Running title: Calendrical savants

Do calendrical savants use calculation to answer date questions? A functional magnetic resonance imaging study.

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Abstract

Calendrical savants can name the weekdays for dates from different years with remarkable speed and accuracy. Whether calculation rather than just memory is involved is disputed. Grounds for doubting whether they can calculate are reviewed and criteria for attributing date calculation skills to them are discussed. At least some calendrical savants possess date calculation skills. A behavioural characteristic observed in many calendrical savants is increased response time for questions about more remote years. This may be because more remote years require more calculation or because closer years are more practised. An experiment is reported that used functional magnetic resonance imaging to attempt to discriminate between these explanations. Only two savants could be scanned and excessive head movement corrupted one savant's mental arithmetic data. Nevertheless, there was increased parietal activation during both mental arithmetic and date questions and this region showed increased activity with more remote dates. These results suggest that the calendrical skills observed in savants result from intensive practice with calculations used in solving mental arithmetic problems. The mystery is not how they solve these problems, but why.

Keywords: arithmetic; savant syndrome; fMRI

Calendrical savants

1. INTRODUCTION

Calendrical savants are people with pervasive disabilities who can tell you the weekdays corresponding to dates without resorting to external aids such as calendars or computers. Some surveys suggest it is the most common savant skill, (e.g. Saloviita et al. 2000). It is certainly one of the strangest. These may be linked: so rarely is it reported in typically functioning people that any indication of it is remarkable. In this paper we use existing research to argue that some calendrical savants have skills that go beyond rote memory. They therefore challenge accounts of savant skills in terms of rote learning just as the originality of savant artists and the inventiveness of savant musicians do (O'Connor & Hermelin 1987; Sloboda et al. 1985). Although we shall argue that the skills of several previously studied calendrical savants include date calculation, this does not imply they calculate to answer every date question. In the second part of the paper we describe a functional magnetic resonance imaging (fMRI) investigation to determine whether savants take longer to answer questions about more remote dates because these involve additional calculation or more extensive memory search.

Before discussing the grounds for attributing date calculation skills to savants we consider why some have rejected calculation as a basis for their skill. A principal reason is that calculation draws on cognitive processes that constitute general intelligence. It thus seems paradoxical that people with low measured intelligence should show prowess in a form of calculation that is rarely shown by people with superior levels of cognitive functioning.

The simplest explanation is that the calculations involved are not very demanding. Calendrical skills are not rare in typically functioning people because they are difficult to acquire: Cowan et al. (2004) described two typically developing boys who showed calendrical skills at the ages of 5 and 6. Both had developed them without instruction.

It is more likely that calendrical skills are uncommon in the general population because few people are motivated to develop them. Indeed on following up the boys two years later neither had progressed much in calendrical skill. Both had found more conventional domains in which to excel and receive attention and praise. In contrast calendrical savants may not have opportunities to develop other socially engaging skills.

Amongst those motivated to develop calendrical skills, level of intelligence is likely to affect development of skill: in a set of calendrical savants there is a relation between WAIS IQ and calendrical skill (Hermelin & O'Connor 1986; O'Connor et al. 2000). Omnibus intelligence tests such as the WAIS have limitations for assessing people with autism (Frith 2003; Happé 1994). Most of the sample in O’Connor et al. (2000) had received diagnoses of autism.

Even stronger relationships might be observed between calendrical skill and intelligence when measured with tests that require less informal knowledge, though this would depend on whether amounts of practice were similar. Although some claim that savant skills do not develop with practice (e.g. Snyder & Mitchell 1999), there is evidence that they do (Cowan & Carney 2006; Hoffman 1971; Horwitz et al. 1965; Rosen 1981; Scheerer et al. 1945).

The confounding of informal knowledge with computation might also have led to claims that calendrical savants cannot be calculating to solve date questions because they lack even basic arithmetical skills. The WAIS Arithmetic subscale features story problems, arithmetical problems embedded in verbal contexts. The context may cause difficulty, not the computation. Ho et al. (1991) described a calendrical savant who performed poorly on WAIS Arithmetic but was very successful on tests that just required calculation.

Cowan et al. (2003) also observed differences between WAIS Arithmetic scores and a test of mental arithmetic, the Graded Difficulty Arithmetic test (GDA, Jackson & Warrington 1986) in a sample of calendrical savants. In normal adults, performance on the GDA is highly related to WAIS Arithmetic. The calendrical savants showed no such association: several showed marked discrepancies between tests. No savant performed at a superior level on the WAIS Arithmetic test and several performed poorly. In contrast several calendrical savants were at ceiling level on the GDA: they were also more proficient on calendrical tasks.

