

# Two-digit number processing in professional mathematicians reveals the same behavioural signatures as in control samples

## Introduction

- Processing two-digit numbers cannot be reduced to processes involved in processing single-digit ones [1].

- **Unit-Decade Compatibility Effect (UDCE):** it is faster to compare numbers like

$$21_{87} \quad (2 < 8; 1 < 7)$$

than

$$28_{94} \quad (2 < 9; 8 > 4)$$

even though the numerical distance is identical, points to decomposed processing of unit and decade digits.

- **Numerical distance effect takes form of:**

(a) **Decade Distance** i.e. it takes longer to compare numbers in which the difference in decade numbers is small than when the decade distance is large (e.g., 34\_47 vs 34\_75),

(b) **Unit Distance** i.e., slower comparisons when difference between number of units small than when it is large.

**We compare UDCE, Decade Distance, Unit Distance effects in professional mathematicians and three control groups:**

- (a) professional engineers;
- (b) social scientists;
- (c) reference group.

## Method

Target: 30 participants per group. Preliminary data based on 99 participants (17 mathematicians, 30 engineers, 22 social scientists and 30 reference). Participants performed a computerised two-digit number magnitude task. On top of testing for group-level effects of UDCE, Decade Distance (between decade trials e.g., 21\_76), and Unit Distance (within decade trials e.g., 23\_28), we used bootstrapping methods to test for individual prevalence of these effects, and whether prevalence differs between groups [2].

## Results

### Mean Accuracy:

- Engineers: 98% (highest).
- Mathematicians and reference group: 97%.
- Social scientists: 95%.

### Effects Across Groups:

- UDCE, Decade Distance, and Unit Distance were robust with no significant group differences.

- Marginally significant group Decade Distance interaction ( $p = .0499$ ). Social scientists were faster than engineers and the reference group in trials of small Decade Distance.

### Individual Prevalence:

- No group differences for UDCE and Unit Distance prevalence.
- Significant group difference in Decade Distance prevalence ( $p = .048$ , Fisher's exact test). All mathematicians showed a regular Decade Distance effect, compared to 21 out of 30 in the reference group, with 9 showing none.

**Interestingly, no participant demonstrated a reliable reverse UDCE, Decade Distance, or Unit Distance effect.**

## Discussion

- Well-established effects were replicated: Unit-Decade Compatibility, Decade Distance, and Unit Distance. Decade Distance effect appears to be a dominant phenomenon observed in most individuals [3].

- **Effects in Mathematicians:** These effects were also present in professional mathematicians.

- **No robust between-group differences were observed**, indicating no evidence that professional mathematicians differ from others in two-digit number processing.

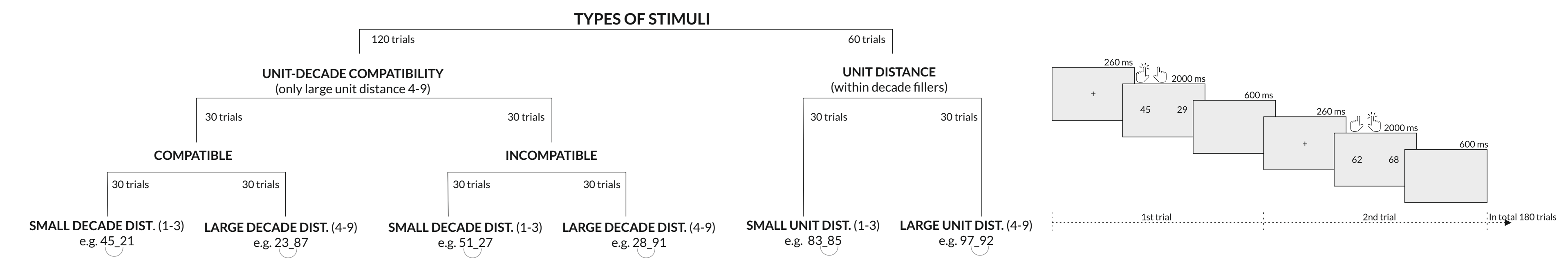
Preliminary Bayesian analysis supports these findings.

