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Is Human Factors Really Necessary?

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Do We Need Human Factors?

A day in the life of a human factors engineer…

Is human factors really important?

Can't we just train people to use the system the right way?

Can't we wait until the system is fielded and see if people have problems?

Professionals should know how to use whatever we develop.

We hire the best and the brightest—they don't need a human factors crutch.

We've never used human factors before, and there haven't been any problems.

We (developers) are human, so we've got human factors covered.

Research about the value of human factors didn't come from SNL, so it doesn't apply to our people.

How to Convince People?

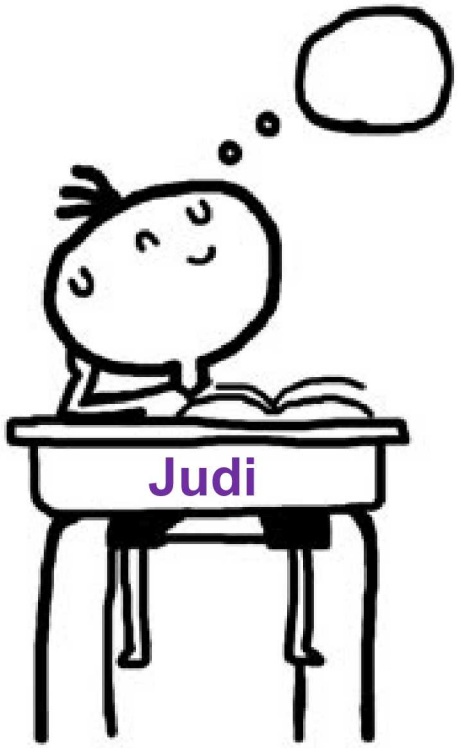
- Every human factors professional understands the value and important of incorporating human factors
- Many professionals outside the field just don't get it

How Do We Convince Them???

- ✓ **Set requirements for human factors**
- ✓ **Provide research evidence for value of human factors**
- ✓ **Provide evidence-based guidance**
- ✓ **Highlight typical returns on investment**

What Else Can Be Done?

Just make stuff up



Study Background

Benefits of Human Factors

- Design phase and O&M phase
- Improved safety
- Increased effectiveness
- Increased efficiency
- Improved productivity
- Enhanced operator satisfaction
- Reduced training time and costs
- Fewer accidents
- Fewer errors
- Lower maintenance costs
- Less equipment damage

- Benefits have been demonstrated repeatedly
- ***But***, most evidence is from reactive case studies
- Controlled experiments to establish causality have had limitations

Limitations of Existing Research

- Most studies have been reactive case studies
- Controlled experiments investigated existing flawed systems
- Focus on products and interfaces, not process
- Experimental demonstrations have been scarce since 1990s

Purpose of Current Study

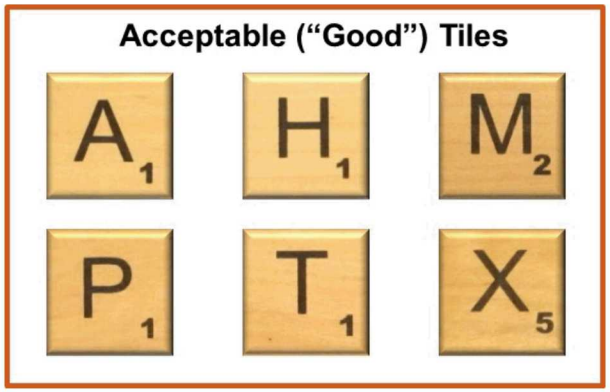
- Conduct a controlled experiment to demonstrate value of human factors and address limitations of previous research

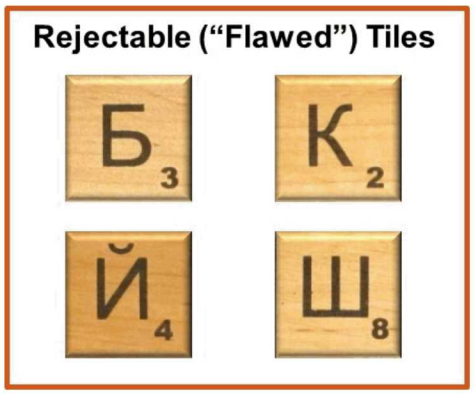
Limitation of Previous Research	Addressed in Current Study
• Focus on product or interface design	• Focus on process design
• Reactive investigations of existing flawed systems	• Design a completely novel task
• Few studies since 1990s	• Provide current evidence for value of human factors

Process *refers to activities completed in order to accomplish a mission or goal. Examples of processes include inspection, assembly, disassembly, fabrication, and dismantlement.*

