Do professional mathematicians differ from controls in their number-space associations? Evidence from the SNARC effect

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BACKGROUND

1. In speeded bimanual setting small magnitude numbers are responded faster on left hand side whereas big magnitude numbers are responded faster on right hand side. This effect is referred to as Spatial Numerical Asscciation of Response Codes (**SNARC effect)** [1]
2. Across studies it was found that about 70% reveal SNARC effect [2]
3. Various factors were considered to account for interindividual variability in the SNARC effect, one of them is arithmetic skill level [2,3].
4. Different research approaches have been taken to study relationships between elementary numerical processing and math skill / expertise [2]
5. Especially several ways of defining math skill / expertise were used (see the graph below)

Calculation prodigies differ from controls not only in arithmetic skills
High arithmetic skills are not necessarily linked to the factors of high mathematical expertise. Skills are usually limited to arithmetic. Prodigies differ from general population in wide array of personality / mental health (e.g. Asperger syndrome).

Comparing students is not comparing high level experts
Mostly early year's students were recruited. This inclusion criteria in fact does not ensure examining high level math experts.

MATH SKILL / EXPERTISE

Usual math performance measures assess arithmetic skill not math
The utilized tasks may simply measure processing automaticity since they comprise abilities being part of obligatory math curriculum.

Studying professional mathematicians
Professional mathematicians differ qualitatively from general population in math expertise. They differ from prodigies as well.

Objectives of the presented study
Comparing three groups:
1. Professional mathematicians
2. Professionals who use advanced mathematics in their work but are not mathematicians per se
3. Matched controls

We aimed to compare the SNARC effect while controlling for associated variables (IQ).

METHOD

Participants
N = 44 (6 F); Mean age = 27.9 (SD = 1.1).
Advanced doctoral students 3rd year or higher.
All right-handed, native Polish speakers.
3 groups:
1. Mathematicians [M group] (n = 14, 2F)
2. Engineers [Engineers – E group] (professionals who use advanced math in their work (n = 15, 2F)
3. Controls [C group] (studies in the field of humanities and social sciences; n = 15; 2F)

Materials and procedure
Parity judgment task (typical setup)
- Numbers 1, 2, 3, 4, 6, 7, 8, 9; each number presented 30 times within a block
- Preceded by short training session

Advanced Raven Matrices test (Measuring fluid intelligence)

Order of administration: parity judgment task preceded fMRI testing (not reported here), Raven Matrices were administered at the end of the session

RESULTS

Descriptive statistics

	Overall	M	E	C
RT	533	515	550	532
Variability in RT	97	94	97	101
Raven score *	27.5	30.9	26.6	25.3
Proportion of participants revealing negative slopes	.80	.64	.87	.87