The GDA just involves addition and subtraction but algorithms for date calculation typically involve division (e.g. Berlekamp et al. 1982; Carroll 1887). However the suggested process of date calculation by calendrical savants does not involve division. Instead it involves converting the target year into a known year by addition or subtraction (Cowan & Carney 2006; Thioux et al. 2006).

Another feature of calendrical savants that has been considered to argue against calculation is that they are typically unable to give an account of how they solve date questions (O'Connor 1989). Normally one would expect conscious awareness of calculation. However savants may not be able to introspect even when they can be observed counting when solving problems (Scheerer et al. 1945). If savants do not mention calculation even when they can be observed to be calculating then what they do not say about their method is inconclusive about the basis of their skill.

In summary, calculation by calendrical savants has been considered unlikely because of their measured intelligence, their apparent lack of arithmetical skills, and their silence about their method. None of these is compelling.

Positive evidence that the skill does not just reflect memory for calendars is provided when savants can answer questions outside the range of calendars they could have memorized. Just being able to answer questions about dates in the future is not decisive as there are several sources of information about future dates: diaries often give the calendar for years in the near future. Calendars for more remote years can be obtained from reference books such as Whitaker's Almanac, and perpetual calendars. The range of years these cover is, however, limited. Reference books and perpetual calendars do not cover more than 400 years in the Gregorian period as the Gregorian calendar repeats every 400 years. Typically they cover fewer. So a savant who can answer questions about years more than 400 years in the future must calculate to work out the correspondence between a remote year and a closer one. Several reports of savants with very large ranges exist: Tredgold & Soddy (1956) mentioned an inmate of an idiot asylum who could answer questions on any date in the years from 1000 to 2000. George, the more able of the twins studied by Horwitz et al. (1969), correctly answered all questions asked concerning years between 4100 and 40400. O'Connor et al. (2000) described three savants who correctly answered questions for years further in the future than 8000: GC, MW, and HP.

Systematic errors provide another form of evidence that the skills are not just the product of memorizing calendars. Century years such as 1800, 1900, and 2000 are only leap years in the Gregorian calendar if they are exactly divisible by 400. Some savants respond to date questions as though all century years were leap. They answer questions about dates in the 19th century with the day before the correct answer, e.g. claiming that the 14th July 1886 was a Saturday when it was a Sunday. For dates in the 18th century their answers are two days before the correct day and for future centuries their answers are days after the correct answer, e.g. claiming that 1st July 2192 will be a Monday rather than a Sunday and that 22nd May 2209 will be a Wednesday instead of a Monday. These systematic deviations are inconsistent with a method solely based on remembered calendars. Extrapolation from calendars studied is more likely but this implies they have detected regularities to extrapolate from and that they have used these to calculate correspondences between remote and proximal years (Hermelin & O'Connor 1986; O'Connor & Hermelin, 1984). Calendrical savants who made such systematic errors have been described by several researchers: Kit (Ho et al. 1991), TMK (Hurst & Mulhall 1988), Donny (Thioux et al. 2006), DM and JG (O'Connor et al. 2000).

The remote past can also provoke systematic errors inconsistent with memorizing. Before adopting the Gregorian calendar, European countries used the Julian calendar in which every year exactly divisible by four is leap. Countries adopted the Gregorian calendar in different years: from 1582 for Italy, France, Spain and Portugal, to 1923 for Greece. Adoption of the Gregorian calendar involved more than just the change to century years: a number of days were dropped in the year of change. When Great Britain adopted the Gregorian calendar in 1752 the days between 3 and 13 September did not happen, a cause of some civil unrest. False extrapolations of the Gregorian calendar to years before 1752 were made by George (Horwitz et al. 1969), and MW (Cowan et al. 2003). GC assumed that 1700 was a leap year but was ignorant of the omission of days in 1752 (Cowan et al. 2003). Donny (Thioux et al. 2006) and DM (Cowan et al. 2003) extrapolated their versions of the calendar across the change date. Only HP (Cowan et al. 2003) responded consistently with the change and knew what dates had been omitted.

Another way of establishing that savants can calculate to solve date problems was derived by analogy with research on children's arithmetic. Dowker (1998) devised a test of children's knowledge of arithmetical principles which involves first determining the range of problems a child could reliably solve and then presenting them with problems beyond it but with the solution to a problem related to it by an arithmetical principle. So for example a child who could solve single digit addend problems such as 9 + 8 but not two digit addend problems such as 26 + 72 would be told that 44 + 23 = 67 and asked if they could solve 23 +44 (related to it by commutativity). The calendrical analogue involved first establishing the limits of the range of years within which the savant could answer correctly, telling them days for dates outside that range and then asking them to solve date questions related to them by calendrical regularities. Two such regularities are the one year, one day rule (the same date in adjacent years falls on adjacent days unless there is an intervening 29 February) and the 28 year rule (the same date in years 28 years apart in the same century falls on the same day). Answering both types of problem correctly requires knowledge of the principles and discrimination –the correct answer to one year, one day problems is never the same weekday but it always is for 28 year rule problems. Savants who answered both types of problem correctly included DK and PE as well as GC and MW (Cowan et al. 2001).

