Neuroscience and Biobehavioral Reviews 178 (2025) 106376

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

Calendar calculation: A systematic review of 100 years of research

Jade Desrosiers [a,b], David Gagnon [b,c], Alexia Ostrolenk [b,d], Alice Boutros [b,e], Boris C. Bernhardt [f,g], Valérie Courchesne [a,b], Laurent Mottron [b,c,*]

[a] Département de Psychologie, Université de Montréal, 90 Av. Vincent-D'Indy, Montreal, QC H3C 3J7, Canada
[b] Collectif de Recherche, Évaluation et Intervention en Autisme (CRÉIA), Rivière-des-Prairies Hospital, CIUSSS du Nord-de-l'ile-de-Montréal, 7070 Boulevard Perras, Montreal, QC H1E 1A4, Canada
[c] Département de Psychiatrie et d'Addictologie, Université de Montréal, 2900 Bd Édouard-Montpetit, Montreal, QC H3T 1J4, Canada
[d] St. Michael's Hospital, Unity Health Toronto, 36 Queen St E, Toronto, ON M5B 1W8, Canada
[e] University of Lausanne, Institute of Psychology, Géopolis, 1015 Lausanne, Switzerland
[f] McConnell Brain Imaging Centre (BIC), Montreal Neurological Institute, McGill University, 3801 University St, Montreal, QC H3A2B4, Canada
[g] Département de psychologie, Université du Québec à Montréal, 100, rue Sherbrooke Ouest, Montréal, QC H2X 3P2, Canada

A R T I C L E I N F O

Keywords:
Autism
Savant syndrome
Calendar calculation
Development
Cognition

A B S T R A C T

Calendar calculation is the ability to answer rapidly to questions such as "What day of the week was May 12, 1978?" or "For which years is February 15 a Monday?" This ability is mastered by some "savant" autistic people with a surprising level of speed and accuracy. The quasi-specificity of calendar calculation in autism justifies its importance for understanding autistic information processing and learning mechanisms and is informative of certain extreme possibilities of human cognition. A registered (PROSPERO: CRD42021254855) systematic review was conducted using PRISMA guidelines, generating 76 articles (1920–2023) documenting 105 calculators (95 M). We examine: the clinical characteristics of calculators, their cognitive performances, the development and the behavioral correlates to the ability, the empirical findings on calendar calculation, as well as the overall available brain imaging results during calendar tasks. Our findings indicate that calendar calculation is associated with autism and is typically acquired implicitly and in an autodidactic manner, often during school age. Participants tend to demonstrate superior cognitive abilities in their area of interest compared to other domains. When assessed using standardized tools, their performance generally falls within the low full-scale IQ range. 49.5 % had a total calculation range under 100 years. Distance and priming effect were not consistently found showing performance variability. Brain imaging results highlighted three different neural networks that were activated during calendar tasks: memory, visual and arithmetic. This knowledge enables us to establish the common characteristics of calendar calculators and identify gaps in knowledge related to the acquisition of calendar calculation.

1. Background and objectives

Seguin (1870) used in first the term "idiot-savants'' to describe a person with an intellectual deficit, but which contrasts with the presence of exceptional ability in a specific area (Miller, 1998). According to Treffert (2009), descriptions of savants dating back to 1783 (Mortiz, 1783) and 1789 (Rush, 1789) have been found. Tredgold's (1908) descriptions of various savant cases also attracted interest in the early 1900s. The empirical studies of autistic special abilities conducted by Hermelin and O'Connor (1984–2003) were seminal in the development of the first cognitive model of autism. How these capabilities overlap with autistic "special abilities'' had been debated, but Heaton & Wallace concluded that autism was the quasi-exclusive developmental context for "savant'' abilities in their informative review on the topic (2004). Empirical, hypothesis-driven studies of special abilities over-represented in autism allows, despite their rarity, to put forward developmental and cognitive hypotheses to be tested on a larger population of autistic people. For instance, the in-depth study of an autistic artist (Mottron and Belleville, 1993; 1995) has inspired models that have proven fruitful in explaining current imaging results in autism (e.g.: Bernhardt et al., 2025). An exhaustive review of all the available facts on hyperlexia (Ostrolenk et al., 2017) was decisive in the empirical

* Corresponding author at: Collectif de Recherche, Évaluation et Intervention en Autisme (CRÉIA), Rivière-des-Prairies Hospital, CIUSSS du Nord-de-l'ile-de-Montréal, 7070 Boulevard Perras, Montreal, QC H1E 1A4, Canada.
E-mail address: laurent.mottron@gmail.com (L. Mottron).

https://doi.org/10.1016/j.neubiorev.2025.106376
Received 13 February 2025; Received in revised form 28 August 2025; Accepted 15 September 2025
Available online 17 September 2025

investigation of accelerated decoding abilities in large populations of autistic children (Gagnon et al., 2025; Ostrolenk et al., 2024) as well as to produce innovative models on language acquisition in autism (Kissine et al., 2023).

Calendar calculation (CC) is the ability to answer rapidly a question like: "What day of the week was it on May 12, 1978?" (Miller, 1999). This very rare ability can be mastered by some mathematically gifted typical persons, explicitly applying complex algorithms (Hermelin, 2001). However, some "savant" autistic individuals master CC in a precocious, self-taught, extremely fast, and unexpected way (Thioux et al., 2006). Nevertheless, the learning trajectory of CC, the cognitive mechanisms, and why it frequently co-occurs with autism remain minimally understood and has not been synthetized. In Hughes et al. (2019), participants completed an explicit CC training program and ultimately took a final test to assess their performance. However, the results are variable, cannot indicate the presence of the ability and do not provide a better understanding of the acquisition and the development of CC. This ability has been documented for many years primarily through single cases due to its low prevalence and the heterogeneity of profiles. Systematically reviewing all published cases therefore allows a reappraisal of the developmental path of this special skill by considering both longitudinal and cross-sectional information.

The objectives of this systematic review were to exhaustively document the calendar calculators' characteristics, the empirical neuro cognitive findings about this skill, and knowledge gaps. The characteristics of calendar calculators were inventoried to delineate distinct profiles. Descriptive and empirical attributes of CC ability were pigeonholed to identify scientific gaps. By systematically grouping and organizing all findings, this review can ground and facilitate future research, for instance in brain imaging. The comprehensive description of participants from both a clinical and ability perspective provides a more comprehensive understanding of CC, enabling a better understanding and contextualization of the theory behind it. In a first step in this direction, a companion paper (Desrosiers et al., 2025) evaluates the current models of CC in the face of strengths and gaps of existing empirical data, and develops a new theoretical framework accounting for the acquisition, development and cognitive underpinnings of CC.

2. Method

2.1. Transparency and openness

The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) was used as a guideline. The systematic review protocol was registered on Prospero (registration number: CRD42021254855). All data are available in Supplemental.

2.2. Literature search

A literature search was conducted in July 2021, updated in August 2024 and revised in August 2025. The search terms *(Calendar calculation (s), Calendar calculator(s), Calendar computation, Calendrical calculators, Calendar calculating, Calendrical calculation, Calendrical savants, Calendar savant)* without filters or restrictions were used on *PubMed*, *Web of Science*, *PsychInfo*, *Proquest Dissertations and Theses*, and *Linguistics and Language Behavior Abstracts*. The reference lists of included publications were also examined. Publications in all languages reporting on participants able to identify the correct day of the week for a specific date at a success rate higher than chance, based on author description, were included. Publications without original data were excluded. Prevalence or group studies that did not provide individual information on the capacity of the calendar calculator were excluded. If the ability was only reported by self-administered questionnaire and was not tested by the author, the article was excluded. For publications in languages other than English (n = 9), translation software (DeepL, 2025) was used.

2.3. Study selection

Search results were processed through Endnote X9 software (The EndNote Team, 2013). The database search yielded 540 publications, of which 92 were duplicates and removed. Titles and abstracts were independently reviewed (by JD and a research assistant) to identify relevant reports. A total of 448 titles and abstracts were screened, 145 of which were deemed eligible. Disagreements were resolved by discussion (agreement: 93.10 %) and LM was consulted when necessary. JD and a research assistant independently read selected texts to verify that they met the inclusion criteria, and 93 publications were excluded, either due to insufficient information to determine if the participant was a calendar calculator or not, absence of original data, no calendar calculator included in the article based on the authors' description. Thirty-three publications were identified in the reference lists of included publications and of these, 24 additional papers were included after eligibility assessment. These were mostly older studies that had not been systematically included in the databases, or for which no abstracts or electronic files were available, preventing extraction by the keywords used (Fig. 1).

2.4. Data extraction

JD and a research assistant independently extracted characteristics related to publication (title, author, year of publication, language), participant (sex, age at assessment, cognitive performance, clinical description), and CC (reported onset of CC, developmental history of CC, introspection, other intense interests), question type (simple or reverse, see Question Types section for definitions), range of accurate calculation (the term "range" refers to the limit of years in the past and/or future for which a calendar calculator provides accurate answers above chance level), empirical tasks, and results. Due to the absence of a standardized procedure for evaluating CC, the data could not be compared statistically but only synthesised qualitatively.

