<table>
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</thead>
</table>

Name of Principal Author and all other author(s): LTC Ilean Keltz & Dr. Len Adelman

Principal Author’s Organization and address:  

Phone: 703-697-7434  

Fax: 703-614-4706  

Email: ilean.keltz@js.pentagon.mil

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**Information Order Effects: Examining The Effect Of Sequencing And Complexity In A Long Information Series**

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Information order effects: Examining the effect of sequencing and complexity in a long information series

LTC Ilean Keltz, Ph.D.
Phone: 703-697-7434
Email: ilean.keltz@js.pentagon.mil

Dr. Len Adelman
Phone: 703-993-1624
Email: ladelman@gmu.edu

MORSS
June 2007
As operators become dependent on systems for decision support, their decisions may be susceptible to order effects which may result in over-weighting of prior or recent information.
Research Question

Does the theory of anchoring & adjusting on average accurately predict the results of a long series of sequentially presented information when complexity and sequencing are manipulated?
## Literature Review

<table>
<thead>
<tr>
<th>Evidence Items:</th>
<th>Simple</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Items:</td>
<td>EoS</td>
<td>SbS</td>
</tr>
<tr>
<td><strong>Short Series</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primacy</td>
<td>21/68%</td>
<td>2</td>
</tr>
<tr>
<td>Recency</td>
<td>6</td>
<td>23/88%</td>
</tr>
<tr>
<td>No Effect</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Long Series</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primacy</td>
<td>15/79%</td>
<td>3/60%</td>
</tr>
<tr>
<td>Recency</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>No Effect</td>
<td>-----</td>
<td>-----</td>
</tr>
</tbody>
</table>
H&E’s Belief Revision Model

\[ S_k = S_{k-1} + w_k[s(x_k) - R] \]

- \( S_k \) = degree of belief in some hypothesis
- \( S_{k-1} \) = anchor or prior opinion
- \( w_k \) = adjustment weight for the kth piece of evidence
- \( s(x_k) \) = subjective evaluation of the kth piece of evidence
- \( R \) = reference point or background to which the impact of the kth piece of evidence is evaluated. \( R = 0 \) in evaluative tasks and \( S_{k-1} \) in estimative tasks.

\[ S_k = \alpha S_{k-1} + \alpha S_{k-1}[s(x_k) - R] \text{ for } s(x_k) \leq R \text{ (negative evidence)} \]
\[ S_k = \beta(1 - S_{k-1})[s(x_k) - R] \text{ for } s(x_k) > R \text{ (positive evidence)} \]

- \( \alpha \) = sensitivity toward negative evidence; \( \beta \) = sensitivity toward positive evidence.
- As information accumulates and individuals become more committed to their beliefs, values of \( \alpha \) and \( \beta \) decrease (become less sensitive).
<table>
<thead>
<tr>
<th>Encoding Evidence:</th>
<th>( R = S_{k-1} )</th>
<th>( R = 0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>All</strong></td>
<td><strong>Mixed</strong></td>
</tr>
<tr>
<td>Response Mode:</td>
<td>EoS</td>
<td>EoS</td>
</tr>
<tr>
<td></td>
<td>SbS</td>
<td>SbS</td>
</tr>
<tr>
<td>Short Series</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple</td>
<td>Primacy</td>
<td>Primacy</td>
</tr>
<tr>
<td></td>
<td>Recency</td>
<td>Recency</td>
</tr>
<tr>
<td>Complex</td>
<td>Recency</td>
<td>Recency</td>
</tr>
<tr>
<td></td>
<td>Recency</td>
<td>Recency</td>
</tr>
<tr>
<td>Long Series</td>
<td>Force towards primacy</td>
<td>Force towards primacy</td>
</tr>
</tbody>
</table>

**Note:** The highlighted cell indicates a specific condition where Force towards primacy is observed in the Long Series under \( R = 0 \).
Class Project Results

Not Coherent

Coherence

Belief vs. Information

Information vs. Belief

Confirming First vs. Confirming Last
Initial Theoretical Framework

- Length
- Complexity (within Subject)
- Sequencing
- Response Mode
- Order
- Mental Effort
- Belief Revision (Primacy/Recency/No Effect)
Hypotheses

1. Anchoring & Adjusting will not always result in primacy in a long series of sequentially presented information when complexity & sequencing are manipulated.

2. Complexity and sequencing will significantly affect belief revision through a mediator, mental effort.
   - High Mental Effort – Primacy
   - Low Mental Effort – Recency
## Experimental Design

<table>
<thead>
<tr>
<th>Manipulation</th>
<th>Variable</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-Subjects</td>
<td>Complexity</td>
<td>Simple, Complex</td>
</tr>
<tr>
<td>Between-Subjects</td>
<td>Sequencing</td>
<td>Grouped, Mixed</td>
</tr>
<tr>
<td>Between-Subjects</td>
<td>Order</td>
<td>Grouped Sequencing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CCCCCC-NNNNNNNNN-DDDDDDDDDD, DDDDDDDDD-NNNNNNNNN-CCCCCC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Sequencing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CC-DNCNDNCNDNCDCNDNCNDNCNDNCNDNCNDNDNDNDNCDCNDNCNDNCDCNDNCNDNDNDNCCDNDNCNDNCNDNDNDNCCDNDNCNDNCNDNDNDNCCDNDNCNDNCNDNDNDNCC</td>
</tr>
</tbody>
</table>
The experiment was conducted in an ROTC classroom during their regular scheduled Military Science Instruction.