Any of the above characteristics might be regarded as sufficient evidence that a particular calendrical savant’s skills are more than just memory. None however are necessary. It would be wrong to conclude that a savant cannot calculate dates just because their range is less than that of a perpetual calendar or because they do not systematically err. An inability to solve related problems outside their range is also inconclusive: it proved beyond the ability of the experimenters to explain the task to some savants (Cowan et al. 2001). So our conclusion is that at least some calendrical savants, and maybe all, can calculate the answers to date questions.

A feature of many calendrical savants, even those with limited ranges, is that they take longer to answer questions concerning years more remote from the present (Cowan et al. 2003; Dorman 1991; O'Connor & Hermelin 1984). This could result from increased calculation for more remote years (O’Connor & Hermelin 1984). It might also result from differential effects of practice. As a result of practising date calculations and studying calendars, savants may develop richer networks of associations between dates and weekdays and stronger associations for more proximal years.

Behavioural data are equivocal about why response times increase with remoteness. Imaging studies can help resolve the issue. If areas of greater activation when calendrical savants answer date questions overlap with those when they are calculating answers to arithmetical problems then calculation is the likely basis. If remote years elicit even greater activation of these regions, then these are likely to involve more calculation, as O'Connor & Hermelin (1984) hypothesized.

The neural processing of numbers in the brain involves several different regions. For example, the right fusiform gyrus is implicated in the identification of Arabic numerals (Pinel et al. 2001). However, it is generally agreed that the parietal lobe has the major role (Dehaene et al. 2003). In particular, the intraparietal sulcus (IPS) is involved in representing quantity in both humans (Pinel et al. 2004) and monkeys (Nieder 2005). Supporting this idea are data from an experiment (Pinel et al. 2001) in which subjects had to decide whether a number was larger or smaller than a memorized reference number (65). There were three categories of target, close (60-64, 66-69), medium (50-59, 70-79 and far (30-49, 80-89). Reaction times for classifier target numbers decreased as the distance of the targets from the reference. These reaction time differences were paralleled by the magnitude of the activity elicited in left and right IPS (-40,-44, 36; 44,-56, 48). The more difficult the numerical comparison (i.e. the closer the numbers) the longer was the RT and the greater was the activity in the IPS.

The study of calendrical savants is problematic for a number of reasons. First, there are too few suitable savants for a group study to be conducted. We originally attempted to scan four, but one was unable to remain in the scanner for long enough. Another was unable to learn to press buttons instead of responding orally. It is therefore necessary to conduct single case studies. Given the very limited power from such studies using fMRI we chose to restrict our investigation to the parietal lobe and to test the hypothesis that calendrical calculation engages this region in the same manner as mental arithmetic.

The second problem is that it is not possible to scan ‘normal’ volunteers doing calendrical calculation because their abilities would typically be dramatically inferior. To avoid this problem we asked our calendrical calculators to perform an established mental arithmetic task (Menon et al. 2000) that could be compared with ‘normal’ volunteers. We then used conjunction analysis to locate regions in parietal cortex that were activated both by mental arithmetic and by calendrical calculation. Finally we asked whether these regions also showed a difficulty effect when calendrical calculations were performed on dates that were more or less remote from the present.

2. METHODS

(a) *Participants*

Two autistic calendrical savants (GC and MW) and a normal adult male participated. GC and MW are examples of classic autism and have WAIS IQs of 97 and 82 respectively. Both GC and MW show evidence of being able to calculate dates by having ranges that transcend those of perpetual calendars, making systematic errors for dates in the remote past and by being able to use calendrical regularities to solve date problems outside their range. GC is left-handed and MW is right-handed. Written consent was obtained from both savants before each occasion on which they were scanned. MW's parents accompanied him and also consented to his participation. The study was approved by the National Hospital research ethics committee. The single normal participant was tested on the mental arithmetic task to check that the results of Menon et al. (2000) could be replicated in a single subject.

(b) *Experimental tasks*

Arithmetic. We modified Menon et al.'s (2000) verification task slightly to increase probability of calculation. Initial and final numbers always contained two digits, e.g. '25 – 6 + 8 = 27; true or false?'. The control task presented strings of eight digits and also required both true and false, e.g. '3 4 9 0 5 7 8 6 contains 0; true or false?'.