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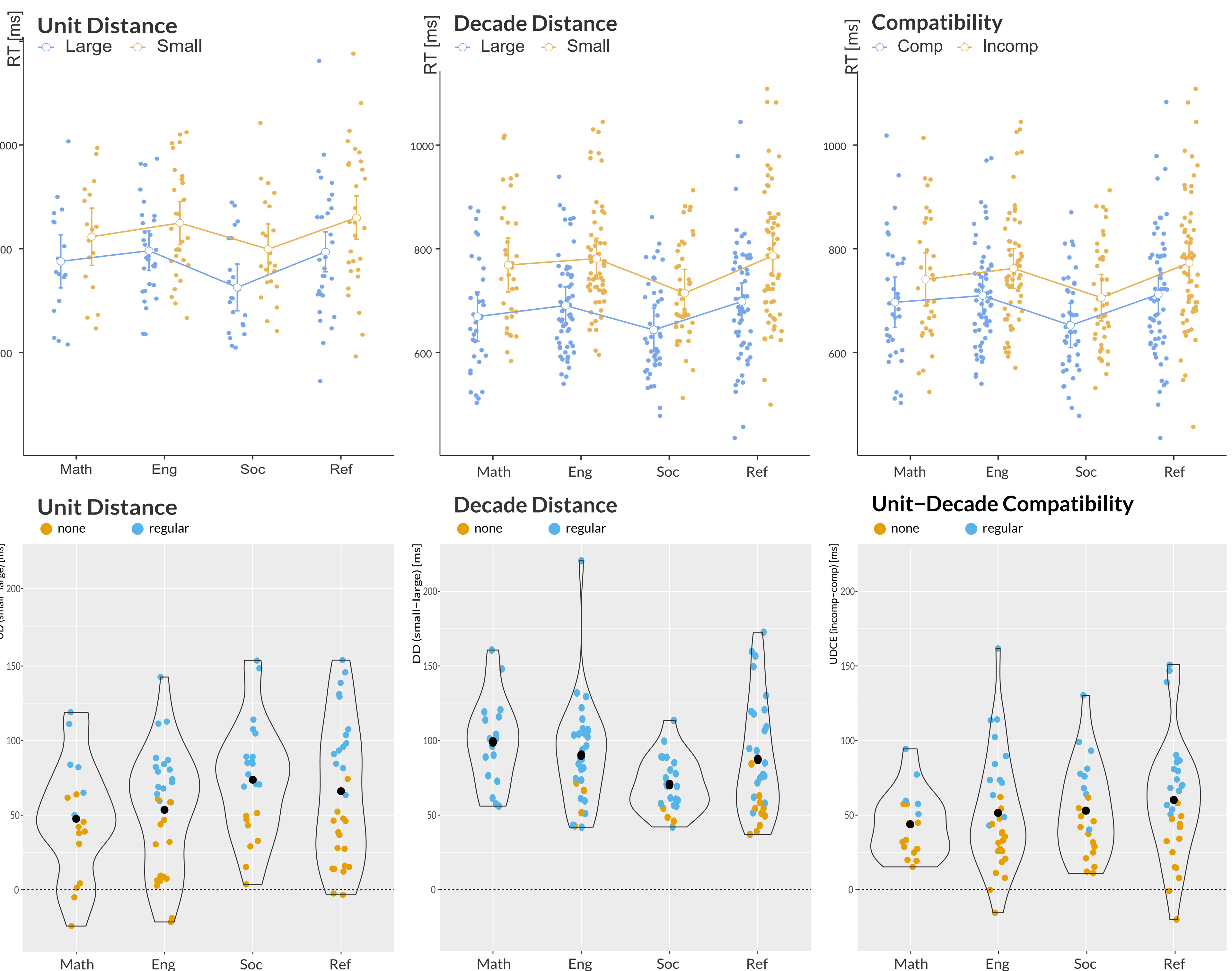


## Take home message

Three well established effects: Unit-Decade Compatibility, Decade Distance and Unit distance were replicated. No participant revealed a reliable reverse UDCE, Decade Distance, or Unit Distance effect.

