127 (2025) 202682

Contents lists available at ScienceDirect

Research in Autism

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

Ageing and subjective cognitive decline in males and females: Associations with objective cognitive abilities, mental health, and autistic traits

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A R T I C L E I N F O

Keywords:
Ageing
Dementia
SCD
Mental health
Sex
Autistic traits
Autism

A B S T R A C T

Little is known about the impact of ageing on Subjective Cognitive Decline (SCD) and objective cognition in adults on the autism spectrum, and autism and autistic traits are not typically considered when assessing older adults in Memory Clinics for dementia. Therefore, individual variation in autistic traits have not been taken into account when producing normative data for such assessments. The current study aimed to examine SCD and objective cognitive performance in older adults (aged 50–78 years), investigating relationships with autistic traits, depression, anxiety, and sex. Relationships varied depending on sex: for males, SCD was associated with higher levels of anxiety and depression, and a higher degree of systemizing was associated with better speed of processing and backwards working memory span. For females, older age was associated with poorer cognitive flexibility. Findings indicate that relationships between subjective and objective cognitive abilities, autistic traits, and mental health differ based on sex in older adults. This may help to explain outcome variability in previous studies, and has important implications for the use, adaptation, and interpretation of tests used in Memory Clinics.

1. Introduction

Despite calls for research from the autism community, relatively little is understood about the impact of ageing on cognition in this population (Hategan et al., 2017; Hickey et al., 2017; Mason et al., 2022; Michael, 2016; Perkins & Berkman, 2012; Piven & Rabins, 2011), and in particular regarding neurocognitive disorders such as dementia (Farley & McMahon, 2014; Happé & Charlton, 2011; Michael, 2016; Povey et al., 2011; Rhodus et al., 2020, 2022; Vivanti et al., 2021). Indeed, a recent review indicated that, of all the adult autism research articles published since 2012, only 0.4 % were in relation to older adulthood (i.e., those aged 50+; Mason et al.,

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https://doi.org/10.1016/j.reia.2025.202682
Received 7 January 2025; Received in revised form 19 May 2025; Accepted 2 August 2025
Available online 12 August 2025

2022), with very few examining cognitive impairment and dementia.

To date, initial findings are inconsistent, and may variably support one of three proposed trajectories of age-related cognitive change in autism (Bathelt et al., 2020), which may also vary in terms of the cognitive process being examined: **1)** Compared to non-autistic adults, autistic adults' age-related cognitive decline may be steeper (Caselli et al., 2018; Crawford et al., 2014; Hand et al., 2020; Happé & Charlton, 2011; Lever & Geurts, 2016; Mason et al., 2021; Mukaetova-Ladinska et al., 2011; Plana-Ripoll et al., 2019; Starkstein et al., 2015; Stewart et al., 2018), possibly due to similar profiles of cognitive difficulties between young autistic adults and non-autistic older adults (e.g., executive functioning, and to some extent, processing speed; Davids et al., 2016; Geurts et al., 2020; Geurts & Vissers, 2012; Lever & Geurts, 2016; Powell et al., 2017; Spek et al., 2017; Stewart et al., 2018; Wallace et al., 2016), with evidence also indicating that the risk of developing dementia, cerebrovascular disease, stroke, and Parkinsonism may be heightened for autistic people; (D. Crawford et al., 2014; Croen et al., 2015; Hand et al., 2020; Plana-Ripoll et al., 2019; Starkstein et al., 2015; Vivanti et al., 2021, 2025); **2)** The trajectory of age-related decline may be similar to that seen in typical ageing (Torenvliet et al., 2022) (e.g., poorer planning; Davids et al., 2016; Geurts & Vissers, 2012), fluency (Davids et al., 2016; but see Geurts & Vissers, 2012), free recall, and processing speed (Powell et al., 2017); **3)** Autism may be protective against age-related decline (e.g., some types of memory; Charlton et al., 2025; and category learning; Powell et al., 2017), possibly due to multiple factors including greater neural plasticity (Oberman & Pascual-Leone, 2014), and the development of cognitive and social strategies or compensation mechanisms over the lifespan (Baxter et al., 2019; Mukaetova-Ladinska et al., 2011; Perkins & Berkman, 2012).