Calendrical tasks. We used two types of calendrical and control tasks on different occasions. Calendrical I featured dates from the 1940s and 2020s, e.g. '3 March 2025 is a Monday; true or false?'. The control task comprised statements about the initial letters of months, e.g. 'July begins with J; true or false?'.

The second session calendrical task, Calendrical II, featured dates from three periods, varying in remoteness from the late 20th century. Close dates sampled from the 1970s and 80s, e.g. '16 July 1981 is a Monday; true or false?'. Medium dates sampled the 1940s and 2020s. Remote dates featured the 1910s and 2050s. The control task presented statements such as '8 June 2055 is a June day: true or false?' using dates from all six decades.

Each task involved equal numbers of true and false statements. There were 60 different items for each of the arithmetic, first session calendrical task, and control tasks and for each of the periods in the second session calendrical task. All calendrical task items concerned Mondays.

Testing occurred in two sessions for the savants and one for the normal participant. Problems were visually presented. The interval between problems was fixed at 8 s. Participants responded by pressing buttons with their left or right thumb to indicate true or false respectively and response times were recorded. Savants were scanned for four blocks in both sessions. In the first session, a block consisted of 30 items from a particular task (arithmetic or calendrical task dates) and 30 items from the corresponding control task. In the second session, a block consisted of 45 calendrical task items, 15 from each period, and 15 control items. The normal participant received the two arithmetic blocks. The order of problems within each block was randomised.

(c) *Data acquisition*

Images were acquired using a 1.5 Tesla Siemens Sonata MRI scanner to acquire gradient-echo, echoplanar T2*-weighted echo-planar images (EPI) with blood oxygenation level-dependent (BOLD) contrast. Each volume comprised 36 axial slices of 2 mm thickness with 1 mm slice gap and 3 x 3 mm in-plane resolution. Volumes were acquired continuously every 3.077 s. Each run began with 6 "dummy" volumes discarded for analyses. At the end of each scanning session, a T1-weighted structural image was acquired.

(d) *Data analysis*

The images were analyzed with SPM2 (Wellcome Department of Imaging Neuroscience, London, UK) using an event-related model (Josephs et al. 1997). To correct for motion, functional volumes were realigned to the first volume (Friston, Ashburner et al. 1995), spatially normalized to a standard template with a resampled voxel size of 3 x 3 x 3 mm, and smoothed using a Gaussian kernel with a full width at half maximum (FWHM) of 8 mm. In addition, high pass temporal filtering with a cut-off of 128 s was applied. After pre-processing, statistical analysis was carried out using the general linear model (Friston, Holmes et al. 1995). The response to each problem was modelled by convolving a 4 s boxcar starting at problem onset with a canonical hemodynamic response function (HRF) to create regressors for each problem type. Problems that were incorrectly answered were omitted. Residual effects of head motion were corrected for by including the six estimated motion parameters for each subject as regressors of no interest. Contrast images (e.g. arithmetic vs. control problems) were then calculated by applying appropriate linear contrasts to the parameter estimates for the parametric regressor of each event. Unless stated otherwise probabilities are corrected for multiple comparisons using false discovery rate (FDR). In session 2, regions where there was a relationship between activity and increasing remoteness of the date were identified by the conjunction of the contrasts (remote – medium) and (medium – close).

3. RESULTS

According to an experienced clinical radiologist, inspection of the structural scans of the two savants indicated no structural abnormalities. We also looked for small scale differences in structure using voxel-based morphometry (Ashburner & Friston, 2000), but found no consistent differences in our two subjects in comparison to an age matched control group. In particular we found no differences in the parietal lobe.

(a) *First session: Mental arithmetic and Calendrical I*

Mental arithmetic. Behavioural data are summarised in Table 1. In testing GC, but not MW, there were a few invalid trials due to failure to press buttons (Arithmetic, 7/60, Control 8/60). Table 1 shows both savants responded correctly to almost all valid trials and their response times were fast, though not as fast as the control subject.

Unfortunately MW's first session data could not be analysed further due to excessive head movement (within session movement > 7mm). Table 2 shows activation in parietal cortex while performing the mental arithmetic task (vs control) for the group reported by Menon et al. (2000), the control participant, and GC. Both the control participant and GC show considerable correspondence with Menon et al.'s data. The only difference is the indication of bilateral activation of the inferior parietal region in GC.

Calendrical I. Table 1 shows the accuracies and response times for the two calendrical savants on the calendrical and control tasks. Accuracy was high on both calendrical and control tasks and there were no invalid trials.

A conjunction analysis (Friston et al. 2005) was performed on the data for GC to identify regions that were activated by both mental arithmetic and calendrical tasks. This analysis revealed activations in the same regions of parietal cortex (Table 3).