2.4.1. Clinical decisions

Given the evolution of diagnostic classifications over the years covered by the study, we grouped together previous diagnoses of childhood schizophrenia, early onset psychosis, infantile psychosis, Asperger's syndrome, Pervasive Developmental Disorder, Pervasive Developmental Disorder- Not Otherwise Specified, Autism, which are now included in the general category of "autism spectrum disorder" in the DSM-5 (APA, 2013). We included participants who met all DSM-5 diagnostic criteria as described by the authors, but without a formal diagnosis, in the category "probable autism". Participants with an insufficient number of signs to be included in the previous category were classified under "features of autism". Participants without reported signs of autism or whose autism diagnosis was explicitly ruled out by the authors were assigned to "No features of autism" category. All diagnostic assignments were made by inter-judge agreement between two clinical experts (LM and another child psychiatrist). Cases for which assignment was not clear (17.14 %) were discussed until both clinicians agreed.

2.5. Quality

The quality of publications was assessed using *The Mixed Methods Appraisal Tool* (MMAT; Hong et al., 2018), which is designed for systematic literature reviews that incorporate different study designs. It consists of five sets of criteria, each comprising two primary questions and five additional "yes", "no", or "don't know" questions. This assessment did not lead to the exclusion of articles with lower ratings but facilitated a critical evaluation of the reported findings and the strength of the evidence they provide.

3. Results

A total of 76 publications published between 1920 and 2023 were

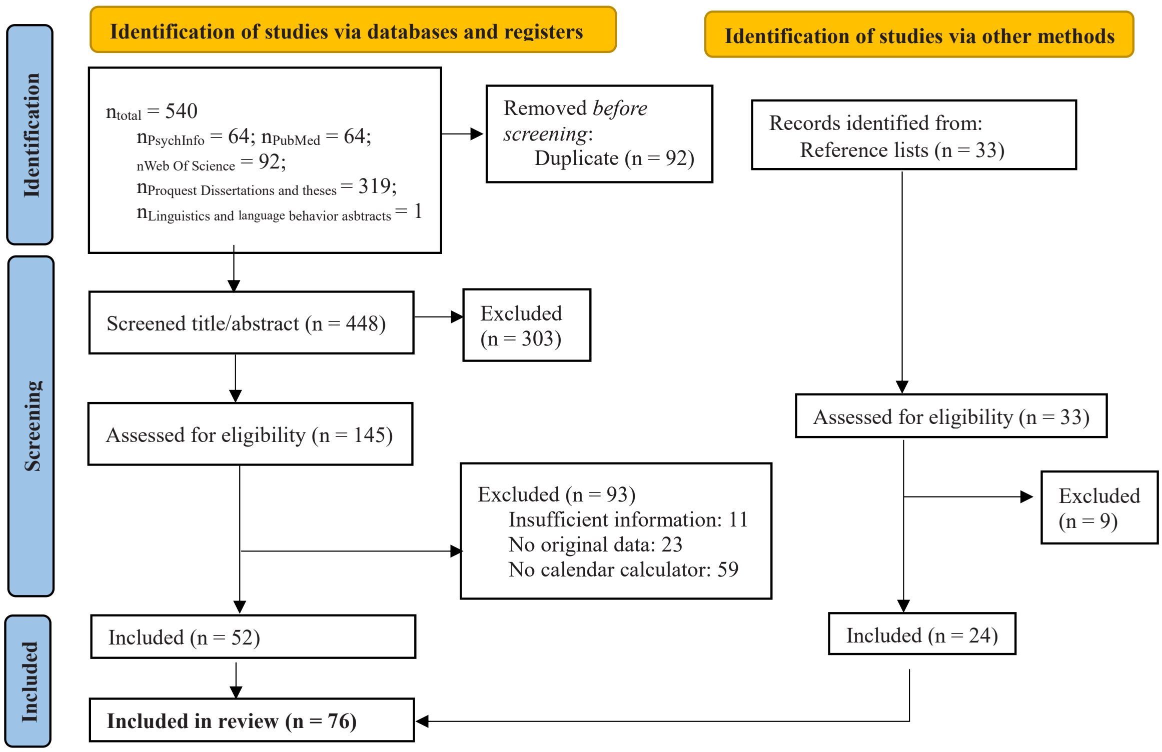


Fig. 1. Flow-chart of selection process adapted from PRISMA (Page et al., 2021).

included, documenting a total of 105 calendar calculators (Appendix 1). Scientific interest on CC has remained constant but modest over the period studied, with 1–17 publications per decade. The number of publications on CC did not follow the exponential trend observed for autism (Fig. 2). Fifty-three publications report only one calendar calculator (Supplemental- Table 1), while 23 publications have more than one participant.

About the quality of the articles, the MMAT tool identified seven articles (6.67 %) that did not meet the criteria for being considered articles with a clear research question and rigorous data collection. However, articles have not been excluded to preserve all data and ensure exhaustive collection. For nine articles (8.57 %), "don't know" was answered for at least one question, thus diminishing the overall quality.

4. Participants clinical and socio-demographic characteristics

4.1. Diagnosis or clinical description

Fifty-nine participants (56.2 %) were identified as autistic, 14 (13.3 %) as probably autistic, and seven (6.7 %) as having at least one sign consistent with the DSM-5 definition of autism (Appendix 1- see 2.4.1 for description). Among the remaining 25 calendar calculators (23.8 %; Supplemental- Table 2), 10 participants were diagnosed with other neurodevelopmental disorders, including global developmental delay, intellectual disability, Gilles de la Tourette, and non-specific learning disabilities. Three participants had medical conditions: infantile paralysis, blindness, left hemisphere removal, and one had a

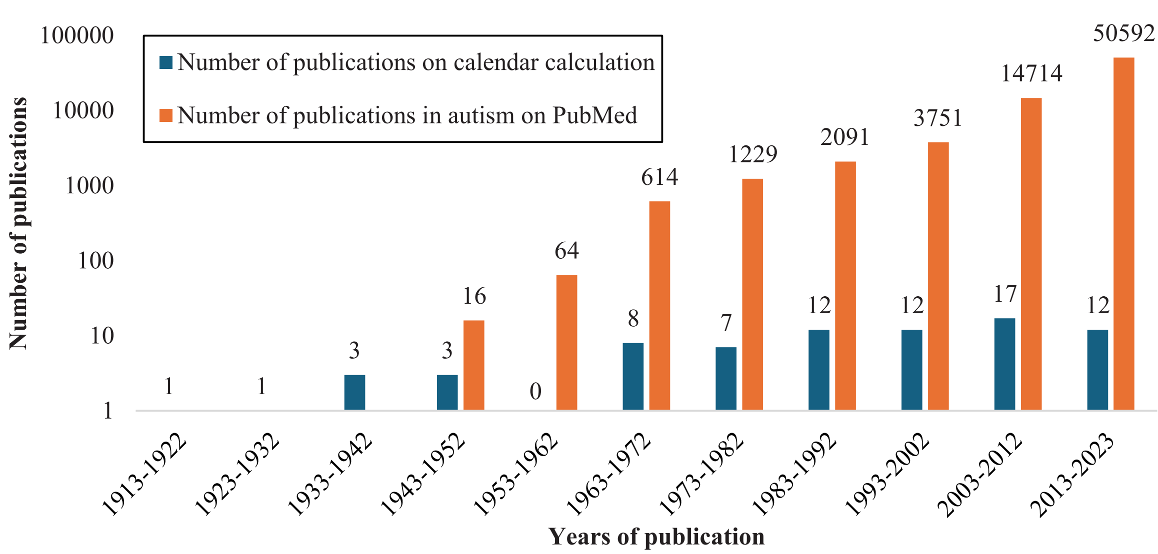


Fig. 2. Evolution of publications on CC in the last 100 years and evolution of publications on autism during the same period. Note. On PubMed, the first publication dates to 1946 due to database restrictions.

psychiatric condition, depression. Eleven were neurotypical according to available information.

Most calendar calculators (76.2 %) either met the full diagnostic criteria for autism or exhibited at least one characteristic pertaining to the autistic phenotype. Consistent with the previous conclusions of O'Connor and Hermelin (1988) and Heaton and Wallace (2004), some calendar calculators did not fall within the autism spectrum, but most of them explicitly exhibit autistic features or other neurodevelopmental disorders.

4.2. Sex ratio

Of the 105 calendar calculators, 95 were male (90.5 %) and 10 were female (Appendix 1), resulting in an estimated male-to-female ratio of 9:1. This ratio is higher than that observed in savant syndrome, which is known to have a predominance of males over females (Bennett and Heaton, 2012; Hill, 1977), with an estimated ratio of approximately 7:1 (Itzchak et al., 2013). When the analysis is restricted to the 80 calendar calculators with at least one feature of autism, the male-to-female ratio increases to 16:1.

This ratio is significantly higher than what is typically observed in the autistic population, where the male-to-female ratio is approximately 4:1, or even lower in recent estimates (3:1) (Loomes et al., 2017). These findings suggest that the male predominance among calendar calculators may exceed that observed in autism and, to a lesser extent, savant syndrome in general.

4.3. Age at testing

At the time of testing, the ages of the 91 participants with available information ranged from 5 to 68 years, peaking between 21 and 25 years (median = 25; interquartile range = 18) (Fig. 3).