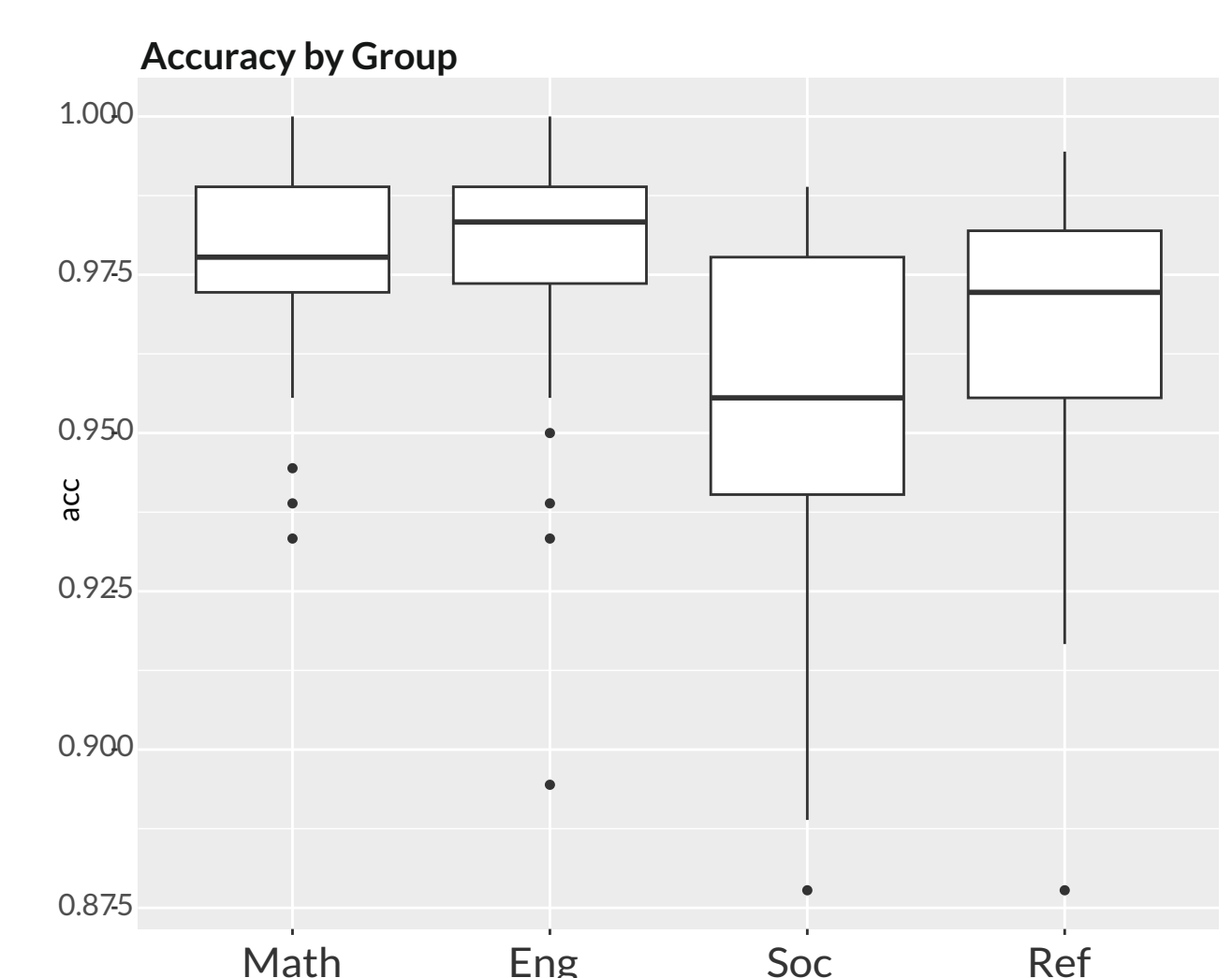
There were no robust differences between groups (mathematicians, engineers, social scientists and reference group) in all three effects.

Decade Distance effect appears to be a dominant phenomenon present in most individuals. The UDCE and Unit Distance effect were more varied.



Individual Prevalence (Bootstrapping Analyses)

Group	Effect	Unit Distance		Decade Distance		UDCE	
		none	regular	none	regular	none	regular
Mathematicians		11	6	0	17	12	5
Engineers		14	16	4	26	18	12
Social scientists		8	14	3	19	13	9
Reference		16	14	9	21	13	17
Overall prevalence		51%		84%		43%	



References  
 [1] Nuerk HC et al. In: Kadosh RC, Dowker A, eds. Oxford Handb Numer Cogn. (2015) 106-39. Oxford Univ Press.  
 [2] Hohol, M. et al. Acta Psychologica (2022) 230, 103765.  
 [3] Rouder JN et al., Advances in Methods and Practices in Psychological Science. (2018)1(1):19-26  
 [4] Cipora K et al. Psychol Res. (2016) 80:710-26.