Table 1

Accuracies and Mean Correct Response Times (s) for Arithmetic and Calendrical Tasks and Corresponding Control Tasks

			Task					
			Main			Control		
Item type	Person	Period	%	M	SD	%	M	SD
Arithmetic	GC		96	4.68	1.07	96	1.57	0.64
	MW		97	3.42	0.81	97	1.55	0.45
	Control		95	2.86	0.86	97	1.06	0.22
Calendrical I	GC		97	3.63	1.24	100	1.71	0.73
	MW		98	2.63	0.91	100	1.30	0.42
Calendrical II	GC	Close	96	3.51	1.19			
		Medium	81	5.06	1.44	95	3.88	1.41
		Remote	85	5.18	1.67			
	MW	Close	100	2.05	0.59			
		Medium	98	2.85	0.86	83	2.65	1.03
		Remote	97	3.78	1.13			

Table 2

Areas of Greater Parietal Activation during Arithmetic Reported by Menon et al. (2000) and Observed in Control Participant, and Calendrical Savant GC

Location	MNI coordinates			Z-value	P-value (FDR-corrected)
	x	y	z		
Menon et al. (2000)					
Inferior parietal lobe (BA40)	-48	-50	50	9.46	< .0001
Superior parietal lobe (BA7)	-26	-78	42	5.37	< .0001
Superior parietal lobe (BA7)	30	-76	40	5.61	< .0001
Control participant					
Inferior parietal lobe (BA40)	-36	-36	42	7.46	< .0001
Superior parietal lobe (BA7)	-30	-60	48	>8.0	< .0001
Superior parietal lobe (BA7)	21	-69	51	>8.0	< .0001
GC					
Inferior parietal lobe (BA40)	-42	-54	42	4.14	< .003
Inferior parietal lobe (BA40)	39	-42	42	4.46	< .001
Superior parietal lobe (BA7)	-24	-60	42	4.48	< .001
Superior parietal lobe (BA7)	33	-60	39	4.78	< .001

Note. Data from Menon et al. (2000) are copyright 2000 by Elsevier. Reprinted with permission.

Table 3

Activity in the Parietal Lobe Observed During Mental Arithmetic and Calendrical I in GC

Location	MNI coordinates			Z-value	P-values (FDR corrected)
	x	y	z		
Inferior parietal lobe (BA40)	-40	-56	52	4.48	< .004
Inferior parietal lobe (BA40)	40	-50	50	3.62	< .041
Superior parietal lobe (BA7)	-26	-68	52	3.84	< .025
Superior parietal lobe (BA7)	34	-64	52	4.08	< .013

Figure 1 shows all the activity in common between mental arithmetic and calendrical calculation in GC using the glass brain format. In addition to parietal cortex, activity can be seen in premotor cortex, the supplementary motor area (preSMA) and in left inferior temporal cortex. These areas were also activated by the mental arithmetic tasks in the study of Menon et al. (2000). The inset shows the major regions of activity superimposed on a horizontal slice from the structural scan of GC's brain.

(b) *Second session*

GC, but not MW, had a few invalid trials (Close, 3/60, Medium, 6/60, Remote, 7/60). For valid trials, overall accuracy was high, as Table 1 shows. GC's accuracy for medium and remote dates was lower than that for close dates but MW's accuracy did not vary: GC, χ^2 (2, 164) = 6.45, $p < .05$; MW, χ^2 (2, 180) = 2.03, *ns*. MW made 10 errors on the task II control problems. All but one were correct answers to the corresponding calendrical question, suggesting that he failed either to recognize them as control items or to inhibit the response to the calendrical question.

Correct response times varied with remoteness of years according to analyses of log response times: GC, F (2,141) = 24.22, $p < .0005$, $\eta^2 = .26$; MW, F (2,174) = 67.70, $p < .0005$, $\eta^2 = .46$. Both answered close questions faster than medium but only MW took longer to answer remote than medium questions, according to post hoc Ryan-Einot-Gabriel-Welsch Range comparisons (*p*s < .05).

Neither savant showed excessive head movement during scanning. For GC we could predict which regions in parietal cortex should show increasing activity with increasing remoteness on the basis of the first session. For MW, however, we had not been able to identify the relevant regions. As a strict test of the replicability of the results for GC we used the regions identified for GC in the first session to guide our analysis of the data for MW in the second session. These were the two most significant regions of parietal cortex identified from the conjunction analysis of GC's mental arithmetic and calendrical calculation (left parietal cortex, -40 -56 52; right parietal cortex, 34 -64 52; Table 3). The nearest locations where there was significant activity (uncorrected) in session 2 were used to plot the data shown in figure 2. In addition we performed an unconstrained analysis to identify regions were activity increased with increasing remoteness of dates.