5. General cognitive performance of calendar calculators

5.1. Intellectual quotient (IQ)

Various instruments were used across studies to document the participants' intellectual profiles (Appendix 1), allowing for the extraction of Full-Scale IQ (n = 79), Verbal IQ (n = 59) and Non-Verbal IQ (n = 65). For the six participants who underwent repeated testing across multiple studies and obtained different results, only the most recent result was considered. Thirty-three participants (41.8 % of participants for whom data was available) obtained standard scores that positioned them below the 2nd percentile rank compared to their reference group for Full-Scale IQ (Standard score < 70, exceptionally low score; Fig. 4). Low intelligence quotient was neither an obstacle nor a prerequisite for achieving CC (Dorman, 1991; Heavey et al., 2012; Ho et al., 1991; O'Connor and Hermelin, 1988). However, CC accuracy showed a positive correlation with IQ ($r = 0.78$; $p < 0.01$) when specifically evaluated in 10 calendar calculators (O'Connor et al., 2000). Reaction times (RT), on the other hand, did not show any correlation with IQ in the two studies that evaluated it (O'Connor and Hermelin, 1984; O'Connor et al., 2000), nor with the range of years for which CC was possible (O'Connor et al., 2000). These results are based on standardized test which may not accurately reflect fluid intelligence or domain-specific skills (Mackintosh, 2011). The choice of verbally loaded assessment instruments may also significantly reduce scores (Courchesne et al., 2019).

5.2. Language skills

A total of 63 calculators were described in terms of their language and literacy skills (Table 1; Supplemental- Table 3), which included language development, expressive and receptive language, reading skills, writing skills, and interest in written material. Language skills appear as variably related to CC skills. The language level of calendar calculators displays the large range of levels observed in the autism spectrum, from speech onset delay, persisting or not in adulthood, to precocious and excellent verbal skills in reading or writing. However, these results must be interpreted in the context of many autistic participants (or with autistic features) of different ages, for which language skills are themselves very heterogeneous (Vogindroukas et al., 2022). It is therefore not possible to define a specific, central trend among the calendar calculators.

5.3. Memory skills

Information on memory skills was available for 68 calculators (Table 1; Supplemental- Table 3). While memory for general information evaluated with standard test is heterogeneous among participants, date-related or facts memory (specific structured information) is widely

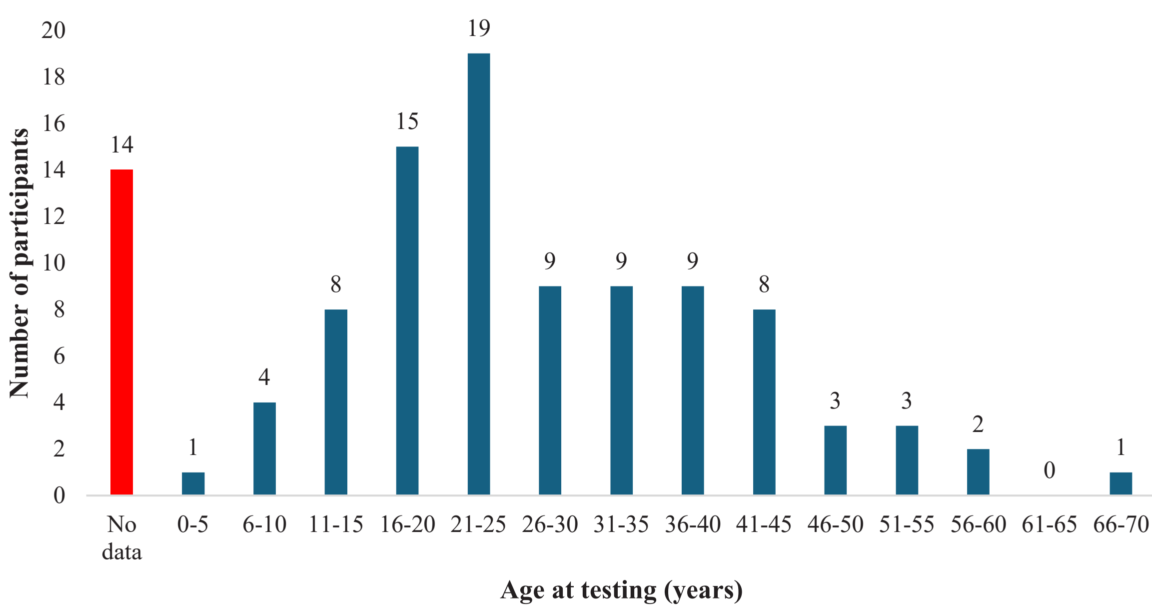
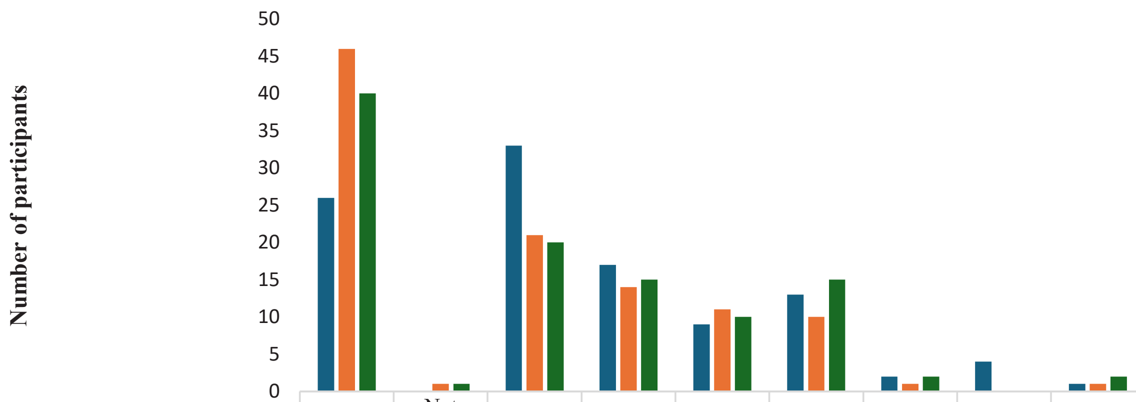


Fig. 3. Number of participants by age group at testing.



Standard Score	No data	Not testable	< 70	70-79	80-89	90-110	111-119	120-129	≥ 130
Full-Scale (n = 105)	26	0	33	17	9	13	2	4	1
Verbal Scale (n = 105)	46	1	21	14	11	10	1	0	1
Non-Verbal Scale (n = 105)	40	1	20	15	10	15	2	0	2

Fig. 4. Score for intellectual assessment *Note.* Classification follows the guidelines set by the American Academy of Clinical Neuropsychology Consensus (Guilmette et al., 2020). Standard Score Labels: <70: Exceptionally low, 70–79: Below average, 80–89: Low average, 90–110: Average, 111–119: High average, 120–129: Above average, ≥130: Exceptionally high.

reported (50.5 %; Supplemental- Table 3). It appears that proficient memory skills are not a prerequisite for executing CC since 10.5 % of calendar calculators obtained low score or less at standardized memory tests but still manage to show exceptional CC skill (Table 1).

5.4. Arithmetic skills

Quantitative or qualitative information on arithmetic skills was available for 66 calculators (Table 1; Supplemental- Table 3), ranging from basic arithmetic operations (addition, subtraction) of increasing levels of complexity (multiplication, division) to more abstract numerical reasoning and advanced calculations. Arithmetic skills specific to CC may easily go unnoticed through standardized tests and numerical competence itself could be specific to the calendar context (Horwitz et al., 1965, 1969). However, the correlation between arithmetic proficiency and calendar calculation performance (range, accuracy or RT) appears to be non-existent (O'Connor et al., 2000). Being an expert in mathematics is thus not a prerequisite for CC.

5.5. Other special skills

Information regarding other special skills was available for 84 of the 105 participants (Table 1; Supplemental- Table 3). The presence of at least one other special skill appears as the rule rather than the exception (62.9 %), more specifically related to the memorization of specific information (Table 1).

6. Development and behavioral correlates of CC

6.1. Age of awareness for family or caregivers

For eight participants, information on the age at which CC skills were noticed was imprecise, indicating adolescence (Cowan and Carney, 2006; Dorman, 1991; Nelson and Pribor, 1993; Sevik et al., 2010; Shields-Wolfe and Gallagher, 1992) or school age (Moriarty et al., 1993; Nurcombe and Parker, 1964; Young and Nettelbeck, 1994; Young, 1995) (Appendix 1). Among the 50 calculators for whom quantitative data were available, the age of discovery of the skill ranged from 4 to 58 years, with a peak between 6 and 10 years of age (median = 9.5; interquartile range = 6.25) (Fig. 5).

When reported retrospectively, age of onset may be plagued by backward or forward telescoping bias (Johnson and Schultz, 2005). Also, the estimated age of onset of CC reported by a third party is not necessarily representative of the actual time of onset, as it may have gone unnoticed. Despite these limitations, results suggest that a substantial proportion of calculators master their skill as early as school age.

6.2. Mode of acquisition of the skill

Qualitative data provided by the participant (n = 13), by a member of their entourage (n = 15) or an unknown source (n = 17) regarding the history of acquisition and development of CC were reported for 45 participants (42.9 %; Supplemental- Table 4). Twenty-one individuals (20 %) acquired their skill independently, without external assistance. For 22 calendar calculators (21 %), it was explicitly reported that their skill was discovered accidentally by another person. Only two calendar calculators (1.9 %) mentioned learning a mathematical formula; notably, these individuals were high-level, non-autistic mathematicians. Despite their inconsistent precision, retrospective nature, dependence on conjectural event, risks of bias and of being non-systematic, these data indicate that the CC skill is dominantly developed spontaneously, without pressure or prompts by the participant's familial or professional context.

