INL/CON-20-57044-Revision-0

Data Collection and Analysis Challenges and Mitigation Strategies for Quantitative Human Factors Research Studies in Nuclear Power Plant Modernization

February 2020

Casey R Kovesdi, Katya L Le Blanc, Ruixuan Li, Andrea L Mack

Changing the World's Energy Future

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

INL/CON-20-57044-Revision-0

Data Collection and Analysis Challenges and Mitigation Strategies for Quantitative Human Factors Research Studies in Nuclear Power Plant Modernization

Casey R Kovesdi, Katya L Le Blanc, Ruixuan Li, Andrea L Mack

February 2020

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Final Edge of Poster

www.inl.gov

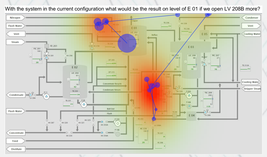
Idaho National Laboratory

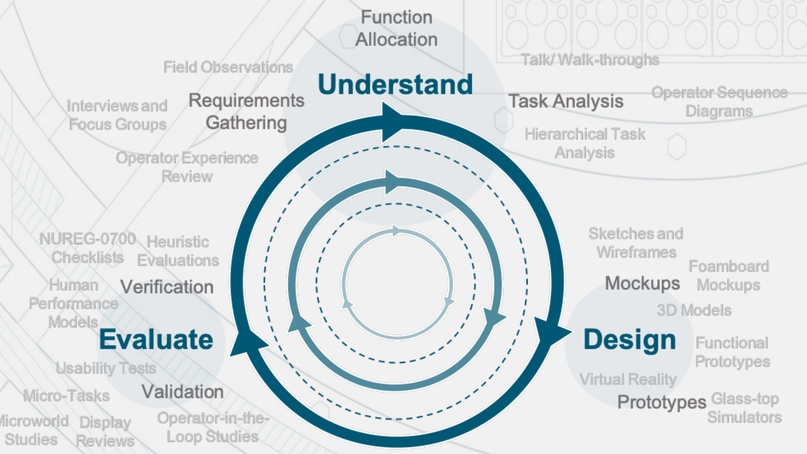
Data Collection and Analysis Challenges and Mitigation Strategies for Quantitative Human Factors Research Studies in Nuclear Power Plant Modernization

Casey Kovesdi, Ruixuan Li, Andrea Mack, & Katya Le Blanc

LWRS LIGHT WATER REACTOR SUSTAINABILITY

Human factors engineering (HFE) has an important role in ensuring new digital plant technologies enable broad innovation and business improvement with continued operational safety.





- **Evaluation** is an important activity that occurs iteratively through the system design lifecycle.
- HFE evaluation requires both qualitative and **quantitative data** to make design decisions.

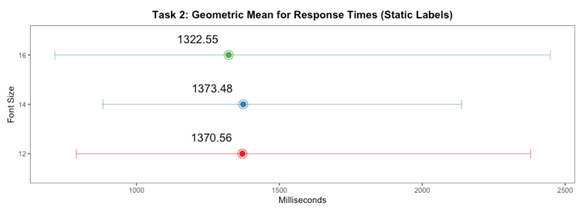
There are **notable challenges in collecting and analyzing quantitative data** in the nuclear HFE domain that creates difficulty in using standard methods and techniques to make valid and reliable inferences.

1. **Small Sample Size**
2. **Limited Resources**
3. **Large Error Variances**
4. **Heterogeneity of Variance**
5. **Small Effect Sizes**
6. **Ceiling Effects**
7. **Multivariate Mixed Type Response Distributions**

Small Sample Size and Limited Resources

- **Licensed operators' availability** and **time** is limited, which limits sample size and consequently, statistical power. This can limit inference from experiments.
- Research simulators such as the **Human System Simulation Laboratory (HSSL)** serves as a full-scale/ fully-configurable testbed to enable higher fidelity simulation for operator-in-the-loop. Testbeds such as the training simulator can be expensive and complex to use, limiting the amount of experimental data that can be collected.
- Highly controlled HFE studies such as **micro-tasks and microworlds** are used with a more generalized population to address these challenges, however, many challenges remain.

