The Multiple-Strategies Strategy: When It Works It REALLY Works

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54°N, 113° W
Working w/ Bob

• 1985-1989
  – RSM, IBM Watson Research Center
    • “Working to little, getting payed too much”

• 1989 to 1992
  – NIMH Fellow (1st two years)

• Intersection of Interests
  – Understanding and improving real-world (me)
    quantitative estimation (Bob)

Working w/ Bob: Main Contributions

Insight:
• Judgment as weighted blended of heuristic-based intuition & domain-specific knowledge

Theory
• Metrics & Mappings Framework

Method
• Seeding the Knowledge-Base
Publications w/ Bob


The Best Review…Ever

Brown & Siegler (ms. 95-166)

In my book, this is an obvious winner. The article is short, clear, and direct. The results are clear, and they have both practical and theoretical implications. I'm not going to waste your time by repeating what you've already read — and making my review longer than the article. My recommendation is to publish the article forthwith without modification. (Tell the authors that this is high praise from a grouchy old man!)
Brown & Siegler (1996)

Procedure:

- **Phase 1**: Rate knowledge of 99 countries
- **Phase 2**: Estimate pop. of 99 countries
- **Phase 3**: Learn pop. of seed 24 countries
- **Phase 4**: Re-estimation pop. of 99 countries

Wait 4 months

Phase 5: Re-estimate pop. of 99 countries.

Participants: 24 Carnegie-Mellon undergrads

Metric Improvement: Seeds & Transfer

![Graph showing Metric Improvement: Seeds & Transfer]
Mapping Improvement: Just Seeds

Wait 4 Months
Seeds Forgotten

Transfer Countries: Metric ↑ Retained
Transfer Countries: Mapping knowledge Unaffected

• Seeding – efficient, effective method for reducing real-world innumeracy
• Seeding has not yet been tested in the classroom.

• TRY IT!

Shameless 
Plug

• Seeding – efficient, effective method for reducing real-world innumeracy
• Seeding has not yet been tested in the classroom.

• TRY IT!
Publications w/ Bob


Publications w/out Bob


Publications Inspired by Bob


Actually Inspired by Siegler (????)

Actually Inspired by Siegler (1987)

The Perils of Averaging Data Over Strategies: An Example From Children’s Addition

Robert S. Siegler
Carnegie-Mellon University

The Multiple-Strategies Strategy at Work

3 Demonstrations

1. Telescoping Bias in Date Estimation

2. Voluntary Retrieval of Autobiographical Memories

3. Estimation of Event Frequencies (plus Sex)
Telescoping Bias in Date Estimation

In collaboration w/ Peter J. Lee

Event Dating Biases

Biasing Effects in Date Estimation
Event Dating Biases

Backwards Telescoping

Event Dating Biases

Forwards Telescoping
The Boundary Effects Model

Huttenlocher, Hedges & Prohaska, 1988

- Assumption 1: Unbounded estimates are unbiased.

James Byrd dragged to death by white racists in Jasper, Texas: May 1998

The Boundary Effects Model

- Assumption 2: Boundaries truncate variance, resulting in a net forward bias

- Assumption 3: Variance increases with event age

Note – Single-Process Account
The Multiple Strategies Perspective

- Quantitative estimation often involves different cognitive strategies (e.g. Brown, 1995; Siegler, 1987)
- Different strategies can effect the type and strength of estimation bias
- Misinterpretation from collapsing over strategies
- This study focuses on two strategies: Guessing and Reconstruction (or knowledge based inferences)

Boundary Dependent Guessing

- Assumption 1: Guesses approximate the middle of the range

![Graph](image-url)
Boundary Dependent Guessing

• Assumption 2: There’s a lot of guessing going on

• Assumption 3: That non-guessed responses are reconstructed & not particularly biased (e.g. Brown, 1990; Friedman, 1993; Thompson et al., 1996)

• Assumption 4: Non-guessed responses are unaffected by boundaries

Experimental Overview

• Event age held constant: Participants estimate the same events

• Boundary manipulations: 4 conditions:
  - boundaries (true boundary) ↓↓↓ + unbounded
Predictions

All Responses: As boundaries recede to the past....