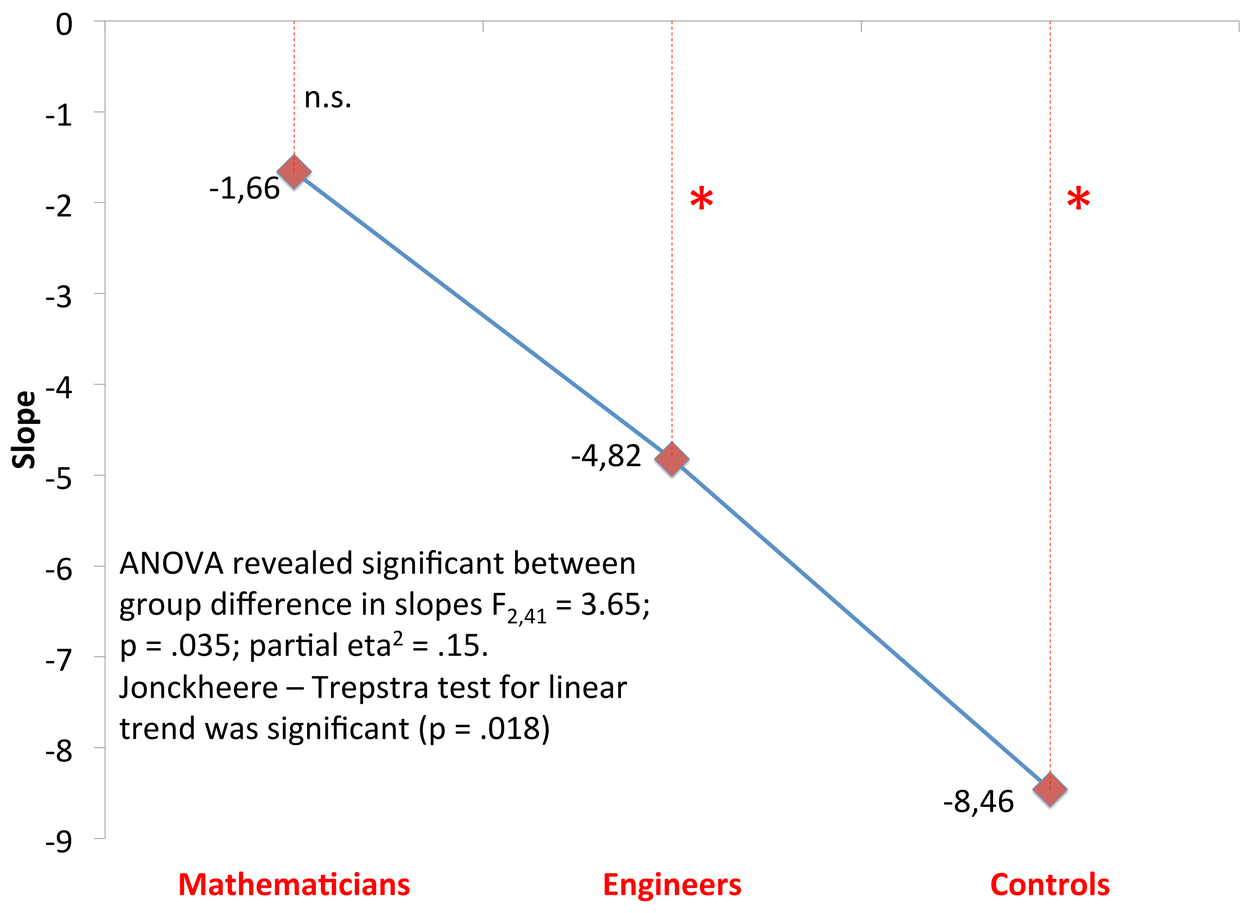
* Significant between group difference. M group differs significantly from other groups p = .001

There was significant SNARC effect at the group level (t_{43} = -4.66; p < .001). Mean slope was -5.06 (SD = 7.20). 35 out of 44 participants revealed negative slopes.

Correlations between SNARC slopes, RT characteristics and fluid intelligence

Measure	1	2	3	4
1. Slope	-			
2. Mean RT	-0,26	-		
3. SD (RT)	-.40*	.82*	-	
4. Standardized Slope	.79*	0,07	-0,02	-
5. Raven	0,25	-.36*	-.49*	0,11

Between group difference held when controlled for RT characteristics.
There was no correlation between SNARC slopes and Raven scores at the level of entire sample nor in any group when analysed separately.



CONCLUSIONS

1. Contrary to *Engineers* and *Controls*, professional *Mathematicians* did not reveal SNARC effect and differed significantly from other groups
2. Inconsistent results of previous studies can be accounted for by:
   1. Including early years students who may not be advanced enough in their respective professions.
   2. Treating mathematicians and those who use advanced mathematics in their work but are not interested in math per se.
3. The difference between mathematicians and other groups in SNARC effect can be accounted for by:
   1. Domain-general factors referring to more flexible cognitive control (i.e. Task irrelevant spatial component of the representation is inhibited effectively see [4]).
   2. Domain-specific factors such as more abstract or flexible numerical representation present in Mathematicians.

References:
[1] Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. *Journal of Experimental Psychology: General*,*122*, 371-396.
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