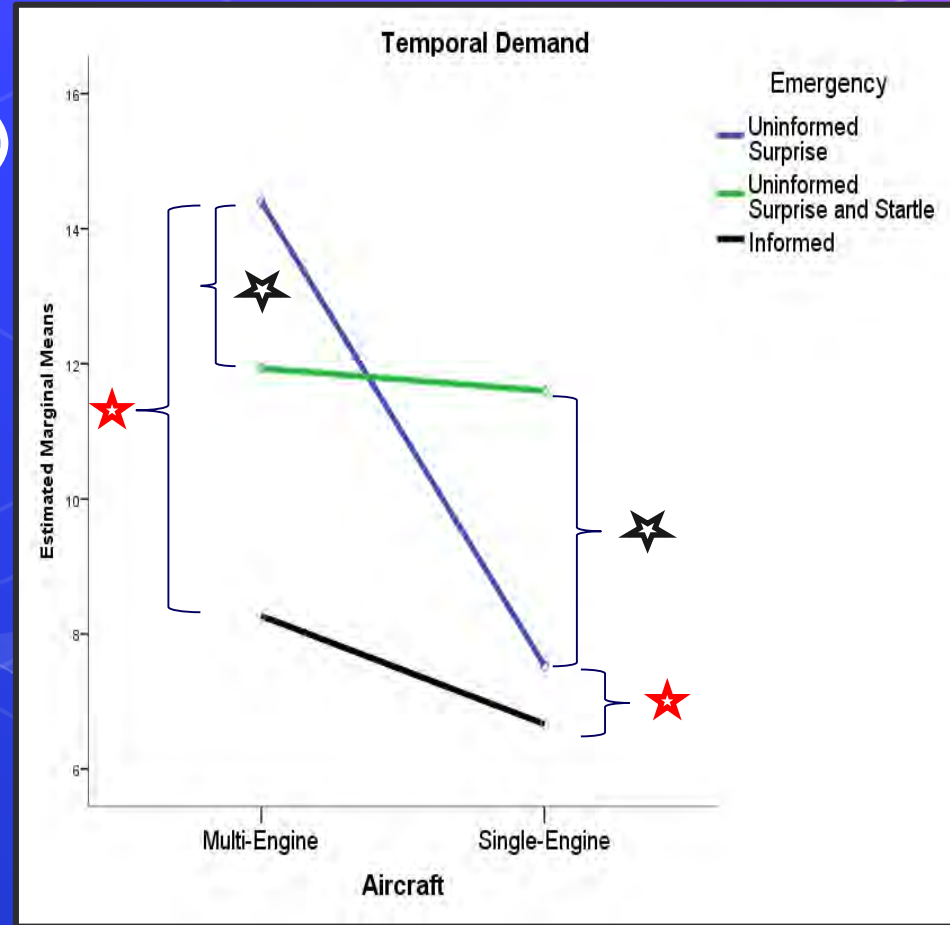
* $p < .05$

** $p < .01$

^{ns} Non-significant

Significant Findings

- **NASA-TLX (Temporal Demand)**
 - Temporal demand was higher in the uninformed surprise condition for the multi-engine aircraft
 - No difference in the uninformed surprise and startle condition between the aircraft



Significant Findings

■ Performance

- Multi-engine (Altitude Deviation)
 - $F(2, 28) = 56.75, p < .001, \eta^2 = .80$ (Large effect)
 - Post hoc indicated that there were significant differences between informed emergency when compared to uninformed surprise ($p < .001$) and uninformed surprise and startle ($p < .001$). Uninformed surprise was significantly less than the uninformed surprise and startle ($p = .018$)
- Single-engine (Number of Engine-Failure checklist steps followed)
 - $F(2, 28) = 39.417, p < .001, \eta^2 = .738$ (Large effect)
 - Post hoc indicated that there were significant differences between informed emergency when compared to uninformed surprise ($p < .001$) and uninformed surprise and startle ($p < .001$)

Discussion

■ Heart Rate and Respiration Rate

- Informed emergency is predictable hence heart and respiration is low
- Startle and surprise condition increases the heart rate and respiration rate more than surprise condition
- Very significant finding for general aviation pilots
- Heart rate and respiration rate is directly related to each other

■ NASA-TLX

- All six workload factors had a significant main effect for scenario
- The researchers expect to find significant interactions for the workload factor with the addition of more data

■ Performance

- Expect to find significant difference between uninformed surprise and uninformed surprise and startle condition for each aircraft with a larger sample size

Discussion

- All dependent variables except temporal demand increased when participant flew surprise uninformed emergency condition to when they flew surprise and startle uninformed emergency
- The score for all dependent variables for the informed emergency condition was less than the uninformed surprise and the uninformed surprise and startle condition
- The study found that performance, vital signs, and workload are significantly different when the pilots fly an emergency that is informed vs the emergency that is uninformed

Recommendations

- Propose more scenarios that can startle and surprise pilots
- Pilot training should incorporate scenarios that are startling and surprising
- Future studies should record other vital signs (i.e., blood pressure) and skin conductance



Thank you

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