



Does Synesthesia Contribute to Mathematical Savant Skills?

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Introduction

We present a preliminary case report of a unique mathematical savant-synesthete, "Arithmos", whose synesthesia may have been caused, in part, by severe epileptic seizures during childhood. Synesthesia is the phenomenon where stimuli in one sensory domain evoke perceptions in multiple domains. For example B-sharp sounds red (tone-color synesthesia), chicken tastes pointy (taste-shape synesthesia).

Arithmos reports that as far back as he can remember he had specific 3-D shapes ("landscapes" as he calls them) associated with the numbers 0-9999, which incorporate size, color, texture, and sometimes movement or sound. He also reports that the digits 0-9 have specific sizes, locations in space, and other attributes.

Arithmos claims that these number-specific sizes and shapes allow him to form a "mental landscape" for a series of numbers, thus aiding his memory. For example, he recently set the European record for Pi memorization (22,500 digits).

He further claims that the shapes help him to perform superfast computations without consciously 'doing math'. In order to test the extent to which Arithmos' synesthesia aids numerical cognition, we tested the consistency of his "numerical landscapes" across time and performed a Stroop memory test to show that his numerical sizes facilitated his memory.

Methods

Number Shapes

We asked Arithmos to use play-dough create 3-D models of 20 different number shapes. After 24 hours there was a surprise retest of Arithmos' number shapes.

Size Stroop Memory Test

If Arithmos is using his number shapes / sizes to aid his memory, then giving him numbers whose physical sizes do not correspond to his synesthetic sizes should make it harder for him to perform well

We gave Arithmos sheets of 100 random items to memorize.

Condition 1: Number sizes were all equal

Condition 2: Number sizes were congruent with Arithmos' number sizes

Condition 3: Number sizes were incongruent with Arithmos' number sizes

Condition 4: Normal size letters of the alphabet

He was given 3 minutes to memorize the numbers, followed by a 5 minute delay period during which the number sheet was hidden during and we conversed with Arithmos to prevent him from using a verbal loop to enhance memorization.

He was asked to recall as many numbers as he could, in order.

He was given two surprise retests; one 24 hours later and one 72 hours later

Experiment 1: Number Shape Consistency



- Each of the shapes was unique and included a lot of very minor textural details and colors
- Upon surprise retest, all 20 of Arithmos' number shapes were almost identical to the original shapes.

Experiment 2 : Size Stroop Memory Test

Normal										Congruent										
0	1	7	0	5	0	9	1	4	0	7	4	2	5	7	9	4	1	4	8	
2	9	1	5	4	7	6	0	5	3	7	2	1	8	7	1	5	7	9		
3	9	9	8	9	9	5	1	7	5	5	1	4	2	4	7	2	9	5		
0	8	0	9	0	2	6	6	1	6	4	1	8	1	5	1	5	8	1		
5	6	7	2	6	2	9	9	4	3	7	2	7	1	1	1	2	2	2		
0	5	7	9	0	6	2	3	6	7	2	1	8	1	4	1	1	1	1		
3	6	5	2	3	0	4	3	6	7	1	8	4	4	5	7	8	9	1	4	
4	6	8	3	6	5	3	1	0	5	1	8	7	1	1	8	7	4	8		
4	5	0	7	4	8	9	6	3	2	5	8	2	7	1	8	8	1	7	2	
6	3	3	7	1	6	7	6	5	4	4	7	1	5	8	2	9	1	9	4	
3	+	3	-	-	2	1	-	-	1	C	W	U	Y	M	L	N	A	E	V	
1	8	-	3	3	2	4	1	-	-	Y	D	Z	A	O	A	Q	R	D	D	
3	-	7	3	-	-	-	1	-	-	T	F	U	T	H	L	W	A	T	M	
9	-	5	6	-	7	0	4	-	-	A	L	E	O	M	D	L	K	Q	G	
0	-	5	1	-	2	9	-	-	-	Y	Q	V	U	D	K	B	E	R	G	
5	5	1	4	-	-	-	-	-	-	A	P	Q	F	B	R	F	H	O	Y	
9	5	4	7	9	1	-	-	-	-	U	J	B	E	K	I	X	U	D	C	
8	1	5	4	7	2	0	2	-	-	C	M	E	R	U	P	S	A	J	I	
0	0	0	2	1	2	6	1	-	-	I	R	G	X	V	G	H	H	Y	W	
1	-	5	2	1	6	2	1	-	-	U	B	K	C	I	M	L	Q	N	Y	

	Total Number of Items Recalled (out of 100)					
	5 Minutes	24 Hours	72 Hours	5 Minutes	24 Hours	Control Average
Normal Number Size	68	68	68	7.8	4.3	
Congruent Number Size	50	50	50	6.2	3.8	
Incongruent Number Size	16	4	0	6.4	2.5	
Alphabet	29	30	30	18.3	5.2	

Additional Observations

Arithmos is especially skilled at identifying prime numbers. He claims that prime numbers do not have textures like other numbers, thus he can easily identify primes the smoothness of the shape.

When doing 4-digit x 4-digit mental multiplication, the most common number that Arithmos missed was '6'... his smallest synesthetic number

Arithmos claimed that while performing multiplication he would mentally put 3D images of each number next to each other and a third shape, the product of the two, would automatically form in the space between them ('Figure/Ground'). This third shape was then 'read' by Arithmos as the correct answer.

Conclusions

As in all cases like this we need to consider the fact that Arithmos may be performing almost of his 'mental feats' via pure memorization. However his severe deficit in the incongruent Stroop size task suggests that Arithmos might directly correlate numbers and his synesthetic sizes / shapes.

Furthermore, Arithmos reported that the only way he was able to memorize the matrix of letters by mentally replacing the letters with similar number forms. This is contrary to some control subjects who reported that they tried to make words out of the letters.

Arithmos' score on the memorization task was consistent whether testing after 5 minutes or 3 days, except in the case of the incongruent numbers where there is very clear decay. This suggests that it may have been more difficult for him to encode the synesthetically incongruent numbers.

References

- Ramachandran, V.S. and Hubbard E. (2003), Hearing Colors, Tasting Shapes, *Scientific American*, 288(5): 42-49.
- Ramachandran, V.S. & Hubbard, E.M. (2001). Synesthesia: A window into perception, thought and language. *Journal of Consciousness Studies*, 8(12) 3-34.
- Synesthesia: A Union of The Senses*, 2nd edition. Cambridge: MIT Press 2003. 1st edition, New York: Springer-Verlag, 1989
- Hermelin, B. & O'Connor, N. (1990), Factors and Primes: A specific numerical ability. *Psychological Medicine*, 20:163-189.
- Hill, A.L. (1978). In N.R. Eller (ed.), *Mentally retarded individuals with special skills*, Vol. 9. New York Academic Press.
- Snyder A. & Thomas M. (1997). Autistic savants give clues to cognition. *Perception*, 26:93-96.
- Luria, A (1968), *The Mind of a Mnemonist*. New York: Basic Books
- Dixon, M. J., Smilek, D., Cudahy, C., & Merikle, P. M. (2000). Five plus two equals yellow. *Nature*, 406, 365.