Visual Inspection Task

- Created a task simulating a receipt inspection process
  - Parts for visual inspection consisted of 350 Scrabble tiles
  - Tiles contained either Roman characters (acceptable tiles) or Cyrillic characters (rejectable tiles)
  - 15 tiles (4%) were rejectable (335 acceptable)
  - Inspector task was to sort and count tiles and calculate vendor fees





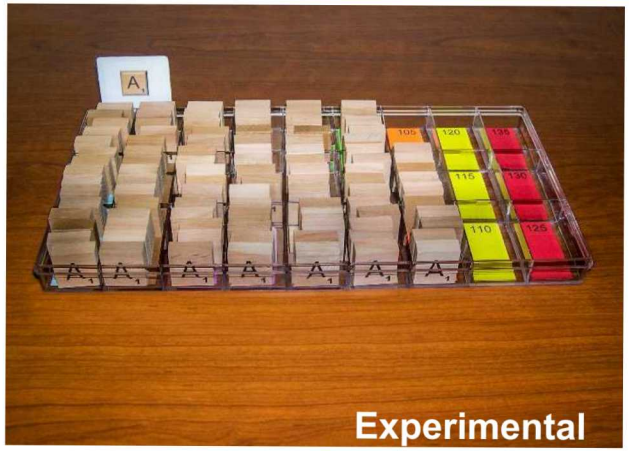
Tile	Value	#	$
A	1	100	$100
H	1	70	$70
…	…	…	…
X	5	14	$70
Totals		335	$433

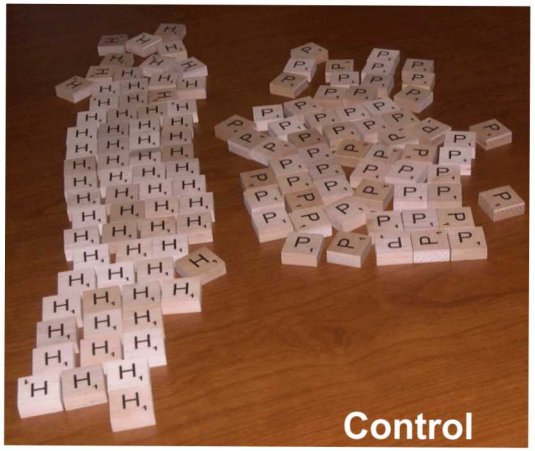
Task Design

- Each step of the process was designed with adherence to human factors principles (experimental group) and without (control group)

Step	Experimental Group	Control Group
Configure workspace	Full customization	No customization
Use work instruction	Comprehensive formatting; precise text and photo definitions of inspection criteria	Minimal formatting; broad text definitions of inspection criteria
Sort tiles	Labeled, numbered, and color-coded sorting bins	No sorting bins
Count tiles	Numbered slots in sorting bins	Individually determined
Enter quantities	Electronic pre-populated form	Manual paper form
Compute vendor fees	Auto calculations in form	Handheld calculator

Task Implementation





Experimental

Tile	Value	Quantity	Total Amount to Be Paid
A_1	1	100	$100
H_1	1	70	$70
M_2	2	42	$84
P_1	1	60	$60
T_1	1	49	$49
X_5	5	14	$70
	Totals	335	$433

Control Group

Tile	Value	Quantity	Total Amount to Be Paid
A	1	100	100
H	1	70	70
P	1	60	60
M	2	42	84
T	1	49	49
X	5	14	70

Total $: 433

Procedure

- Twenty-four SNL volunteers were randomly assigned to experimental and control groups, with 12 per group
- Each participant individually completed 1.3-hour session
- Experimenter observed task completion
- Participants provided NASA-TLX subjective workload ratings
  - Global workload score from weighted average of six subscale ratings
  - Ratings and scores range from 0 to 100
- Participants also rated task usability
  - Satisfaction with inspection task ease of completion, amount of time, and task work instructions
  - Rating scales ranged from *Strongly Disagree* (1) to *Strongly Agree* (7)
- End-of-session interviews were conducted

NASA-TLX Subscales
- Mental Demand
- Physical Demand
- Temporal Demand
- Performance
- Effort
- Frustration

Results – Performance Accuracy

- Experimental group committed fewer errors
  - Acceptable Tiles 
    - Experimental Group: single error was a miscount leading to $5 overpayment
    - Control Group: quantity errors led to underpayments ranging from $44 to $98 and overpayments up to $24
  - Rejectable Tiles 
    - Experimental Group: no errors at all for rejectable tiles
    - Control Group: quantity errors led to undercharging of $2 to $24

INCORRECT RESPONSES

Variable	Group	Acceptable Tiles	Rejectable Tiles
Tile Values	Experimental Control	0 0	0 1
Quantities	Experimental Control	1 3	0 4
Dollar Amounts	Experimental Control	1 5	0 4