Indeed, autistic people, those with Broader Autism Phenotype (BAP), or those with high levels of autistic traits show difficulties with executive functioning across the lifespan (Delorme et al., 2007; Demetriou et al., 2018; Hill, 2004a, 2004b; Hughes et al., 1999; Pennington & Ozonoff, 1996; Stewart et al., 2018; Wallace et al., 2016), and levels of autistic traits are associated with executive functioning abilities (Brunsdon & Happé, 2014; Happé & Ronald, 2008; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022). In addition, speed of processing and executive abilities have been found to predict independent living in this group (Bell-McGinty et al., 2002; Gothe et al., 2014). However, findings with regard to the trajectory of executive functioning abilities in autistic ageing are limited and inconsistent (Geurts et al., 2020). Some studies indicate that autistic adults' working memory may deteriorate with age (but see Spek et al., 2017), that declined abilities may be mediated by IQ (Lever et al., 2015), or may only be apparent when visual, but not verbal measures of working memory are used (Tse et al., 2019). Both self-report (Davids et al., 2016) and objective measures such as the Trail Making Task (B) indicate that autistic older adults have difficulties with task switching (Powell et al., 2017), but other studies indicate no age-related decline in working memory, semantic fluency, or planning (Geurts et al., 2020; Geurts & Vissers, 2012; Lever et al., 2015; see also Norris et al., 2024 for evidence of task-specific effects). Some evidence indicates that older autistic adults may have a specific deficit in processing speed (Spek et al., 2017; Tse et al., 2019; but see Geurts & Vissers, 2012).

There is therefore a mixed evidential picture regarding age-related decline or preservation of cognitive abilities in autism, especially in relation to the kinds of tasks used in clinical practice, such as in Memory Clinics (Davids et al., 2016). Memory clinics conduct a range of tests with patients in order to measure performance across various cognitive abilities when assessing an individual for dementia or mild cognitive impairment (MCI). Dementia is an umbrella term for changes in the brain leading to impaired cognition, stemming from a variety of causes, including Alzheimer's disease, Vascular Cognitive Impairment (VCI), frontotemporal dementia, Parkinson's disease, etc. MCI can be an early sign of dementia, although not all cases of MCI progress to dementia (Gale et al., 2018). Alongside objective measures of cognitive functioning, other factors are of crucial importance in attaining a diagnosis of MCI/dementia, including the reporting of Subjective Cognitive Decline (SCD; the degree to which an individual perceives that their own cognitive abilities have declined over time; Reisberg & Gauthier, 2008; Stewart, 2012; Tales et al., 2015) and mental health (e.g., anxiety and depression). Indeed, when investigating possible neurocognitive disorder, practitioners must rely on the patient to self-report feelings of SCD when determining whether to refer to a Memory Clinic. However, with limited understanding of neurocognitive disorders such as dementia, SCD, and MCI in autistic people and those with high levels of autistic traits, combined with clinicians' often poor knowledge of autism in adults (Mukaetova-Ladinska et al., 2011; Nicolaidis et al., 2015; Nicolaidis & Raymaker, 2013; Stuart-Hamilton et al., 2010; Wright et al., 2019), practitioners might not consider that older adults within this population may not fully report their symptoms using self-report questionnaires (Findon et al., 2016; Mazefsky et al., 2011), nor when asked about them under neurotypical questioning structures (Hudson et al., 2018; Norris et al., 2020; Norris, Lei et al., 2024).