Both Models

• Accuracy →
  Forward Telescoping ↓
  Backwards telescoping ↑

Main Effect of Condition
Main Effect of True Year
No Interaction

Predictions

Guesses Responses: As boundaries recede to the past....

Both Models

• Accuracy ↓
  Forward Telescoping ↓
  Backwards telescoping ↑

Main Effect of Condition
No Main Effect of True Year
No Interaction
Predictions
Knowledge based responses:
As boundaries recede to the past....

B. E. M.

- Accuracy ↑
  - Forward Telescoping ↓
  - Backwards telescoping →

Sig. Boundary x True Date Interaction

B. D. G.

- Accuracy →
  - Forward Telescoping →
  - Backwards telescoping →

Main effect of True Date
No main effect of Cond.
No interaction

Knowledge Driven Responses
Procedure

• Task 1:


  • Participants rate knowledge for events using a 0-8 scale.
    Zero = “never heard of the event”
    Eight = “know almost all the event’s salient details”

  Example: Russian space station Mir crashes back to earth in S. Pacific, Mar. 2001

• Task 2:

  • Events shown again, P’s date events to the nearest month and year.

  • P’s assigned to one of four conditions:
    • Condition 1: Jan. 1997 (true boundary)
    • Condition 2: Jan. 1994
    • Condition 3: Jan. 1991
    • Condition 4: Unbounded


  • Participants tested individually. Materials presented/data collected by computer
Data Reduction and Analysis

• Guessing: Prevalence of guessing and the distribution of guessed responses
  • Percentage of responses eliciting “zero” knowledge
  • Distribution of “zero” knowledge responses by estimated year

• Biasing: All events collapsed by true year
  • The biasing associated with guessed and non-guessed responses and their effect on overall performance

Results: Event Knowledge

• 37% of responses elicited zero knowledge ratings.
Results: Biasing

The Effects of Guessing and Boundaries on Telescoping

All Responses

- No Main Effect of True Year
  \( F = 0.67, p < 0.56 \)

- Main Effect of Condition
  \( F = 11.2, p < 0.001 \)

- No interaction
  \( F = 0.82, p < 0.63 \)

---

Guessed Responses

- Main Effect of Condition
  \( F = 2.76, p < 0.04 \)

- No Main Effect of True Year
  \( F = 0.67, p < 0.56 \)

- Sig. interaction
  \( F = 2.23, p < 0.01 \)
Results: Biasing

The Effects of Guessing and Boundaries on Telescoping

Knowledge Driven Responses

- No Main Effect of Condition
  \[ F = 0.73, p < 0.53 \]

- Main Effect of True Year
  \[ F = 37, p < 0.001 \]

- No interaction
  \[ F = 1.04, p < 0.408 \]

Median Estimated Date


True Year

Results: Biasing

The Effects of Guessing and Boundaries on Telescoping

Knowledge Driven Responses

- No Main Effect of Condition
  \[ F = 0.73, p < 0.53 \]

- Main Effect of True Year
  \[ F = 37, p < 0.001 \]

- No interaction
  \[ F = 1.04, p < 0.408 \]

Median Estimated Year


True Year

All Responses

Guessed Responses

Non-Guessed Responses

1997 Boundary
1994 Boundary
1991 Boundary
Unbounded estimates
Conclusions

- **Different cognitive strategies** account for different telescoping biases
- Biased Guessing accounts for forwards telescoping
  - Boundaries are numerically informative
  - Forward telescoping – an artefact of biased guessing
- **No support for the Boundary Effects Model**

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**Voluntary Retrieval of Autobiographical Memories**

In collaboration w/ Tugba Uzer & Peter J. Lee
Context

• Two processes used to retrieve autobiographical memories
  – Generation – effortful, time consuming
  – Direct retrieval – automatic, rapid
• **General** Assumption:
  – Generation (almost) always required for deliberate retrieval
• Significance: Reconstruction central process in dominant theory, Conway’s SMS Model

