The Connotative Meaning of Independence in System Evaluations

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Introduction

– Problem Statement
  • Including independent evaluation can be costly
  • Value to the decision-maker not yet been measured
  • Independence can not be scaled with any precise rationale

– Problem Motivation
  • Need for a shared understanding of what independence means
  • Do not know how to tailor for cost saving
– Problem Background

• Little to no research into independence definition and measurement found in systems engineering literature

• Aspects of the decision making process include
  – thinking (rational, cognitive),
  – feeling (affective, motive), and
  – behaving (habitual, customary, traditional)

• More research in other disciplines, including
  – Financial Accounting
  – Program/Policy/Regulatory Evaluation
  – Corporate Governance, Central Banks

• Commonalities in the structure of evaluation scenarios across multiple disciplines makes this a “systems problem.”
Background/Evaluation Model
Background/Decision Influences

Diagram showing the decision-making process influenced by various factors such as performance value, independent evaluation, perceived competence, perceived objectivity, visible structure of evaluation, and all other factors including political.
• **Hypothesis 1: Reliable Measure:** The connotative meaning of evaluator independence can be described by the Evaluation-Potency-Activity (E-P-A) three-factor model for affective response.
  – [Alternatively, the measurement may be 1-factor (uni-dimensional), or 2-factor].

• **Hypothesis 2: Stakeholder Roles:** There are statistically significant differences in factor scores between groups of participants.
  – (Roles: Decision makers; Developers/Producers; and Evaluators).

• **Hypothesis 3: Independence Parameters:** There are statistically significant differences in factor scores between the alternative independence scenarios for the three IEEE parameters.
Methods/Research Design

• Methods Employed
  – In situ controlled-task protocol
  – Scenarios based on IEEE Software V&V Standard, Annex C
  – Two Scenarios; first w/no impairments to independence, using
    • Semantic Differential Scales (Indirect – 7-point)
    • Direct Scalar (7 pt Likert: Agreement w/statement of independence)
    • Direct Binary Satisfaction question
  – Factorial Design: 3 Roles x 4 Scenarios = 12 Analysis Cells
  – Sample Size Achieved: 343 Usable surveys, 686 Scenarios
    • In profile: older, highly educated, working in, or retired from, very critical industries,
    • dealing frequently with evaluation reports and considering them important in their work.
    • Transportation (53%+), Military Systems (17%), Space Systems (5%)
Results/Factor Structure

- 22 scales used to test correlations around Evaluation (8), Potency (7) and Activity (7) concepts

- Initial Factor Analyses found 3 eigenvalues above 1.0, one clearly dominant (11.209; 1.433; 1.134; 0.960)
  - High loadings from Evaluation and Potency on first factor

- On subsequent trials, eliminated weaker variables, one at a time, down to 19 variables, by
  - Lowest Communalities
  - Lowest maximum loadings

- Second factors were never reliable (< 80% shared variance) across split-halves and all role subsets
Results/Single Factor Solution

- Scenarios Distinct
- Roles Clustered
  - Shared Meaning
- Order of Value
  - No impairments
  - Financial Imp.
  - Technical Imp.
  - Managerial Imp.
  - All Impairments
- Binary question supported order
  - 89% Correlation
• The findings indicate that:
  – The relative value of independent evaluation alternatives can be measured.
  – Independence is viewed through the same lens by diverse parties to evaluations.
  – Managerial independence is more important than Technical or Financial independence (using IEEE standard definitions).

• Hypothesis 1 Measure for Relative Value of Independence Scenarios
  – 3-Factor E-P-A Not Supported
  – One Factor solution reliable

• Hypothesis 2 Stakeholder Roles: Not Supported

• Hypothesis 3 Independence Parameters: Supported
Results/Quality of Measures

- Performed discriminant analysis to determine which measures best predicted Satisfactory / Unsatisfactory
- Indirect questions have potential to reduce bias in conflicted environment

<table>
<thead>
<tr>
<th>Input measure for Discriminant Analysis</th>
<th>Percentage correct in cross-validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor score from 22 variables</td>
<td>88.10%</td>
</tr>
<tr>
<td>Top variable - P7WS (Weak – Strong)</td>
<td>86.30%</td>
</tr>
<tr>
<td>Top 2 variables, adding E2BG (Bad – Good)</td>
<td>88.30%</td>
</tr>
<tr>
<td>Top 3 variables, adding E4RS (Risky – Safe)</td>
<td>88.80%</td>
</tr>
<tr>
<td>Top 4 variables, adding P2IR (Imaginary – Real)</td>
<td>89.10%</td>
</tr>
<tr>
<td>Top 5 variables, adding E1AB (Adverse – Beneficial)</td>
<td>88.80%</td>
</tr>
<tr>
<td>Top 6 variables, adding P3IC (Incomplete – Complete)</td>
<td>88.90%</td>
</tr>
<tr>
<td>Top 7 variables, adding E5SO (Subjective-Objective)</td>
<td>88.90%</td>
</tr>
<tr>
<td>Factor score from same 7 variables</td>
<td>89.10%</td>
</tr>
<tr>
<td>Question 1, independence maintained?</td>
<td>85.90%</td>
</tr>
<tr>
<td>Question 11, important to your occupation?</td>
<td>51.50%</td>
</tr>
</tbody>
</table>
Conclusions/Future Research

• Successfully established a reliable measure for the connotative, affective meaning of independence in system evaluations

• Demonstrated other measures which may have the same discriminating power for assessing acceptability of independence scenarios
  – Can be used to discriminate between alternative evaluation independence scenarios and in some cases will be more reliable than direct questions in establishing the strength of affective meaning.

• Determined that this affective meaning is substantially shared across the stakeholder groups involved in systems engineering decision making.

• Future Research: refinement of constructs

• Future Research: use in studies with broader scope

• Future Research: much more in current data base