Table 4 shows the coordinates so identified. The regions of interest identified from the conjunction analysis of the first session for GC were included in clusters identified by the unconstrained analysis for both GC and MW. Figure 2 shows response time and associated activity in the parietal cortex on the same graph, as in Pinel et al. (2001). It reveals a striking correspondence between the increase in response time and neural activity with increasing date distance.

Figure 1. Activity in common between mental arithmetic and calendrical calculation in GC using glass brain format. All voxels reaching a significance level of $p < .01$ (uncorrected) are shown. Inset shows major regions superimposed on horizontal slice from GC's structural scan.

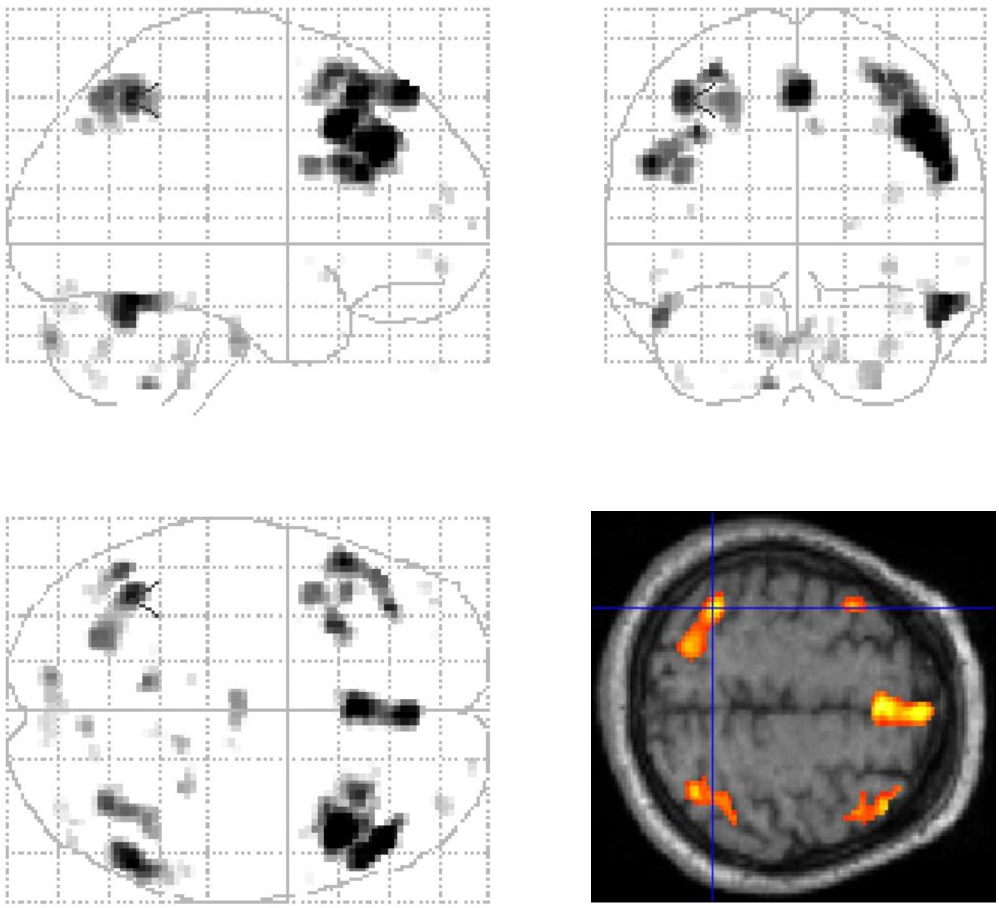


Table 4

Activity in the Parietal Cortex Associated with Increasing Distance of Dates in Calendrical II. Coordinates (Used for the Plots in Figure 2) are of Nearest Location to Activations in Conjunction Analysis of Arithmetic and Calendrical I for GC and Peaks in an Unconstrained Analysis of Effects of Increasing Remoteness of Dates

	Nearest location to conjunction activations			Peaks in unconstrained analysis				
	Coordinates			MNI coordinates			Z-value	P-values
Savant	x	y	z	x	y	z		
GC								
	-40	-58	48	-42	-54	46	2.91	< .002[a]
	34	-64	40	30	-56	40	2.95	< .002[a]
MW								
	-42	-48	46	-42	-40	40	4.30	< .004[b]
	30	-70	48	22	-70	52	4.62	< .002[b]

[a] uncorrected. [b] FDR-corrected

Figure 2

Correspondence between brain activation estimates in left and right parietal regions and reaction times for each savant with increasing date distance. Activation estimates are in contrast to those for the control task. Figure 2a shows data for GC in left parietal region (-40 -58 48) and right parietal region (34 -64 40). Figure 2b shows MW's data in left parietal region (-42 -48 46) and right parietal region (30 -70 48).