6.3. Skill development over time

Only two studies have tackled the question of CC trajectory over time (Cowan et al., 2004; Iavarone et al., 2007). L.E was assessed at the age of 18 and at the age of 28 (Iavarone et al., 2007). The follow-up assessment confirmed the persistence of CC competence, with success rates and RT comparable to those documented a decade earlier. JF and CF were assessed at the ages of 7 and 9 (Cowan et al., 2004). Neither calculator improved over time. Indeed, although JF was faster (13 s to 11 s), his accuracy slightly decreased (76–71 %). For CF, both speed and accuracy decreased (11 s to 21 s and 79–65 %). The paucity of these results does not allow us to generalize about the evolution, or the necessary conditions for the persistence of CC over the years.

6.4. Interest in calendrical materials

The manifestations of an interest in calendrical material were specified for 29 participants (27.6 %; Supplemental- Table 3). They

Table 1
General cognitive performance of calendar calculators by thematic.

Language skills		N
Delays in language acquisition		20
Typical language development		7
Echolalia during development		3
Echolalia at the time of evaluation		9
Expressive and/or receptive language difficulties at assessment		13
Language skills within the average range at assessment		3
Communication difficulties		1
Excellent language skills		1
Unable to read when old enough to read		2
Read with difficulty compared to the norms for their age		27
Read fluently compared to the norms for their age		13
Excellent reading compared to the norms for their age		1
Difficulty with handwriting compared to the norms for their age		4
Average writing skills compared to the norms for their age		9
Excellent writing skills		1
Interest in written material in early childhood		8
Memory skills		**N**
Digit Span subtest of the Weschler Scale	Exceptionally low score	2
	Below average score	2
	Low average score	7
	Average score	13
	High average score	4
	Exceptionally high score	2
Unspecified poor results at memory test		1
Unquantified above-average performance		4
Variable outcomes depending on the instrument		2
Tested general memory skills were reported to be lower than would be predicted by their memory skills related to their respective personal interests		11
Excellent memory regarding episodic or semantic date-related information	Autobiographical events	17
	Celebrity birth or death dates	14
	Weather linked to specific dates	6
	Historical events	4
	Sports statistics	4
	TV programs or statistics	4
Excellent memory facts related to other domains of interest	Transportation schedules or numbers	5
	Musical information	4
	Road maps	2
	Lottery numbers	2
	Religious texts	1
Arithmetic skills		**N**
Arithmetic subtests of either the Wechsler Scale or the Wide Range Achievement Test	Exceptionally low score	10
	Below average score	5
	Low average score	6
	Average score	8
	High average score	3
	Exceptionally high score	2
Unable to perform basic addition or subtraction		2
Basic arithmetic skills with digits 0–9		10
Basic counting and simple addition		6
Perform arithmetic at a level expected from their overall functioning but struggled to apply these same skills in problem-solving		2
Performed well only in calendar-related addition		1
Excelled in subtraction, particularly in date-related problems		1
Unexpectedly strong mathematical skills given their overall level of functioning		8
Identified as mathematical experts with advanced skills		5
Other Special Skills		**N**
At least one additional special skill		66
Specific memory special skill		53
Arithmetic special skill		10
Absolute pitch		9
Proficiency in drawing		7
Hyperlexia		6
Special skill related to handwriting and/or letters		4
Synesthesia		1

Note. See Supplemental Table 3 for the reference associated to each thematic result.

displayed either a frequency of calendar consultation that exceeded typical expectations, or a duration of engagement with calendar material that surpassed what is typically anticipated by the authors. This information was scarce, mostly cross-sectional and limited to the testing period.

6.5. Introspective information by calendar calculators on their skill

Introspection is defined here as the participant's ability to describe the steps that led them to learn CC, or the cognitive processes they use to perform it. Data collection varied from study to study, from brief reports of introspective skill to responses to direct questions, up to in-depth questionnaires. Information about the introspection process was missing for 48 participants (46 %). Twenty-six individuals (25 %) showed no capacity to describe their cognitive processes (Supplemental- Table 5). Among the 31 calendar calculators (29 %) that were able to provide varying levels of information related to their skill, descriptions were varied (Supplemental- Table 5). The most frequent theme (n = 15) was variable knowledge of calendar rules. The paucity of information provided by calendar calculators about the mechanisms that made their skill possible cannot be entirely explained by their limited ability to communicate, since even calculators with excellent communication skills (e.g., Benoit et al., 1965; Parker et al., 2006; Wallace, 2006) could not provide it in detail. In sum, even if knowledge of calendar rules seems useful for some, CC is not the result of a widely shared explicit mathematical strategy. For those who manage to provide some insight, it remains general, unspecific and doesn't enable us to understand all the mechanisms involved.

7. Empirical findings on CC

7.1. Question types

The cardinal question in the calendar calculation asks to identify the day of the week that corresponds to a given month, day (date), and year. (for example, what day was May 12, 1978). This type of question generally follows the same format and has only one correct answer, chosen from the finite set of the seven days of the week. All the participants included in this review were able to answer this type of question.

There are also reverse questions that allow one or more correct answer. The answer could be a year, a month, or a day, depending on the question. They can take a variety of formats, such as: "In which years does March start on a Thursday?", "In which months of 2029 does the 17th fall on a Tuesday?", or "What is the date of the 3rd Tuesday in April 2017?". Another type of reverse question consists of presenting a partial calendar structure with the corresponding year missing and asking participants to identify the correct year. Thirty-nine calendar calculators (37.1 %) could answer one of these reverse question types (Appendix 1). This does not imply that other calendar calculators were unable to answer reverse questions but rather that this type of question may not have been explored or described.

7.2. Range

For 88 participants (83.8 %), information about their total range was indicated (Appendix 1), but for 30 participants, only the overall range was specified, without indicating whether their performance extends to past and/or future dates (Supplemental- Table 6). Reported ranges are represented in Table 2 (see also Supplemental- Table 6).

49.5 % of the participants display a total range under 100 years, but still 34.3 % had a range beyond 100 years (Table 2). It is more common to observe a greater range for the past than for the future than the opposite (45.7 % vs. 7.6 %). However, in the absence of a standardized procedure for evaluating CC, available data do not necessarily reflect the actual limits of each participant, but rather those imposed by the authors.

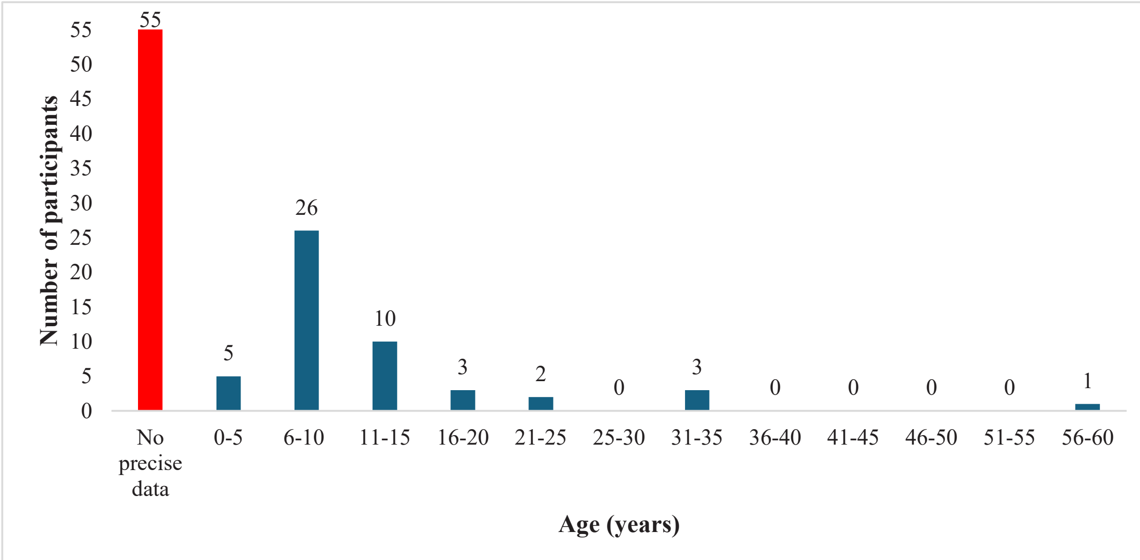


Fig. 5.. *Age of CC Awareness Reported.*

Table 2
Calendar calculators range.

Range result	N
Unknown Range	16
Total range	
Total range under 100 years	52
Total range beyond 100 years	36
Past range	
Past range under 100 years	47
Past range beyond 100 years	10
Unable to answer simple questions on past dates	1
Future range	
Future range under 100 years	28
Future range beyond 100 years	7
Unable to answer simple questions on future dates	22
Differential range	
Greater range for the past than for the future	48
Greater range for the future than for the past	8
Equal ranges for the past and the future	2

Note. See Supplemental Table 6 for the reference associated to each thematic result.

7.3. Distance effect

The distance effect refers to the increase in RT as the temporal distance between the given date in question and the current date increases. The distance effect does not appear to be a feature common to all calendar calculators and it is not consistently represented (Table 3; Supplemental- Table 7). The presence of the distance effect is often noted, but its complete absence in some calendar calculators does not allow this component to be included in a generalizable model.

Table 3
Distance Effect.