Uzer, Lee, & Brown (2012)

• Aim: Assess frequency of direct retrieval
• **General Method:**
  – Timed retrieve AM in response cue word
  – Provide immediate post hoc-strategy report
  – Input event memory
• Cues:
  – 10 object terms
  – 10 emotion terms
    • Previous research – RT: objects < emotions
Three Experiments

<table>
<thead>
<tr>
<th>Exp</th>
<th>Concurrent Verbal Protocol</th>
<th>Strategy-menu Wording</th>
<th>“YES” Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>Did this memory come immediately to mind?</td>
<td>Direct</td>
</tr>
<tr>
<td>2A</td>
<td>No</td>
<td>Did this memory come immediately to mind?</td>
<td>Direct</td>
</tr>
<tr>
<td>2B</td>
<td>No</td>
<td>Did you actively searched in order to find a memory?</td>
<td>Generative</td>
</tr>
<tr>
<td>3A</td>
<td>No</td>
<td>“This memory was triggered by the cue word, so I did not have to use information about my life to help me recall this memory.”</td>
<td>Direct</td>
</tr>
<tr>
<td>3B</td>
<td>No</td>
<td>“This memory wasn’t triggered by the cue word, so I had to use information about my life to help me recall this memory.”</td>
<td>Generative</td>
</tr>
</tbody>
</table>

Wording of strategy menus manipulated to gauge task demands

Replicate Cue-type Effect

Figure 1. Median reaction times by cue type. Exp. = experiment.

RTs: Objects < Emotions
Direct Retrieval

- Very Common
- Objects > Emotions

RTs: Direct Retrieval << Generation

Figure 4. Percentage of direct retrieval by cue type. Exp. = experiment.

Figure 2. Median reaction times by retrieval strategy. Exp. = experiment.
Memory Retrieval: Additional Points

- Personally Relevant Cues: Dir Ret $\approx 80$
- Replicated across several labs
- Under-cut “constructionist” theories of autobiographical memory
- Unites research on voluntary & involuntary memory memories

Multiple-Strategies Perspective on Event Frequency

Collaborators: Fred Conrad & Bob Sinclair
Studying Event Frequency

• Theoretical Interest
  – How does repetition affect memory?
  – Why are frequency estimates so “accurate”? 

• Applied Interest
  – “Behavioral frequency” questions common on surveys
  – Assess accuracy & bias of responses

Studying Frequency Estimation in the Lab

Two Experiments:
• common materials
• common estimation task
• different process-based measures
  – Experiment 1 – concurrent verbal protocols
  – Experiment 2 – RT

Materials & Task

**Study Phase:**
260 word pairs
visual presentation: 6 s / pair

**Word Pairs:**
category label – category instance
*CITY* – *Boston*

**Presentation Frequency of category labels:**
2, 4, 8, 12, 16

**Test Phase:** 36 category labels
“How many times did the word CITY appear on the study list”? 
Two Types of Study Lists:
Different Context & Same Context

<table>
<thead>
<tr>
<th>Different Context Lists</th>
<th>Same Context Lists</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target</strong></td>
<td><strong>Context</strong></td>
</tr>
<tr>
<td>city</td>
<td>Paris</td>
</tr>
<tr>
<td>sport</td>
<td>football</td>
</tr>
<tr>
<td>color</td>
<td>red</td>
</tr>
<tr>
<td>color</td>
<td>green</td>
</tr>
<tr>
<td>city</td>
<td>Cleveland</td>
</tr>
<tr>
<td>metal</td>
<td>iron</td>
</tr>
<tr>
<td>woman</td>
<td>Mary</td>
</tr>
<tr>
<td>city</td>
<td>Boston</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Different Context: enumeration very common

• Same Context: unjustified very common – fluency/availability-based estimates

Results: Process Measures

<table>
<thead>
<tr>
<th></th>
<th>Different Context</th>
<th>Same Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enumeration</td>
<td>57%</td>
<td>---</td>
</tr>
<tr>
<td>Impressions</td>
<td>20%</td>
<td>24%</td>
</tr>
<tr>
<td>Unjustified</td>
<td>25%</td>
<td>69%</td>
</tr>
</tbody>
</table>
**Results: Protocol Results**

**Interpretation:**
- People enumerate when possible because it provides concrete credible basis for an estimate.
- Readily-retrieval instances are a precondition for enumeration.