= statistically significant

Results – Performance Accuracy

- 10 of 11 types of errors were prevented in experimental group

Errors Prevented in Experimental Group

1. Incorrect categorizations
2. Incorrect tile values
3. Incorrect calculations
4. Overturned tiles
5. Missing entries
6. Scratchouts
7. Handwriting ambiguity
8. Space allocation
9. Re-counting
10. End state configuration
11. Miscounts

Experimental Group Mitigations

- Work instruction
  - Formatted for usability
  - Clear text description of acceptance criterion
  - Photos of acceptable and rejectable tiles
- Sorting bins
  - Each slot accommodated five tiles
  - Redundant coding (labeled, numbered, color-coded slots)
  - Clearly delineated space requirements
  - Mechanism for transfer to next level of work
- Electronic spreadsheet
  - Pre-populated with static information
  - Auto calculations
  - Formatted for usability

Results – Process Variation

- Process design minimized individual differences that contribute to process variation
- Experimental group exhibited smaller number and variety of errors during task completion
- Experimental group standard deviations were smaller for all 10 dependent variables
  - Statistically significant for 7 of 10 variables
  - 2 to 26X smaller

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Results – Process Variation

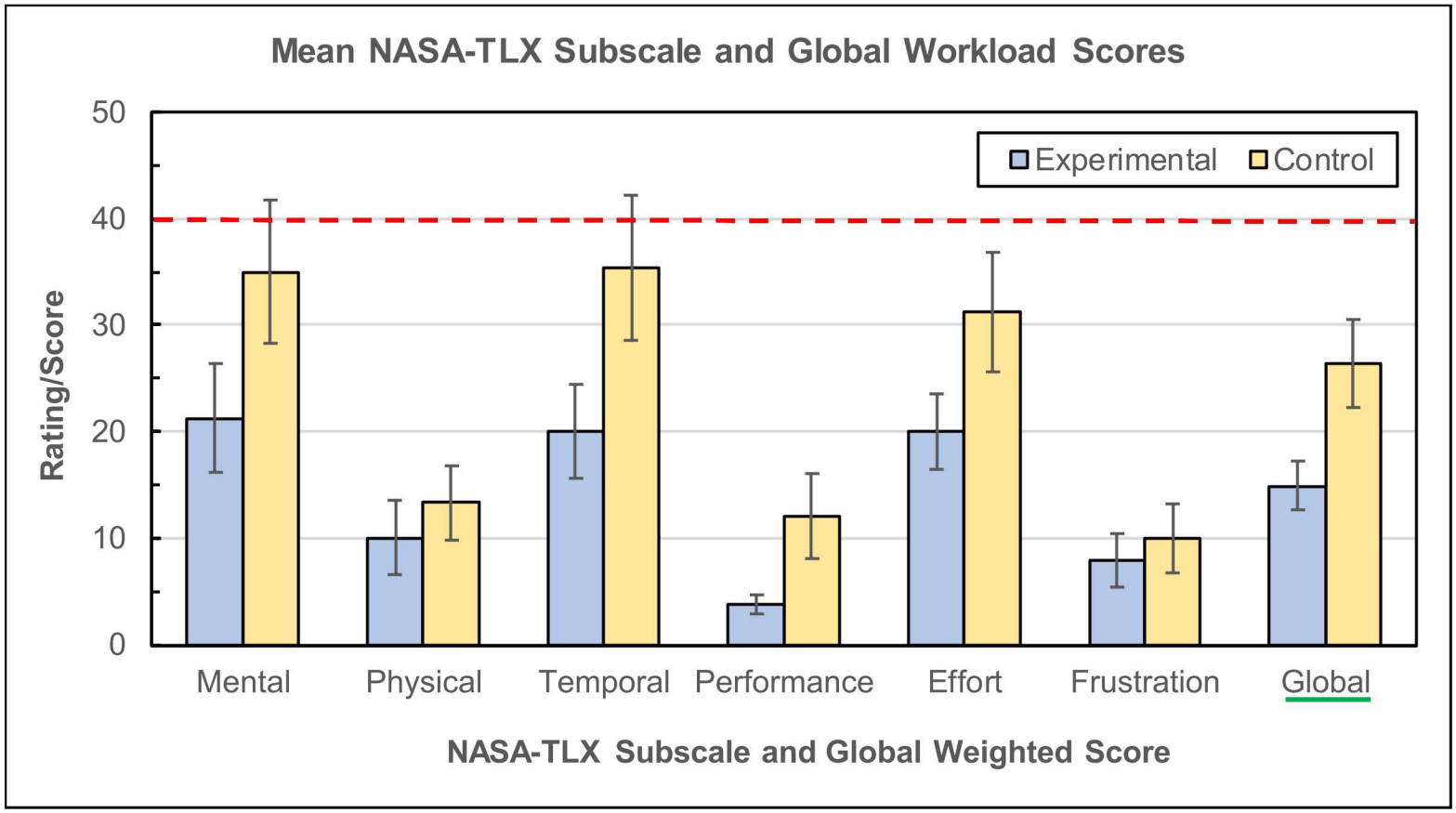
- Experimental group standard deviations were significantly smaller for 7 of 10 dependent variables