Figure 2a

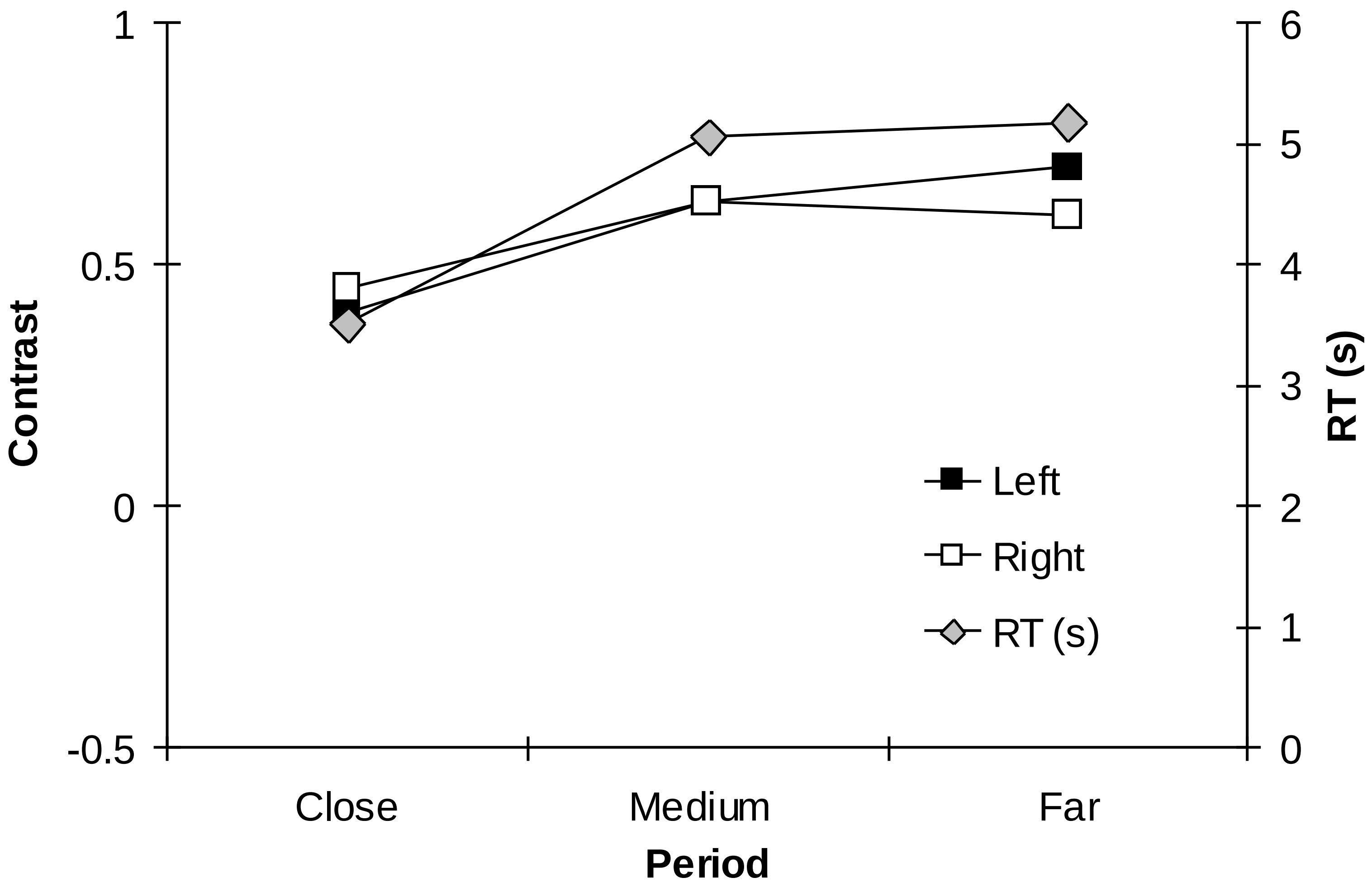
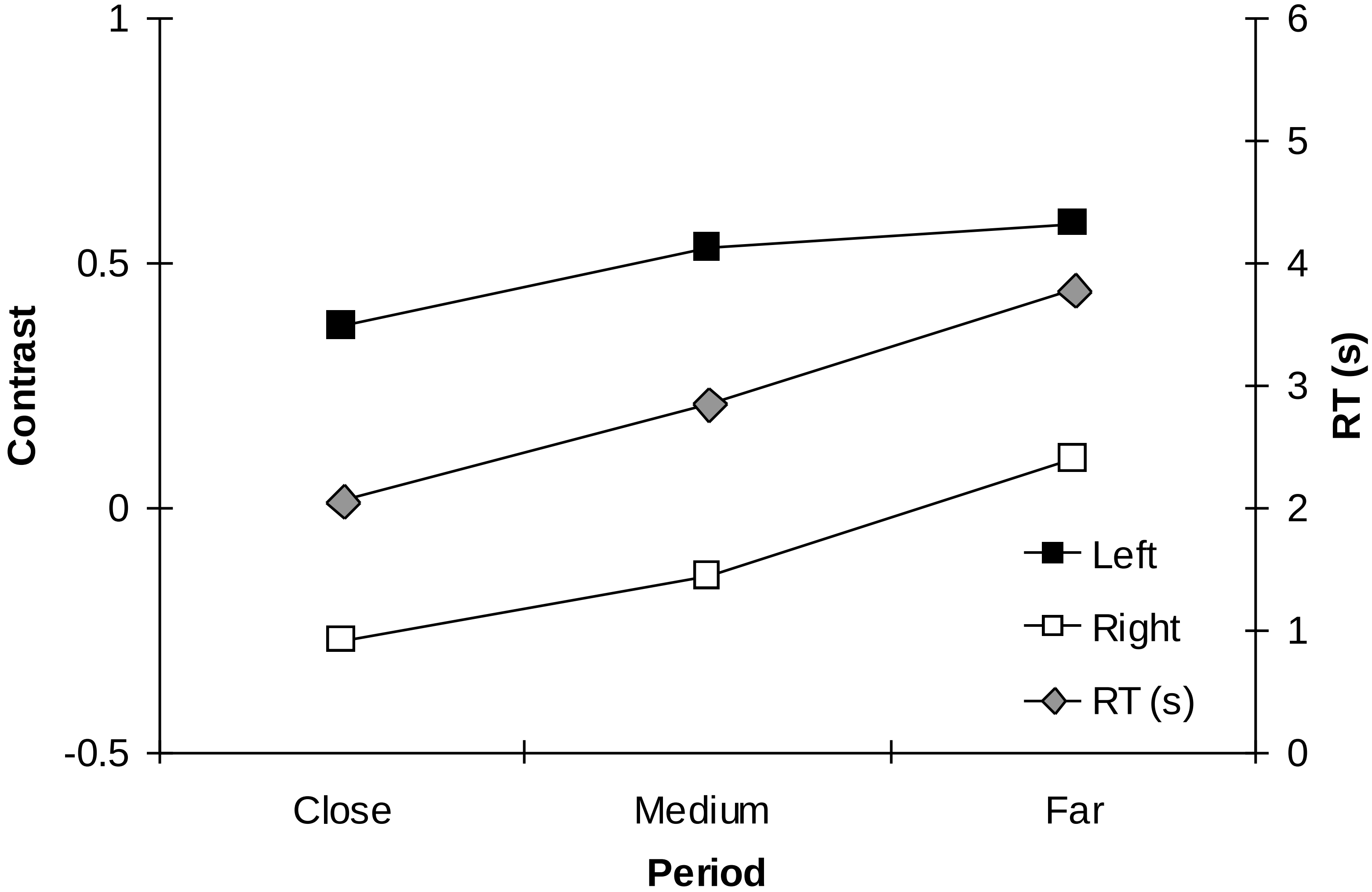

