THE PREFERENCE FOR ROUNDING

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THE PHENOMENON

- This is funny – why?

Krifka (2007)

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THE PHENOMENON

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

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PREFERENCE FOR ROUNDING

- 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)

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PREFERENCE FOR ROUNDING

- 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 Telegaph 14/8/2008; cited in Williams & Power 2009)

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PREFERENCE FOR ROUNDING

- When telling the time:

  Excuse me, can you tell me what time it is?

	Analog Watch	Digital Watch	Predicted Level
5x responses	98%	66%	20%

  - Less rounding when precise answer hearer-relevant

    (van der Henst et al. 2002)

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ROUNDING 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

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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

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RESEARCH QUESTIONS - 1

1. Can the hypothesized processing advantage for round/approximate numerical expressions be demonstrated experimentally?
2. What aspect(s) of 'processing' impacted?

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SOURCE OF PREFERENCE

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

100 meters >> 103 meters

10:40 >> 10:38

  - Form?
  - Meaning?

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SOURCE OF PREFERENCE BREVITY?

- Round numbers typically briefer (e.g. in syllables) than non-round numbers

  100 vs. 103
  'one hundred' *'one hundred and three'*

  10:40 vs. 10:38
  'ten forty' *'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.

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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 = ✗
  - Observed patterns would reflect advantage for numbers that have a privileged status in decimal numeral system

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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

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SOURCE OF PREFERENCE GRANULARITY?

- Property of measurement scales

Scales for clock time:

...	4:21	4:22	4:23	4:24	4:25	4:26	4:27	4:28	4:29	4:30	4:31	4:32	4:33	4:34	4:35	4:36	4:37	4:38	4:39	4:40	4:41	4:42	4:43	4:44	4:45	4:46	4:47	4:48	4:49	...
...			4:25					4:30						4:35						4:40					4:45					...
...								4:30																	4:45					...

- Coarse granularity ≡ approximate interpretation

- Preference would reflect advantage for coarser-grained representation of measurement results
  - 4:45 $>_{coarse}$ 4:40 $>_{coarse}$ 4:38

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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?

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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**

4:30	**4:50**
Less round	**Rounder**
Coarser scale	**Less coarse scale**

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EXPERIMENT 1

Short-term memory for clock times

EXPERIMENT 1

- **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

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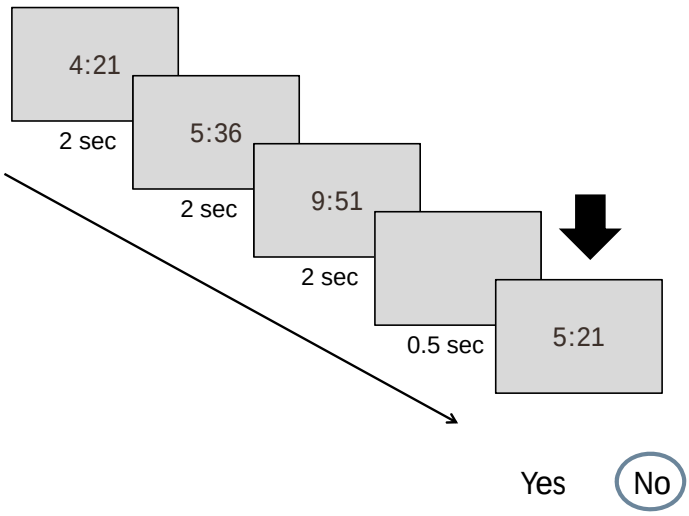
EXPERIMENT 1: PROCEDURE



EXPERIMENT 1

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

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PREDICTIONS

Coarse: 2:15
Medium: 2:10
} Round

Fine: 2:21 Non-round

- **Round** > **non-round**
  - If **granularity** crucial: **coarse** > **medium**
  - If **roundness** crucial: **coarse** = **medium**

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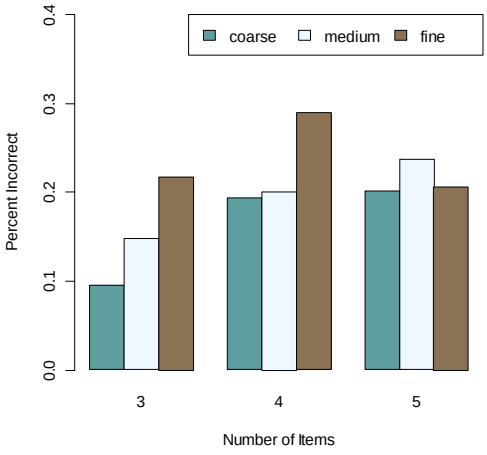
ACCURACY



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

Within round:
- No significant effect of granularity (coarse vs. medium)

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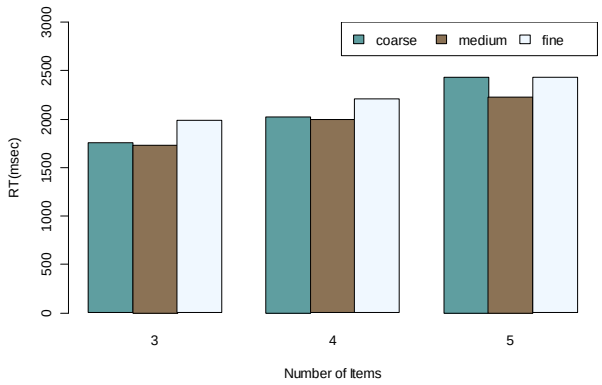
REACTION TIME (CORRECT)



Significant effects of:
- Roundness ($p<0.01$), # of items ($p<0.001$), language

Within round:
- No significant effect of granularity

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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?

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EXPERIMENT 2

Reasoning with clock times

EXPERIMENT 2

- **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

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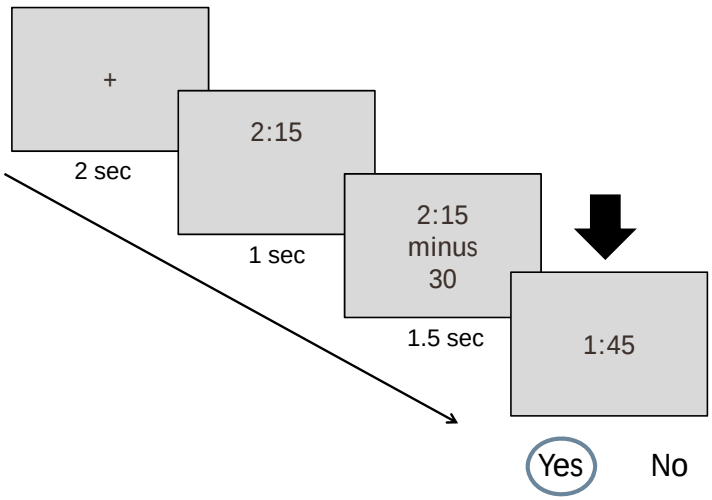
EXPERIMENT 2: PROCEDURE



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

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ACCURACY

		Increment Granularity		
		Coarse	Medium	Fine
Start Granularity	Coarse	3	7	11
	Medium	9	7	15
	Fine	13	16	17

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

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REACTION TIME (CORRECT)

		Increment Granularity		
		Coarse	Medium	Fine
Start Granularity	Coarse	809	945	1222
	Medium	940	970	1259
	Fine	1253	1293	1435

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

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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

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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

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THANK YOU!

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