Result	N
Mean RT tended to be slower for future dates than for past dates	3
RT varied significantly with remoteness regardless of whether the date was in the past or the future	5
RT significantly increased as dates moved further into the past, but effect not found for future dates	6
RT increased with distance for future dates, but not for past dates	2
RT faster for distant dates in future, but no significant effect on RT for past dates	1
Distance effect reported only qualitatively, precluding conclusions on their significance	7
No significant effect on RT according to remoteness of the date	2

Note. See Supplemental Table 7 for the reference associated to each result.

7.4. Priming effect

The priming effect (Hermelin and O'Connor, 1986) is a way of empirically testing the use of structural regularities of the calendar to produce a correct response. In a non-leap year, according to calendar rules, November-March, February-March, April-July, September-December, and January-October share the same structure: the day of the week associated with April 2, 2023, and July 2, 2023 will be the same, here Sunday. RT should then be faster for dates asked consecutively following other dates with structural similarities (e.g., the same template or day of the week, leading to the same response) compared to unrelated dates. Fifteen participants (14.3 %) showed an RT gain attributed to this priming effect, five participants showed no significant difference, and three participants obtained longer RT in priming effect task (Supplemental- Table 7). Consequently, while it is heterogeneous and not consistently studied, and despite the absence of standardized methodologies between studies, the priming effect demonstrates the relatively common, but nonexclusive use of calendar regularities in solving calendar problems.

7.5. Error patterns

Calendar calculators can exhibit errors in their performance, and some are systematic. For instance, D (Barnejee, 1975) made no errors regarding dates in the 20th century but gave the same –erroneous- answers for the previous century without considering that the calendar model is not the same (gradual transition from the Julian to the Gregorian calendar). As a result, the answers provided were always out of sync, but all errors had a systematic pattern: always staggered according to the previous year's calendar. René (Benoit et al., 1965) consistently provided responses systematically shifted by 10 days by failing to account for the transition from the Julian to the Gregorian calendar beyond the year 1582. DM (Cowan and Carney, 2006) reported that he was subtracting 700 years to an anchor date to find the response, whereas he should have been subtracting multiples of 400 instead. Two participants (O'Connor et al., 2000) consistently produced erroneous responses by one day earlier in the 19th century, two days earlier in the 18th century, and one day later in the 22nd century. Similar errors were reported for five calendar calculators (Howe and Smith, 1988; Iavarone et al., 2007; Patti and Lupinetti, 1993; Rubin and Monaghan, 1965; Smith and Howe, 1985; Thioux et al., 2016). Other types or systematic errors were found when analyzing the distance between the erroneous response and the correct response in group analysis (n = 8; O'Connor and Hermelin, 1984).

Alternatively, DBC (Mottron et al., 2006) exhibited errors that did not show consistent patterns across the calendar structure. The random nature of these errors was also observed in Ned and Tim (Rosen, 1981); however, the infrequency of errors compromised the reliability of this observation. Inconstancy of errors across testing sessions is informative on the mechanism of non-systematic errors. When questions previously answered incorrectly by DBC (Mottron et al., 2006) were reintroduced in subsequent sessions, errors were not consistently reproduced. Error correction capabilities are also informative on the "low" (e.g.: attentional) vs "high" (e.g.: computational) nature of errors. Upon receiving feedback indicating an incorrect answer, a participant (Heuyer and Badonnel, 1928) subsequently provided the correct answer, suggesting a non-computational origin of the initial error, meaning it was not due to a high-level problem, but rather to a distraction or a memory error.

Some specific errors are informative on the way certain calendar answers are produced. Easter falls on a Sunday between March 22 and April 25, but its exact date is determined by lunar cycles, independently of calendar rules, regularities, or algorithm. Recalling past Easter dates depends exclusively on episodic memory, and producing future Easter dates requires some exposure to calendars of the years for which the question is asked. FB (De Marco et al., 2016) demonstrated a 90 % success rate in recalling Easter dates he had previously experienced but showed a 0 % success rate for predicting future Easter dates. FB explicitly stated that it was impossible for him to determine future Easter dates and attributed the two mistakes he made for past Easter dates to his young age at the time of those events. Participant AJ (Parker et al., 2006), when asked to recall all the past Easter dates, successfully recalled 24 dates, with only one error. Additionally, she spontaneously provided autobiographical details associated with these dates.

8. Imaging studies

Imaging studies have investigated brain regions implicated in calendar calculation via PET, fMRI, MEG, and SPECT, using both within- and between-subject designs, often in very small case series (Table 4).

In its current form, the existing literature is too heterogeneous and not substantial enough to draw firm conclusions about the structural and functional networks involved in CC. Further complexity is added by work so far not clearly dissociating effects of CC from those of a co-occurring clinical diagnosis of autism. This distinction remains particularly challenging in the context of CC, given that the presence of this skill remains less common among participants without clinical conditions. Although neurotypical participants represent 10.47 % of calendar calculators documented in the literature, they still account for 35.71 % of imaging studies. Autistic calendar calculators constitute most participants included in imaging studies, representing 64.29 %. More specifically, two studies compared the regions activated during calendar calculation between autistic participants and neurotypical participants (Dubischar-Krivec et al., 2014; Fehr et al., 2011). The activation patterns were not the same, suggesting different ways of proceeding. However, his results do not rule out the possibility that intra-group comparisons could also reveal differences in activation, which could indicate that each person, regardless of their clinical condition, may have their own strategy. Moreover, functional interpretations may depend on the choice of specific control conditions (e.g., arithmetic, word repetition, rest) and/or the choice of specific control groups, which may have differed across the different studies.

Taken together, however, there is some support for broad activation of regions implicated in memory processes, visuo-spatial function, as well as control and arithmetic processes supported by fronto-parietal systems during CC. These results suggest a synergistic effect of these different cognitive network processes during CC, particularly for more remote dates.

9. Discussion and Conclusion

Our knowledge of calendar calculation comes mainly from individual studies of people in early adulthood with a clinical observation component and from empirical studies with varying quality. This literature still allows us to identify several informative characteristics, which will need to be further tested.

Clinically, most calculators present an affiliation with the autistic spectrum to varying degrees, but the predisposing factors for an autistic person to develop it are unknown. Calculators consistently have a higher male to female sex ratio than the autism spectrum as currently defined.

At the general cognitive level, low intelligence is neither an obstacle nor a condition for the realization of calendar calculation. Intelligence, language, memory and arithmetic skills encompass a large range of levels, both within and between calendar calculators. The variability of levels attained by each calculator in these functions precluded an explanation of their savant skill by their overall deficit, or, on the opposite, a general superiority of a psychological function. Calendar calculation is associated with specific skills in certain domains in language, memory, and arithmetic, but these are always superior in the domain of interest in comparison with those achieved in other domains of application. A focus on calendar-based materials and other structured stimuli (e.g. arithmetic) through other special skills is not rare. Most calculators have other intense interests and special skills than calendar calculation, especially in terms of memory.

Information on the development of the skill is limited, either on its emergence or on its transformations: information on the development of the skill is minimal. The skill is however mostly revealed at the beginning of school age, but we do not know when exactly it starts to be learned. The discrepancy between the reported ages of discovery and assessment makes it difficult to obtain comprehensive data on the development and progression of these skills. When some introspective description of their methods is available, the use of calendar knowledge and rules among the participants was the most reported. The skill is acquired independently by 20 % of participants, without external assistance and does not seem to be associated with other learning processes detectable by an entourage than an interest and a prolonged inspection of calendars or by the introspection of the participant.

Multidirectional access to calendar information, demonstrated by reverse questions when those have been asked, has been frequently observed. Most calendar calculators can compute both future and past dates, though generally within a range of less than 100 years, but this span may be underestimated by investigators. The distance effect, longer response time or lower accuracy when moving away from the present date, is not consistently found. The priming effect, when found, shows a non-exclusive use of calendar regularities to solve calendar problems. Calendar calculators can exhibit errors in their performance, some are systematic, some not. Distance effect, priming effect, and systematic errors are each found in a subset of participants reflecting the heterogeneity in participants' performance.

The lack of methodological rigor and the absence of a standardized procedure result in a broad but imprecise understanding of calendar performance. Clinical, practical and methodological issues complicate the collection and interpretation of RT and errors. Regarding RT, incidental variation of the participants' mood and testing compliance may require "cleaning" the data to select those possibly informative, which may be arbitrary, biased, and is not usually done. Qualitative reporting or an insufficient number of trials, preclude the study of significance to guide interpretation. Some calculators are questioned orally, through a screen, or using printed material, which modifies RT. Regarding error studies*:* while the nature of the errors should provide insight into the processes used, not all errors should be counted similarly. Errorless responses are exceptional and limited to certain years. Stability or

Table 4
Main Result in Imaging Studies.