**Alternative Interpretation:**
- People generally do not enumerate.
- In protocol study: enumeration common because task demands imply that participants SAY something relevant to justify their response.
  - possible in different context condition
  - not possible in same-context condition

**Results: Process Measures**

**Different Context:**
- RTs $\uparrow$ frequency
- evidence for silent enumeration

**Same Context:**
- RT slope much shallower.
- no enumeration
Different Context $\rightarrow$ underestimation
Same Context $\rightarrow$ overestimation

Enumeration w/ Available of Retrieval Instances

*Figure 3.* Response time difference versus percentage recalled for each study-phase instruction group and each experiment. The straight lines plotted in Figure 3A indicate the best within-experiment linear fit. The curved line plotted in Figure 3B indicates the best quadratic fit across experiments, excluding data from the frequency groups in Experiments 1 and 2.

Brown, 1997
Experimental Summary

Multiple strategies

Strategy selection restricted by memory contents

**Bias & Strategy related:**
- enumeration ➔ *under*estimation
- rough aprox ➔ *over*estimation
Multiple Strategy Perspective

• Encoding factors determine task-relevant contents of memory.

• Contents of memory restrict strategy selection.

• Strategy selection and response bias often related.

Multiple Strategies Perspective

• Numerous estimation strategies identified
  – Lab-strategies subset of real-world strategies

• Enabling conditions identified

• Selection among competing strategies difficult to predict.
A Taxonomy of Estimation Strategies

Relating Encoding, content, strategy & Performance

<table>
<thead>
<tr>
<th>encoding</th>
<th>content</th>
<th>Strategy</th>
<th>performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘memorable’ events</td>
<td>‘on-target’ instances</td>
<td>on-target enumeration</td>
<td>• RT ↑ freq</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• underestimation</td>
</tr>
<tr>
<td>regularity</td>
<td>rate</td>
<td>rate retrieval</td>
<td>• fast, flat RT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• heaping</td>
</tr>
<tr>
<td>intent</td>
<td>tally</td>
<td>tally retrieval</td>
<td>• fast, flat RT</td>
</tr>
<tr>
<td>frequent presentation</td>
<td>vague quantifier</td>
<td>impression retrieval</td>
<td>• fast, flat RT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• overestimation</td>
</tr>
<tr>
<td>indistinct instances</td>
<td>fluency</td>
<td>memory assessment</td>
<td>• fast, flat RT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• overestimation</td>
</tr>
<tr>
<td>encoding/test mismatch</td>
<td>‘off-target’ instances</td>
<td>off-target enumeration</td>
<td>• SLOW, flat RT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• regressive estimates</td>
</tr>
</tbody>
</table>
Applying the MSP
The Partner Discrepancy

The Discrepancy

♂️'s report far more opposite-sex SP*’s than ♀️'s

Magnitude:
• 2 X – 4X

Generality:
• US, UK, France, Canada, Norway, New Zealand

*sexual partners
SP Discrepancy as Case Study:

Explanations

- Sampling
- Response
  - Social
  - Cognitive

Lifetime Partner Discrepancy from the MSP

Multiple strategies:
- Enumeration
- Rough Approximation
- Others(?)