- ROTC cadets were used based on their familiarity with the military.
- Each cadet was asked to sign a consent form approved by GMU’s Human Subjects Review Board and then they were then given a booklet containing both tasks.
- Beliefs were rated on a scale of 0-100.
- Mental effort was measured through two questions where responses were obtained using a 1-9 Likert-type scale after each scenario. This measure was based on a method used when measuring cognitive load.
- Pilot Test was conducted with ROTC Instructors & GMU undergraduate students to validate procedures, evidence coding, and to serve as a manipulation check.
- Performed an ANOVA for a mixed factor design to test my first hypothesis.
- Performed a path analysis to test the second hypothesis.
1. Complexity manipulation check
   - Used 6 ROTC Instructors
   - Included MS Is (freshmen) in Experiment
   - Lengthened Scenarios
   - Bolded and underlined key information
2. Mental Effort manipulation check
   - 14 SEOR Undergrad Students
   - Significant difference (p-value < 0.0001)
   - Movement of neutral information
3. Verbal feedback in the mixed manipulation to ensure correct coding of neutral information
   - Additional 4 GMU Undergrad Students
   - Special evidence integration instructions
Interactions - Mixed

Simple Mixed

Complex Mixed

[Graphs showing interactions with axes labeled 'Belief' and 'Information', with data points indicating different information stages and belief levels for 'Confirming First' and 'Confirming Last' scenarios.]
Mean Mental Effort Scores

The graph shows the relationship between mental effort scores and complexity. As complexity increases from simple to complex, the mental effort score also increases. The data points indicate a linear trend, suggesting that higher levels of complexity are associated with greater mental effort.
Sequencing vs. Neutral Information

Sequence

Abs Sum of Neutral Evidence

-10  -5   0   5   10   15   20   25   30   35   40   45

Grouped  Mixed
Path Analysis of Mixed Factor Design

Position (counter balancing)

Sequencing

Complexity (within Subject)

Order

Neutral Information

Mental Effort

Belief Revision

0.326**

0.55****

0.55****

0.25**

-0.35****

0.23***

0.26*

* Denotes sig. at < 0.05, **Denotes sig. at < 0.01, ***Denotes sig. at <0.005, ****Denotes sig. at <0.001.
Anchoring and adjusting does not always result in primacy in a long series of evidence when task variables are manipulated.

Complexity and sequencing was not mediated through mental effort.
Discussion

- Effect of task variables
  - Complexity
    - Familiarity
    - Amount of information
  - Sequencing
  - Scenario position

- Potential role of individual differences
  - MS Level
  - Experience
  - Working Memory
  - Intelligence
- Globally Measuring the Mediator
- Individual Measurement of Item Sensitivity
  - Extending model with $\alpha_k$ and $\beta_k$
  - Direct measurement (fMRI)
  - Secondary Workload Task
- Mediating Framework
  - Operationalized $\alpha$ and $\beta$ (sensitivity) based on Hogarth & Einhorn’s (1992) theory
  - Anchoring & Adjusting accounts for the grouped manipulation
  - Effect of Neutral Information on mixed sequencing of evidence
- Engineering systems (such as Command & Control) so operators weight information appropriately.
Acknowledgments & Disclaimer

- US Army for funding my research
- Dr. Loerch, Dr. Boehm-Davis, Dr. Schum, & Dr. Miller for advising & reviewing this research and assisting with the statistical analysis
- LTC Jim Overbye, instructors, & ROTC Cadets at GMU’s ROTC detachment for supporting the study
- GMU’s Systems Engineering Undergraduate students for supporting the pilot testing
- Views, opinions, and findings presented are those of the author and should not be construed as an official DoD position, policy, or decision


<table>
<thead>
<tr>
<th>Sequencing</th>
<th>Complexity</th>
<th>Simple Order 1</th>
<th>Simple Order 2</th>
<th>Complex Order 1</th>
<th>Complex Order 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Simple</td>
<td></td>
<td></td>
<td>Complex</td>
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</tr>
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<td>Grouped</td>
<td>9¹</td>
<td>12</td>
<td>9¹</td>
<td>12</td>
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<tr>
<td>Mixed</td>
<td>13</td>
<td>11²</td>
<td>13</td>
<td>11²</td>
<td></td>
</tr>
</tbody>
</table>

Complexity (Simple or Complex) is within subject and Sequencing (Grouped or Mixed) and Order is between subject

Note: 1. Three participants’ initial judgment was greater than 90.
2. One participant’s initial judgment was greater than 90
3-way Interaction Results

Grouped

Mixed

Order

Belief

Confirming First

Confirming Last

Simple

Complex

Simple

Complex