Case (Reference)	Clinical Description	Methodology	Result	Main Conclusion
Case (Boddaert et al., 2005)	Autism	PET and a within-subject experimental design. CC activity for past dates was compared to a resting baseline, including images of five "normal controls" in the resting model and a word repetition control task.	Compared to rest, the CC task activated left inferior, middle and precentral frontal cortex, left anterior cingulum, left superior and middle temporal areas and left hippocampus, and the word repetition task activated left frontal, left temporal and right precentral and postcentral frontal cortex. Compared to the word repetition control task, the CC task induced an activation of the left hippocampus, the left middle temporal gyrus and the left inferior frontal gyrus.	Implication of memory processing.
GC (Cowan and Frith, 2009)	Autism	fMRI brain activity during a mental arithmetic task compared and a CC task.	Mental arithmetic task and CC task revealed a similar pattern of parietal activation. The CC task also activated the premotor cortex, supplementary motor area and left inferior temporal cortex.	Implication of the same regions during arithmetic and CC task.
GC (Cowan and Frith, 2009)	Autism	fMRI brain activity during CC tasks involving close, medium, and remote dates, compared to that of a basic, non computation control calendar task.	Compared to the control task, the CC task activated a bilateral parietal region, with activations increasing with date remoteness.	The parietal activation found in both participants was the same activation found in the arithmetic task in both GC and the control participant.
MW (Cowan and Frith, 2009)	Autism			
ASDCC 1 (Dubischar-Krivec et al., 2014)	Autism	MEG source imaging. CC task involving past, present and future dates were compared between autistic (n = 3) and neurotypical (n = 3) calendar calculators.	The neurotypical group exhibited overall greater activity than the autistic group, and maximal brain activity in right superior medial frontal, right insula, left superior temporal, left paracentral lobule, left middle frontal, left precentral, left cerebellum, right calcarine gyrus, right frontal and right hippocampus. Individually, ASDCC 1 had maximal brain activity in right putamen, right superior frontal, left middle frontal, left insula, right superior temporal, right lingual gyrus and left superior temporal; ASDCC 2 in right superior occipital gyrus, left fusiform gyrus, right superior medial frontal, left calcarine gyrus, left superior temporal, left and right insula; ASDCC 3 in left medial frontal, left middle frontal, right precuneus, right postcentral gyrus, right superior medial frontal, left superior temporal and left lingual gyrus.	Patterns activation of TYPCC and ASDCC revealed network associated with verbal fact retrieval and working memory. Additionally, patterns activation of ASDCC revealed network associated with automatic and practised behavior, and with visual area.
ASDCC 2 (Dubischar-Krivec et al., 2014)	Autism			
ASDCC 3 (Dubischar-Krivec et al., 2014)	Autism			
TYPCC 1 (Dubischar-Krivec et al., 2014)	No features of autism			
TYPCC 2 (Dubischar-Krivec et al., 2014)	No features of autism			
TYPCC 3 (Dubischar-Krivec et al., 2014)	No features of autism			
CD (Fehr et al., 2011)	Autism	fMRI brain activity of an autistic savant compared to that of a mathematical expert explicitly using algorithms, while performing a visually presented past and future CC task and a control task.	In CD, left frontal, bilateral parietal and occipital, right thalamic, right cerebellar regions, cingulate gyrus and left insula were more activated by past and future calendar tasks than in control task. For future calendar task compared to the control task, additional activations were observed in the left superior and middle frontal gyrus, right middle occipital gyrus, left cuneus, right lingual gyrus, bilateral superior and left middle temporal gyrus, left inferior temporal gyrus, bilateral hippocampus and right caudate. Overall CD activated a distinct, and more widely distributed brain network than the mathematical expert. In AB, left inferior frontal, left inferior parietal regions, and right precuneus were more activated by past and future calendar tasks compared to control task. Future dates recruited additional activation in bilateral middle frontal, right postcentral and bilateral superior parietal regions. Past dates recruited additional activation in the right inferior temporal gyrus.	The two participants showed different patterns. CD recruited area related to visual processing and implicit processing. For CD, past dates recruited more area related to memory processing and future dates recruited more diffuse neural area. AB recruited area related to mental calculation.
AB (Fehr et al., 2011)	No features of autism			
YV (Minati and Sigala, 2013)	No features of autism	fMRI brain activity patterns during CC task comparing close and remote dates and a division task to a numerical control task.	Close dates activated more cuneus, right parahippocampal gyrus and left medial temporal lobe, while remote dates activated more cingulate, postcentral gyrus, precuneus, middle and inferior frontal gyri. Greater prefrontal activation was observed for YV, only for distant dates, which, according to the participant require the application of one additional step to his algorithm. Regions like that of the CC task were activated more	Implication of memory processing and arithmetic processing.

(*continued on next page*)

Table 4 (*continued*)

Case (Reference)	Clinical Description	Methodology	Result	Main Conclusion
			strongly during the division task than the numerical control task.	
ND (Sevik et al., 2010)	Autism	fMRI brain activity during a memory CC task.	Task activity was increased relative to rest in the inferior parietal lobule bilaterally, precuneus, superior and middle frontal gyri and medial frontal cortex.	Memory processing
MW/GW (Wallace et al., 2009)	Autism	Structural MRI analyses to compare cortical thickness in an autistic CC, to that of a control group (n = 14) matched by age and vocabulary.	Thinner cortex for MW/GW was observed in bilateral superior frontal gyrus, medial prefrontal cortex, left primary motor/ precentral gyrus and left middle temporal gyrus regions compared to the control group. Conversely, thicker cortex was observed in bilateral portions of the superior parietal region.	Thinner regions were associated with social cognition. Thicker regions were associated with drawing, visuospatial processing and calculation skills.

instability of errors between sessions is relevant to disentangle systematic from random errors. Inconsistent, random, unpredictable errors suggest a low level, or noise process (e.g., attentional) when producing the answer. Systematic, constant errors suggest the misapplication (overgeneralization or ignorance) of calendar rules, i.e. a strict application of the structure without considering the possibility of exceptions, such as leap years or Gregorian leap. Only errors below chance level can be informative on processes, those above being only informative on range. Different processes are used to produce responses at different times, with varying success rates for each process. Lastly, RT and errors patterns should be interpreted conjointly in search of a speed-accuracy trade-off.

Imaging studies indicate the potential involvement of three neural networks: a memory, a visual and an arithmetic network. However, brain imaging studies produce knowledge a posteriori, with few initial hypotheses. In addition, the comparison group remains imprecise due to the special and rare nature of the capacity.

Future studies on CC would benefit from documenting in detail the exposure to calendar material, the development of verbal and decoding abilities, and the possible association with hyperlexic behaviors or other abilities, as well as documenting the prototypicality of the autistic phenotype when relevant. Some developmental and cognitive aspects of CC are virtually undocumented. The main gaps in our knowledge concern the circumstances triggering the development of CC, its temporal evolution, the stability of the range and errors over time, and its relation with perceptual skills. One of the main challenges in this area of research is the spontaneous emergence of CC abilities, which are often discovered by chance. Consequently, those close to the individual may lack relevant information about the phenomenon. Highlighting this unique ability helps raise awareness and sheds light on early indicators of its development, such as frequent manipulation or exposure to dates and calendars.

Because CC is not widely recognized, its actual prevalence may be higher than currently documented. This highlights the need for further research and a broader understanding of the phenomenon. On an empirical level, observing and quantitatively validating individual-specific behaviors—such as a strong interest in calendars—in relation to performance accuracy and the predictions of the most advanced models (e.g., Desrosiers et al., 2025) is essential.

Systematically identifying gaps in the literature can guide future research toward adopting more standardized methodologies and collecting more comprehensive data, similar to practices in other cognitive domains like language. In this context, developing a standardized assessment battery for CC would be a promising direction. Such a tool would help define the ability more precisely, particularly in terms of accuracy and response time. Standardized measurement would also facilitate comparisons between individual cases, which is especially valuable given the rarity of this ability. Moreover, standardization could enhance the impact and replicability of neuroimaging studies. Future research might also explore the genetic and genomic profiles of calendar calculators or examine post-mortem histological data to better understand the biological underpinnings of CC.

The majority of CC cases are based on single-case reports or small case series, sometimes with heterogeneous clinical profiles. The results obtained by a single participant may not be generalisable to the entire Calendar Calculator population, nor to autism more broadly. The scientific value of these results depends on whether the phenotypes of autistic savants are similar to those of autistic individuals to whom certain abilities may be generalised. A compelling example is hyperlexia: although only a limited number of cases have been formally published (Ostrolenk et al., 2017), research has shown that this ability manifests as a specific interest in a significant proportion of the typical autistic population (Ostrolenk et al., 2024). This highlights the possibility that rare abilities may be more prevalent than documented and emphasises the importance of ongoing research using standardised methods and broader data collection.

The uniqueness of CC comes from the constraints of autism, and those linked to calendar material, not primarily to the cognitive functions used to master it. Calendar questions are the means of knowing that someone has this knowledge, but this knowledge does not happen for this purpose. Calendar calculators do many other things with calendars than answer questions, such as contemplating them, completing them, copying them, using them to structure episodic information, and overall take pleasure in their manipulation. Thus, under optimal conditions (e.g., exposure to structured material, unrestricted manipulation of material), the autistic brain can achieve CC. Even in the presence of an intellectual potential considered lower by standardized instruments, the autistic brain can develop very specific special abilities. CC may in fact be just one example of optimal learning in autistic individuals, demonstrating the importance of providing autistic individuals with adapted learning contexts that allow them to reach their full potential.

Understanding CC in the context of autism is intimately related with our understanding of autistic children processing of structured information, why some types of information are objects of interest, and to which extent their perception of the world differs from that of non-autistic people.

Funding

This work was supported by a CIHR (Canadian Institutes of Health Research) Master's award to JD (2022), a FRQS (Fonds de recherche du Québec) doctoral training award to JD (2025-2028; 341207), and by the Chaire de Recherche Marcel et Rolande Gosselin en neurosciences cognitives de l'autisme de l'Université de Montréal (E-2-8) held by LM.

Declaration of Competing Interest

None.