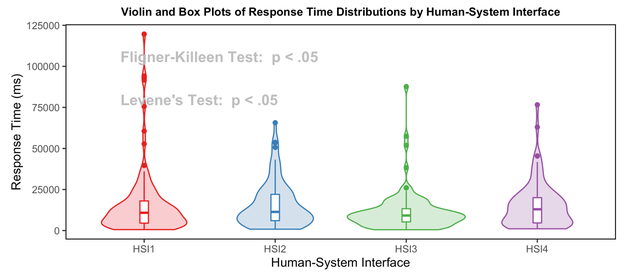
Small Effect Sizes and Ceiling Effects

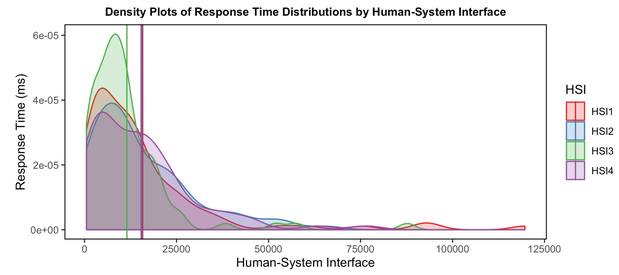


	Correct	Incorrect
Red/ Green	156	1
Red/ Gray	154	2

- Licensed operators are so **highly trained with their existing control room configuration**, that observing differences in performance with a new design is limited due to the **small effect size** (left).
- Similarly, **operators' performance is near perfect** even with a less optimal human-system interface design. There is typically a **ceiling effect** observed where operators perform near perfect in either condition (right).

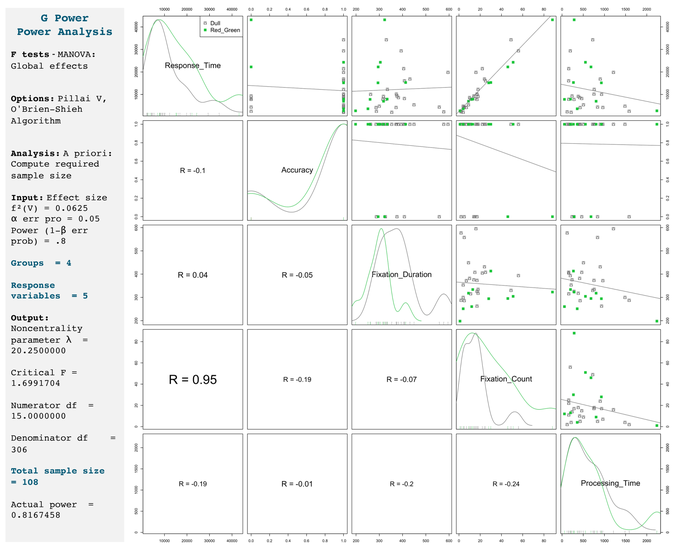
Large Error Variances and Heterogeneity of Variance





- Human-system performance measures like reaction time, eye tracking, and self-report can have **large error variances** and **lack homogeneity** across experimental conditions.
- **Reaction time**, for example, shows large variability within each condition and heterogenous variance across the experimental conditions.

Multivariate Mixed Type Response Distributions



- In many circumstances, HFE studies deal with **multiple dependent variables (DVs)** to detect differences for the design question at hand.
- Many of the DVs used in a study are not normally distributed, which violates the normality assumption for using traditional multivariate methods like MANOVA. Further, other challenges discussed compound issues with applying multivariate methods. For instance, low sample size can increase Type 2 error.
- One approach often used in HFE is to use univariate approaches like multiple ANOVAs, which can increase Type 1 error. Measures are sometimes combined into a compositive measure, driven by HFE theory[1,2].

1. Kantowitz, B. H. (1992). Selecting measures for human factors research. Human factors, 34(4), 387-398.
2. Sauro, J., & Lewis, J. R. (2016). Quantifying the user experience: Practical statistics for user research. Morgan Kaufmann.

Final Edge of Poster