Strategy & magnitude related.
- enumeration < rough aprox

Strategy selection related to sex
- Enumeration: ♀ > ♂
- Rough Aprox: ♂ > ♀
A Questionnaire Study: Brown & Sinclair (1999)

**Method:**

- Demographics

- SP reports:
  - *lifetime* estimate & written strategy report
  - *past-year* estimate & written strategy report

- Attitude measures

**Participants:**

University Students: **AB, PA, NJ**

1036 ♂  687 ♀

Age:  \( M = 20.7 \)

\[ MD = 19 \]
Distribution of SP Estimates -- AlbertaQ

Estimated Number of Lifetime SPs

<table>
<thead>
<tr>
<th>Percent of Participants</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean SP     MD SP
Men          3.5              1
Women        2.4             1

Sexual Active Subset -- AlbertaQ

- Most active 10%; SP ≥ 8
- Heterosexual
- **90 Females**
  - Age: md = 22
  - SPs: m = 13.61
- **85 Males**
  - Age: md = 23
  - SPs: m = 19.91
SP Est– Sexual Active Subset -- AlbertaQ

Estimated Number of Lifetime SPs

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean SP</td>
<td>19.9</td>
<td>13.6</td>
</tr>
<tr>
<td>MD SP</td>
<td>15</td>
<td>12</td>
</tr>
</tbody>
</table>

Protocol Content – AlbertaQ
Sample Protocols -- AlbertaQ

Enumeration (Retrieve & Count)

• "By retracing chronologically the partners I've had. Beginning with the first, ending with the present." -- M, 20

• "I recalled and counted." -- F, 18

• "Counted all the names I remembered." -- F, 11

• "I can recall who they were and can count them." -- F, 15

Sample Protocols -- AlbertaQ

Rough Approximation

• “Rough guess, give or take 1 or 2 partners." -- M, 16

• "Rough estimate plus-or-minus error 5" -- M, 20

• "I used to keep count. # has slowed down is likely about there" -- M, "30 (or so)"

• "It is a guess based on the amount of partners I have had at the minimum." -- M, 50
Sample Protocols -- AlbertaQ

Retrieved Tally

• "Keep track of them as they occurred." -- M, 21
• "I know the number without thinking as it has been previously discussed among friends." -- M, 10
• "I didn't estimate. I've kept count." -- F, 11
• "I kept track in my diary and I know that my boyfriend is #27." -- F, 27

Sample Protocols -- AlbertaQ

Rate

• "Avg of 5/year from 16-21, then remained monogamous." -- M, 25
• "The average length of relationship since the time I became sexually active." -- M, 20

Ambiguous/Unclear

• "Memory." -- M, 22"
• “I remember them." -- M, 10
Strategy Usage – Sexual Active – AlbertaQ

EN = ENumeration  TA = TAlly  AP = rough APproximation  AM = AMbiguous

MD Lifetime SPs X Strategy Sexual Active  AlbertaQ

EN = ENumeration  TA = TAlly  AM = AMbiguous  AP = rough APproximation
Replications

• US-Based **Random Sample** Surveys
  – Telephone; n = 1427
  – Web-Base: n = 1692

• Procedure:
  – Estimate # SP
  – Select strategy from menu

![Mean SP](image-url)
Outliers (Se Hs)

Strategy Selection: Sex Differences
Relation between Strategy & SPs: Sex Differences

![Graph showing median estimated SP by strategy and sex for Telephone and Web surveys.]

Partner Discrepancy: Conclusions

- Multiple Strategies used.
  - ♂ favor rough approximation
  - ♀ favor conservative strategies
- MSP partial account of Partner Discrepancy
Partner Discrepancy: Conclusions

• Three-pronged Account necessary
  – Direct evidence for
    • Strategy Differences
    • Social Desirability
  – Sampling
    • PSW – “conspicuous by their absence”

General Conclusions

• Real-world knowledge is complex.
• Ubiquitous individual differences:  
  – knowledge
  – motivation
• Default assumption:
  – Multiple strategies ALWAYS at play
General Conclusions

• The Burden:
  – Identify strategies
  – Specify their conditions/characteristics
  – Alas…not **ALWAYS** possible
• The Consequences
  – Multiple Strategies Strategy not always applicable
• But, when it works, it really works.

Thanks for everything, Bob!

There are indeed many ways