Acknowledgments

We thank Audrey Cote and Angela Clermont for providing research assistance. We also thank Dr Olivier Lafrance Mc Guire for providing his clinical judgment on the case descriptions. We thank Michelle Dawson for providing feedback.

Appendix 1

Table 1
characteristic of calendar calculators

Case	Author (Publication date)	Age at testing	Sex	FSIQ (VIQ, PIQ)	Diagnosis or clinical description**	Reported onset of CC	Question type	Range total (past range, future range)
1/H.P.	Heavey (1996)		M	u* (80[e], 102[a])	Autism	7	Simple	200 (u*, u*)
	Heavey et al. (2012)	30		u* (80[e], 102[a])				
3/R.D.	Heavey (1996)		M	u* (64[e], 73[a])	Autism	9	Simple	99 (99, 0)
	Heavey et al. (2012)	27		u* (64[e], 73[a])				
5/J.P.	Heavey (1996)		M	u* (44[e], 58[a])	Autism	17	Simple	170 (u*, u*)
	Heavey et al. (2012)	28		u* (44[e], 58[a])				
7/P.M.	Heavey (1996)		M	u* (55[e], 58[a])	Probable autism	17	Simple	170 (u*, u*)
	Heavey et al. (2012)	44		u* (55[e], 58[a])				
8/P.E.	Heavey (1996)		M	u* (78[e], 108[a])	Autism	13	Simple	180 (u*, u*)
	Heavey et al. (2012)	43		u* (78[e], 108[a])				
AB	Fehr et al. (2011)	35	M		No features of autism		Simple	1300 (700, 600)
Adam	Bicakci et al. (2021)	25	M	90[d] (101[d], 76[d])	Autism	22	Simple	508 (182, 326)
AJ	Parker et al. (2006)		F	93[d] (96[d], 91[d])	Features of autism	8	Simple	31 (31, 0)
A.M.	Patti (1994)	20	M	48 [g]	Autism		Simple Reverse	11 (u*, u*)
A.P.	Abhyankar et al. (1981)	32	M	75[b]; 90[c] (u*, average[a])	Features of autism	11	Simple Reverse	99 (81, 18)
AT	Heavey (1996)		M	u* (Not testable[a], 51[e])	Autism	13	Simple	99 (u*, u*)
Autistic Savant Subject 1	Malkoff (1982)	20	M	94[k] (96[k], 100[k])	Autism		Simple	50 (50, 0)
Autistic Savant Subject 5	Malkoff (1982)	20	M	83[k] (84[k], 76[k])	Autism		Simple	132 (132, 0)
B	Hill (1975)		M	54 [h]	No features of autism		Simple	26 (26, 0)
BB	Mazzoni et al. (2019)	20	M	In the top 90th percentile[d]	No features of autism		Simple	u* (u*, u*)
	De Marco et al. (2021)							
BL[1]	O'Connor and Hermelin (1984)		F		Autism	17	Simple Reverse	85 (85, 0)
	Hermelin and O'Connor (1986)							
	O'Connor et al. (2000)			50[d] (51[d], 55[d])				
	Cowan et al. (2003)			50[d]				
BL[2]	Young and Nettelbeck (1994)	20	M	76[d] (74[d], 82[d])	Autism	Young age	Simple Reverse	315 (u*, u*)
	Young (1995)	20		76[d] (74[d], 82[d])				
C.A	Courchesne et al. (2020)	13	M	3[e] percentile[d] (u*, 13[e] percentile[a])	Autism	13	Simple	37 (18, 19)
Case	Boddaert et al. (2005)	22	M	66[d] (83[d], 45[d])	Autism	4	Simple	16 (16, 0)
Case 1	Otsuka et al. (1991)	17	M	70 (65, 96)	Autism		Simple	8 (8, 0)
Case 2	Otsuka et al. (1991)	16	M	84 (70, 102)	Autism		Simple	u* (u*, u*)
Case 3	Otsuka et al. (1991)	24	M	60 (72, 64)	Autism		Simple	22 (22, 0)
Case 4	Otsuka et al. (1991)	15	M	51 (u*, 66)	Autism		Simple	u* (u*, u*)
Case B- Arthur	Nurcombe and Parker (1964)		M	66[d] (75[d], 58[d])	Probable autism	Primary school	Simple	2 (1, 1)
CD	Fehr et al. (2011)	45	M		Autism		Simple	1300 (700, 600)
CF	Cowan et al. (2004)	6	M	141[f] (145[f], 133[f])	No features of autism	6	Simple	5 (5, 0)
Charles/A	Horwitz et al. (1965)		M		Probable autism	9	Simple	100 (u*, u*)
	Altshuler and Brebbia (1968)	28		58[d]				
	Horwitz et al. (1969)	24		Between 60 and 70[d]				
	Patti (1994)	51		66[d]				
Child 2	O'Connor and Hermelin (1992)	10	M	u* (91[e], 90[a])	No features of autism	5	Simple	48 (u*, u*)
CT	Young (1995)	30	M	72[d] (76[d], 70[d])	Autism		Simple	u* (u*, u*)
D	Barnejee (1975)	21	M	71[d] (72[d], 73[d])	Autism	9	Simple Reverse	98 (73, 25)
Dave/X	Smith and Howe (1985)	14	M	54 [f] 50 [h]	Probable autism		Simple Reverse	160 (85, 75)

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Table 1 (*continued*)

Case	Author (Publication date)	Age at testing	Sex	FSIQ (VIQ, PIQ)	Diagnosis or clinical description**	Reported onset of CC	Question type	Range total (past range, future range)
	Howe and Smith (1988)	14		54 [f] 50 [h]				
DB	Young and Nettelbeck (1994)	36	M	65[d] (65[d], 70[d])	No features of autism	8	Simple Reverse	107 (u*, u*)
	Young (1995)	36		65[d] (65[d], 70[d])				
D.B./TYPCC 1	Dubischar-Krivec et al. (2009)	34	M	124 [g]	No features of autism	33	Simple	100 (53, 47)
	Dubischar-Krivec et al. (2014)	38		124 [g]				
DBC	Mottron et al. (2006)	18	M	82[d] (74[d], 94[d])	Autism	12	Simple Reverse	18 (18, 0)
DG	Kennedy and Squire (2007)	T_1: 9 T_2: 13	M	52 [f] (58 [f], 53 [f])	Autism		Simple	u* (u*, u*)
DK/6	O'Connor and Hermelin (1984)		M		Autism	12	Simple Reverse	252 (u*, u*)
	Hermelin and O'Connor (1986)			u* (66[e], 76[a])				
	Heavey (1996)			u* (66[e], 76[a])				
	O'Connor et al. (2000)			74[d] (70[d], 82[d])				
	Cowan et al. (2003)			74[d]				
	Cowan and Carney (2006)							
	Heavey et al. (2012)	37		u* (66[e], 76[a])				
DM	O'Connor et al. (2000)		M	52[d] (59[d], 50[d])	Autism	13	Simple Reverse	203061 (u*, u*)
	Cowan et al. (2003)			52[d]				
	Cowan and Carney (2006)							
Donny	Thioux et al. (2006)	21	M	74[d] (81[d], 69[d])	Autism	5	Simple Reverse	9599 (1606, 7993)
DS	Young (1995)	25	M	86[d] (88[d], 88[d])	Autism		Simple	399 (u*, u*)
Enfant	Fauville (1936)	11	M	48 [h]	Probable autism		Simple Reverse	4 (0, 4)
Eugene Hoskins	Byrd (1920)	24	M		Features of autism		Simple Reverse	23 (19, 4)
FB	De Marco et al. (2016)	22	M	78[d] (81[d], 77[d])	Autism	22	Simple	50 (26, 24)
FC[1]	Young and Nettelbeck (1994)	42	M	76[d] (82[d], 72[d])	No features of autism		Simple	u* (u*, u*)
	Young (1995)	42		76[d] (82[d], 72[d])				
FC[2]	Bouvet et al. (2014)	21	M	68[d] (66[d], 76[d])	Autism	6	Simple Reverse	38 (20, 18)
GC/2	O'Connor and Hermelin (1984)		M		Autism	8	Simple	817296 (u*, u*)
	Hermelin and O'Connor (1986)							
	Heavey (1996)			u* (100[a], 79[e])				
	O'Connor et al. (2000)			97[d] (99[d], 94[d])				
	Cowan et al. (2003)			97[d]				
	Cowan and Carney (2006)							
	Cowan and Frith (2009)			97[d]				
	Heavey et al. (2012)	32		u* (100[a], 79[e])				
G.D.S.	Malhotra et al. (1973)	15	M	55 [f] (68 [f], 41 [f])	No features of autism	10	Simple	3 (2, 1)
George/B	Horwitz et al. (1965)		M		Probable autism	6	Simple Reverse	40300 (1865, 38435)
	Altshuler and Brebbia (1968)	28		67[d]				
	Horwitz et al. (1969)	24		Between 60 and 70[d]				
	Patti (1994)	51		73[d]				
GF	Young (1995)	53	M	75[d] (78[d], 74[d])	Features of autism	5	Simple	215 (u*, u*)
HP	O'Connor et al. (2000)		M	96[d] (97[d], 95[d])	Autism	8	Simple Reverse	11051 (u*, u*)
	Cowan et al. (2003)			96[d]				
JB/4	O'Connor and Hermelin (1984)		F		No features of autism		Simple Reverse	84 (84, 0)
	Hermelin and O'Connor (1986)							
	Heavey (1996)			u* (59[e], 48[a])				
	O'Connor et al. (2000)			60[d] (72[d], 49[d])				
	Cowan et al. (2003)			60[d]				
	Heavey et al. (2012)	47		u* (59[e], 48[a])				
JF	Cowan et al. (2004)	5	M	105 [f] (115 [f], 94 [f])	Probable autism		Simple	5 (5, 0)
JG	O'Connor et al. (2000)		M	54[d] (50[d], 65[d])	Autism	8	Simple Reverse	393 (u*, u*)
	Cowan et al. (2003)			54[d]				