1
0.5
0
-0.5
Contrast
6
5
4
3
2
1
0
RT (s)
Left
Right
RT (s)
Close
Medium
Far
Period

Figure 2b


1
0.5
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-0.5
Contrast
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1
0
RT (s)
Left
Right
RT (s)
Close
Medium
Far
Period

4. DISCUSSION

Despite some limitations we were able to conduct a case study with one savant, GC, and a normal participant and replicate it with a second savant, MW. The results do contribute to our knowledge of savants, and, in particular, understanding why they take longer to answer questions about more remote dates.

When GC was doing mental arithmetic, the peaks of activation were in regions associated with arithmetic in studies of normal people (Menon et al. 2000). The conjunction analysis indicated that it was these regions that were particularly active when solving date problems. Data from the second session showed that it was these regions which increased in activity in both GC and MW when asked questions about more remote years.

For these savants it seems the relation between response time and remoteness from the present reflects increased calculation for remote dates as hypothesized by O'Connor & Hermelin (1984). Whether this is generally true for savants who vary in response time with period is a matter for future research.

More tentatively, the lack of abnormalities revealed by the brain scans of the two savants does not support the proposal that all savants are severely brain-damaged (Snyder & Mitchell 1999) or that savant skills are achieved by rededication of low-level perceptual systems (Mottron et al. 2006).

In summary, the calendrical skills of savants are most plausibly considered to develop from practice and extensive study of calendars. The skills may be unusual but they do not, in these two cases at least, seem to involve any abnormal cognitive processes or depend on fundamentally different brains.

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