Dependent Variable	Means Experimental / Control	Standard Deviations Experimental / Control
Acceptable Quantity Recorded	335.08 / 335.50	.29 / 1.0
Acceptable Dollar Amount Recorded	$433.42 / $419.25	$1.44 / $37.27
Acceptable Percent Correct	100.0% / 99.9%	0.00% / .29%
Rejectable Quantity Recorded	15.00 / 14.33	0.00 / 1.16
Rejectable Dollar Amount Recorded	$58.00 / $53.00	$0.00 / $9.32
Rejectable Percent Correct	100.0% / 95.6%	0.0% / 7.7%
NASA-TLX Global Workload	14.9 / 26.4	7.9 / 14.2
Ease of Completion Usability Rating	6.7 / 6.0	.65 / 1.09
Amount of Time Usability Rating	6.3 / 5.8	.62 / 1.03
Work Instructions Usability Rating	6.8 / 6.7	.39 / .65

= statistically significant

Results - Workload

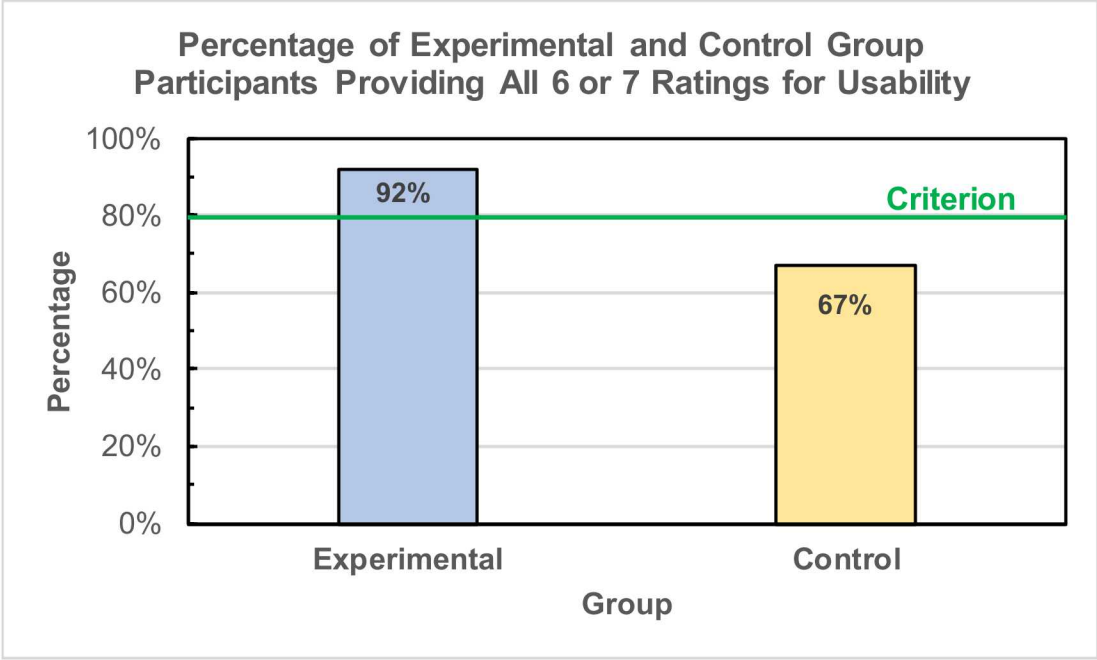
- Two primary challenges increased workload in control group
  - Develop efficient sorting and counting method
  - Perform manual counts and calculations



Results – Usability Ratings

- Criterion for usability in previous studies - 80% of participants rate all usability items at 6 or 7
- This criterion was met in experimental group, but not control group
  - No ratings below 5 in experimental group
  - Control group had ratings as low as 4

Usability
- Ease of Completion
- Amount of Time
- Work Instructions



Is Human Factors Really Necessary?

Yes

- Incorporating human factors in process design positively impacted performance, workload, and usability ratings
- Experimental group process design promoted more uniform task approach, reducing process variation
- Benefits were demonstrated with a very simple visual inspection task
- Greater benefits can be expected for more complex processes

NES Implications

- Humans are a critical part of the system and process
- Incorporating human factors can reduce errors and process variation in NEOPs
- No task is too simple to benefit from human factors
- Including human factors requirements in DOE O 452.2E is justified
- Any potential human factors concerns observed during NES studies should be pursued

This study provides NSE-specific evidence to revitalize the critical message regarding the benefits of human factors involvement for a new generation of process engineers.

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