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Table 1 (*continued*)

Case	Author (Publication date)	Age at testing	Sex	FSIQ (VIQ, PIQ)	Diagnosis or clinical description**	Reported onset of CC	Question type	Range total (past range, future range)
John	Hoffman (1971)	30	M	61 [g]	No features of autism	8	Simple	7 (6, 1)
Joseph	Gilmore and Hayes (1996)	17	M	80 [f] (77 [f], 85 [f])	Autism	8	Simple	156 (96, 69)
JS	Young (1995)	32	M		Autism		Simple	u* (u*, u*)
Kit	Ho et al. (1991)	19	M	75[d] (66[d], 91[d])	No features of autism	15	Simple Reverse	200 (85, 115)
L	Scheerer et al. (1945)		M	48 [h]	Probable autism	6	Simple Reverse	70 (u*, u*)
L.E	Iavarone et al. (2007)	18	M	48[d] (58[d], Lower than 45[d])	Autism		Simple	20 (10, 10)
Mark	Patti (1994)	42	M	68 [g]	Autism		Simple Reverse	2500 (u*, u*)
M.C.	Moriatry et al. (1993)	17	M	u* (79[d], 64[d])	No features of autism	From an early age	Simple	17 (17, 0)
Men	Sipowicz and Pietras (2017)	57	M	92[d]	Autism		Simple	u* (u*, u*)
MG/GW	Wallace (2006) Wallace et al. (2009)	42 42	M	100[d] (104[d], 98[d]) 100[d] (104[d], 98[d])	Autism	32	Simple Reverse	6787 (u*, u*)
MLG	Peru (2022)		F		Autism		Simple	45 (35, 10)
MR	Young (1995)	37	M	82[d] (88[d], 78[d])	Autism		Simple	u* (u*, u*)
M.R./ASDCC 1	Dubischar-Krivec et al. (2009) Dubischar-Krivec et al. (2014)	34 34	M		Autism	7	Simple	100 (53, 47)
Mr. A	Nelson and Pribor (1993)	44	M	31 [g]	Autism	Late teens	Simple	u* (u*, u*)
M.S./ASDCC 3	Dubischar-Krivec et al. (2009) Dubischar-Krivec et al. (2014)	18 24	M	110 [g] 110 [g]	Autism	5	Simple	100 (53, 47)
MW/Child 1	O'Connor and Hermelin (1992) Heavey (1996) O'Connor et al. (2000) Cowan et al. (2003) Cowan and Carney (2006) Cowan and Frith (2009)	10	M	u* (91[e], 92[a]) u* (76[e], 92[a]) 82[d] (79[d], 88[d]) 82[d] 82[d]	Autism	7	Simple Reverse	6606 (u*, u*)
Nat… Claude	Heuyer and Dauphin (1946)	22	M	70 [g]	Probable autism		Simple Reverse	50 (46, 4)
ND	Sevik et al. (2010)	18	M	93[d] (97[d], 89[d])	Autism	Last few years	Simple	300 (300, 0)
Ned	Rosen (1981)	25	M	79[d]	Features of autism	6	Simple	15 (15, 0)
Patient	Palo and Kivalo (1977)		F	34[j]	Probable autism		Simple Reverse	50 (u*, u*)
Patient	Hamatani et al. (2016)	40	M		Autism		Simple	u* (u*, u*)
Patient AC596	Olson et al. (2010)	25	M		Probable autism		Simple Reverse	58 (30, 28)
PE	O'Connor et al. (2000) Cowan et al. (2003)		M	94[d] (84[d], 108[d]) 94[d]	Autism	14	Simple Reverse	112 (u*, u*)
Peter	Pring and Hermelin (2002)	46	M	u* (78[e], 108[a])	Autism		Simple	300 (250, 50)
P.H./ASDCC 2	Dubischar-Krivec et al. (2009) Dubischar-Krivec et al. (2014)	37 38	M	124 [g] 124 [g]	Autism	10	Simple	100 (53, 47)
PM	O'Connor et al. (2000) Cowan et al. (2003)		M	58[d] (60[d], 62[d]) 58[d]	No features of autism	13	Simple Reverse	85 (85, 0)
Professor Conway	Cowan and Carney (2006)		M		No features of autism	Adolescence	Simple	817296 (u*, u*)
R[1]	Roberts (1945)		M	8 [g]	No features of autism		Simple	28 (28, 0)
R[2]	Rubin and Monaghan (1965)	16	F	51 [f]	No features of autism	10	Simple	7 (7, 0)
R.D.	Dorman (1991)	18	M	84[d] (81[d], 81[d])	No features of autism	Adolescence	Simple	25 (10, 15)
René	Benoit et al. (1965)	68	M	u* (93[d], not testable[d])	Probable autism	58	Simple Reverse	543 (383, 160)
Richard	Patti (1994)	37	M	67 [g]	Autism		Simple Reverse	5000 (u*, u*)
RN	Kennedy and Squire (2007)	33	M	104[d] (98[d], 114[d])	Autism		Simple	u* (u*, u*)
R.P./TYPCC 2	Dubischar-Krivec et al. (2009)	56	F	112 [g]	No features of autism	33	Simple	100 (53, 47)

(*continued on next page*)

Table 1 (*continued*)

Case	Author (Publication date)	Age at testing	Sex	FSIQ (VIQ, PIQ)	Diagnosis or clinical description**	Reported onset of CC	Question type	Range total (past range, future range)
	Dubischar-Krivec et al. (2014)	57		112 [g]				
Rudiger Gamm	Pesenti et al. (1999)	24 à 26	M	u* (u*, 110[a])	No features of autism		Simple	u* (u*, u*)
	Pesenti et al. (2001)	26						
R.W.	Puente et al. (2016)	33	M	u* (57[d], 57[d])	Features of autism		Simple	110 (110, 0)
Sam	Goodman (1972)	6	M	37 [h] (u*, 86[i])	Autism		Simple	6 (5, 1)
Sch… Léonide	Heuyer and Badonnel (1928)	12	M		Probable autism	10	Simple Reverse	51 (38, 13)
Shakuntala Devi	Jensen (1990)		F		No features of autism		Simple Reverse	u* (u*, u*)
S.M.	Patti (1994)	42	M	67 [g]	Autism		Simple Reverse	70 (u*, u*)
S.S.	Patti (1994)	30	M	42 [g]	Autism		Simple Reverse	50 (u*, u*)
Subject	Burling et al. (1983)	24	M	53[d] (51[d], 60[d])	No features of autism		Simple	u* (u*, u*)
T.H.	Patti (1994)	31	M	48 [g]	Autism		Simple Reverse	u* (u*, u*)
Tim	Rosen (1981)	36	M	97[d]	Probable autism	6	Simple	15 (15, 0)
T.J.	Patti (1994)	24	M		Autism		Simple Reverse	20 (u*, u*)
TM	Young and Nettelbeck (1994)	22	M	72[d] (67[d], 78[d])	Autism		Simple Reverse	107 (u*, u*)
	Young (1995)	22		72[d] (67[d], 78[d])				
TMK	Hurst and Mulhall (1988)	38	M	71[d] (68[d], 78[d])	Autism		Simple	117 (94, 23)
TS	Young (1995)	48	M	84[d] (82[d], 87[d])	Features of autism	8	Simple	u* (u*, u*)
U.S./TYPCC 3	Dubischar-Krivec et al. (2009)	53	M	124 [g]	No features of autism	10	Simple	100 (53, 47)
	Dubischar-Krivec et al. (2014)	54		124 [g]				
Vera	Patti and Lupinetti (1993)	22	F	49[d] (55[d], 50[d])	Autism		Simple Reverse	13 (13,0)
	Patti (1994)	22		49[d]				
Victoria G	Lafora (1934)	15	F		No features of autism	9	Simple Reverse	27 (24, 3)
	Lafora (1935)							
Wayne	Shields-Wolfe and Gallagher (1992)	21	M	Low-average to borderline ranges of mental ability[d] (Borderline[d], Low-average[d])	Autism	Teenage years	Simple Reverse	131 (33, 98)
YV	Minati and Sigala (2013)	30	M	u* (u*, 157[a])	No features of autism		Simple	516 (u*, u*)

Note. Participants are listed alphabetically in accordance with the identifier (mostly initials) provided in the publication. However, if two different participants are published under the same identifier, they were distinguished by a superscript number (e.g. BL[1] and BL[2]). An empty box indicates that no information was available. Measures used to report IQ are; A: Raven's Progressive Matrices; B: Kamath's test; C: Bhatia's test; D: Weschler Adult Intelligence Scale; E: Peabody Picture Vocabulary Test; F: Wechsler Intelligence Scale for Children; G: Unknown; H: Stanford–Binet Intelligence Scales.
u* unknown
** The diagnosis or clinical description is classified as explained in section **Data extraction**. Further information on the classification system is available on request.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2025.106376.

Data availability

Data will be made available on request.

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