THE PREFERENCE FOR ROUNding

Stephanie Solt (ZAS Berlin)
Chris Cummins (Universität Bielefeld)
Marijan Palmović (University of Zagreb)

87th Annual Meeting of the LSA
January 6, 2013

THE PHENOMENON

This is funny - why?

Krifka (2007)
**THE PHENOMENON**

An overall (speaker? hearer?) preference for numerical information to be communicated in approximate or round terms, rather than precisely

---

**PREFERENCE FOR ROUNDED NUMBERS**

- Dehaene & Mehler (1992): Across a wide variety of languages, round numbers used more frequently than non-round numbers
  - Attributed to use in reporting approximate quantity (cf. Krifka 2007)
PREFERENCE FOR ROUNDED

- Approximate expression of proportion used...
  - concurrently with numerical %
    - A third of voters (34%) supported the proposition
    - According to a new survey, six in ten Americans (59%) read the bible at least occasionally
  - ...in same text as numerical %
    - More than a quarter of papers were marked A...
    - According to figures released today...25.9 percent of A-level papers were awarded an A grade...
      (Daily Telegraph 14/8/2008; cited in Williams & Power 2009)

PREFERENCE FOR ROUNDED

- When telling the time:
  Excuse me, can you tell me what time it is?

- Less rounding when precise answer hearer-relevant
  (van der Henst et al. 2002)
**ROUNDMGIN AND PROCESSING COSTS**

- Van der Henst et al. (2002)
  
  ...a rounded answer...requires *less processing effort* for the same cognitive benefit (p. 459)
  
  Suppose you have an appointment at 3:30 p.m. and it is 3:08. Being told ‘It is 3:10’ is likely to be optimally relevant: the two-minute departure from the exact time is unlikely to have any consequences, and the rounded answer is *easier to process*. (p 464)
  
  ➢ Rounded answer optimally relevant

- Krifka (2007)
  
  *We also can argue that a more coarse-grained representation of information might be cognitively less costly* than a more fine-grained one

---

**EVIDENCE FOR PROCESSING ADVANTAGE**

- Little research to date
  
  - Mason et al. (1996): Memory for numbers in addition problems greater for round (11,000) versus non-round (11,635) numbers
    
    ➢ Even when subjects tested only on first 2 digits
1. Can the hypothesized processing advantage for round/approximate numerical expressions be demonstrated experimentally?

2. What aspect(s) of ‘processing’ impacted?

```plaintext
What aspect of a numerical expression causes it to be favored in this way?

100 meters >> 103 meters
10:40 >> 10:38
```

- Form?
- Meaning?
**SOURCE OF PREFERENCE: BREVITY?**

- Round numbers typically briefer (e.g. in syllables) than non-round numbers
  
  100 vs. 103
  
  `'one hundred'` vs. `'one hundred and three'`
  
  10:40 vs. 10:38
  
  `'ten forty'` vs. `'ten thirty eight'`
  
  - Preference for rounding would reflect more general preference for shorter/simpler expressions (Grice 1975, Horn 1984)

- But...
  
  - 2:43 vs. 2:45; 2:16 vs. 2:15, etc.

**SOURCE OF PREFERENCE: ROUNDNESS?**

- Mathematical property of number, based on divisibility properties (Jansen & Pollmann 2001)
  
  - Single-digit multiple of:
    - $10^n$ (1, 10, 100, ...)
    - $5*10^n$ (5, 50, 500, ...)
    - $2*10^n$ (2, 20, 200, ...)
    - $2.5*10^n$ (2.5, 25, 250, ...)
  
  - 100 = 1*100, 2*50, 5*20, 4*25
  
  - 80 = 8*10, 4*20
  
  - 83 = $\times$
  
  - Observed patterns would reflect advantage for numbers that have a privileged status in decimal numeral system
**SOURCE OF PREFERENCE GRANULARITY?**

- Property of measurement scales
  - Measurement may be reported w.r.t. scales differing in granularity - density of points (Krifka 2007)

The distance between Amsterdam and Vienna is 1000 km

The distance between Amsterdam and Vienna is 965 km

**SOURCE OF PREFERENCE GRANULARITY?**

- Property of measurement scales

  Scales for clock time:

<table>
<thead>
<tr>
<th>4:25</th>
<th>4:30</th>
<th>4:35</th>
<th>4:40</th>
<th>4:45</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:25</td>
<td>4:30</td>
<td>4:35</td>
<td>4:40</td>
<td>4:45</td>
</tr>
</tbody>
</table>

  - Coarse granularity ≡ approximate interpretation

  - Preference would reflect advantage for coarser-grained representation of measurement results
    - 4:45 > coarse 4:40 > coarse 4:38
RESEARCH QUESTIONS - 2

1. Can the hypothesized processing advantage for round/approximate numerical expressions be demonstrated experimentally?

2. What aspect(s) of ‘processing’ impacted?

3. Is the advantage due to:
   - Numerical roundness?
   - Participation on coarse-grained scale?

DOMAIN OF INQUIRY: CLOCK TIME

- Builds on existing work on rounding in telling time
- Multiple granularity levels
  - 15 minute, 5 minute, 1 minute
- Opportunity to tease apart relative role of granularity and roundness

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:30</td>
<td>Less round</td>
</tr>
<tr>
<td></td>
<td>Coarser scale</td>
</tr>
<tr>
<td>4:50</td>
<td>Rounder</td>
</tr>
<tr>
<td></td>
<td>Less coarse scale</td>
</tr>
</tbody>
</table>
EXPERIMENT 1

Short-term memory for clock times

Question: Are clock times that are rounder and/or interpretable relative to coarser grained scale easier to remember?

Method: Sternberg Paradigm (Sternberg 1966)
- Sequence of times displayed
- Probe displayed
- Task: Was probe in sequence?
- Measures: % Correct and Response Time
EXPERIMENT 1: PROCEDURE

Stimuli
- 3 granularity levels
  - Coarse: 15-minute 2:15 6:30 8:45
  - Medium: 5-minute 2:10 6:25 8:40
  - Fine: 1-minute 2:21 6:36 8:51
- 3 sequence lengths
  - 3, 4, and 5 items
- 10 test items/cell (90 total)

Participants
- English: n=19
- Croatian: n=9
- German: n=8
**PREDICTIONS**

Coarse: 2:15  
Medium: 2:10  
Fine: 2:21  

Round

Non-round

**Round > non-round**

- If granularity crucial: coarse > medium
- If roundness crucial: coarse = medium

**ACCURACY**

Significant effects of:
- Roundness (p<0.01)
- # of items (p<0.05)
- Language

Within round:
- No significant effect of granularity (coarse vs. medium)
Significant effects of:
- Roundness (p<0.01), # of items (p<0.001), language
Within round:
- No significant effect of granularity

Experiment 1: Summary

- Round clock times...
  - ...are recalled more accurately
  - ...elicit shorter reaction times

- No evidence (yet) for advantage of coarse granularity above and beyond that of numerical roundness

- Did task require stimuli to be encoded as times? Or as numbers?
**Experiment 2**

Reasoning with clock times

**Question:** Are clock times that refer to a coarser grained scale easier to reason with?
- What is 30 minutes before 2:15?
- What is 27 minutes before 4:13?

**Method:** Clock time addition/subtraction task
- Addition/subtraction problem displayed
  - Possible answer displayed
- Task: Is answer correct?
- Measures: % Correct and Reaction Time
**EXPERIMENT 2: PROCEDURE**

- 2 sec
- 2:15
- 1 sec
- 2:15 minus 30
- 1.5 sec
- 1:45
- Yes
- No

**EXPERIMENT 2**

**Stimuli**
- 3 granularity levels in starting time
  - Coarse (2:15), medium (2:10), fine (2:21)
- 3 granularity levels in increment
  - Coarse (30), medium (25), fine (27)
- Addition and subtraction
- 144 items / subject (3 sessions x 48 items)
  - Items drawn randomly from list of 720 items

**Sample**
- German: n=22
### ACCURACY

<table>
<thead>
<tr>
<th>Start Granularity</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>3</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Medium</td>
<td>9</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Fine</td>
<td>13</td>
<td>16</td>
<td>17</td>
</tr>
</tbody>
</table>

- Significant effects of Start and Increment Roundness ($p<0.001$)
- **Within Round**: Marginal effect Start Granularity ($p=0.09$)

### REACTION TIME (CORRECT)

<table>
<thead>
<tr>
<th>Start Granularity</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>809</td>
<td>945</td>
<td>1222</td>
</tr>
<tr>
<td>Medium</td>
<td>940</td>
<td>970</td>
<td>1259</td>
</tr>
<tr>
<td>Fine</td>
<td>1253</td>
<td>1293</td>
<td>1435</td>
</tr>
</tbody>
</table>

- Significant effects of Start and Increment Roundness ($p<0.001$)
- **Within Round**: Significant effects of Start and Increment Granularity ($p<0.01$)
OVERALL CONCLUSIONS

- Findings support claims that rounding eases processing load for hearer
  - Easier to remember
  - Easier to reason with
- Advantage accrues not only to round numbers, but to those that occur on domain-specific coarse-grained scale
  - Differences by task
- Have not demonstrated advantage for approximate interpretation itself

FOR THE FUTURE

- Additional aspects of ‘processing’:
  - Long-term memory, verification, ...
- Additional domains:
  - Proportion, number, distance, cost, ...
- Advantage of round interpretation
- Formal semantics of granularity
- Practical applications
ACKNOWLEDGEMENTS

Funding for this research was provided by the European Science Foundation, the Deutsche Forschungsgemeinschaft, and the EURO-XPRAG Network

THANK YOU!

(stephanie.solt@gmail.com)

REFERENCES


REFERENCES