In the general older adult population, SCD is found to predict current objective cognitive functioning, as well as risk of later progression to MCI and dementia (Jessen et al., 2010; Lam et al., 2005; Lehrner et al., 2014; Mitchell et al., 2014; Rabin et al., 2017; Reid & MacLullich, 2006; Reisberg & Gauthier, 2008; Stewart, 2012; Tales et al., 2014, 2015), although not all individuals reporting subjective concerns go on to develop cognitive impairment. As those with poorer mental health are more likely to self-report feelings of SCD (Jenkins et al., 2019; Reid & MacLullich, 2006), and people on the autism spectrum display a higher incidence of mental health problems, including anxiety, depression, and suicidality (Cassidy & Rodgers, 2017; Croen et al., 2015; Hand et al., 2020; Richards et al., 2019; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Charlton et al., 2022), this is an area in need of investigation. Indeed, the literature has already begun to establish that commonly co-occurring mental health problems in autistic adults negatively impact cognitive functioning (Dalgleish et al., 2007; Ghaziuddin et al., 2002; Lever & Geurts, 2016; Marx et al., 1992; Taconnat et al., 2010; Williams & Scott, 1988) and quality of life (Mason et al., 2019; Roestorf et al., 2022), and independently predict mortality (Schulz et al., 2000; but see Uljarević et al., 2019). It is therefore reasonable to suggest that older adults with an autism diagnosis and those with high levels of autistic traits may be more vulnerable to developing SCD and objective cognitive decline.

SCD is also a potential early, prodromal stage of dementia, but may not be identified per se or as efficiently in autistic older adults and those with high levels of autistic traits, fuelling inequality in dementia diagnosis and care for this population. Indeed, although some evidence indicates that autistic people may become *more* aware of their own cognitive difficulties as they age compared to non-autistic people (Lever & Geurts, 2016; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022), difficulties with self-reporting internal states, associated with challenges in metacognition, alexithymia, and interoception mean that older autistic adults and those with high levels of autistic traits may be less likely to report subjective concerns about declined cognitive abilities (Cooper et al., 2016; Grainger et al., 2016; Mazefsky et al., 2011). In addition, some evidence indicates non-concurrence between self-reported and lab-measured executive control in autistic adults (Kenworthy et al., 2008). Clinicians in ageing services and memory clinics therefore need to be aware of older adults on the autism spectrum, particularly when treating those with depression and anxiety due to the increased prevalence of mental health problems in this group (Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Charlton et al., 2022; Stewart et al., 2020).

Although research on this topic is in the early stages, a recent study comparing a large sample of autistic and non-autistic older adults found that, regardless of group, the most substantial predictor of SCD was depression symptomology (Torenvliet et al., 2024). Another study investigating older autistic adults (aged 40–81) found that they were more likely to self-report cognitive decline than their non-autistic counterparts, with 30 % reporting perceived significant change in cognition (Klein et al., 2022). In addition, higher levels of autistic traits were associated with a greater degree of SCD (Klein et al., 2022). Autistic older adults frequently endorsed items highlighting a reduced interest in leisure activities, problems with thinking, judgement, and memory, and forgetting appointments. Females were marginally more likely to score above the cut-off for SCD than males. However, this study was not able to compare subjective with objective measures of cognitive abilities in order to disentangle whether these effects were due to actual changes in cognition, or some other factor/s (e.g., poorer mental health). Another recent study using data from a large cohort of older adults found that those with high levels of autistic traits displayed poorer performance than a low-trait comparison group on measures of sustained attention and information processing (using the Choice Reaction Time and Digit Vigilance tasks), working memory (Paired Associates Learning, Digit Span, and Self-Ordered Search tasks), and cued episodic secondary memory retrieval (Picture Recognition task; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022). However, the low- and high-autistic trait groups performed at a similar level on RTs for cued episodic secondary memory, attentional speed (using a Simple Reaction Time task), and verbal reasoning. Crucially, older adults with higher levels of autistic traits reported a greater degree of SCI, but this decline was steeper than that reported by an informant (as in Caselli et al., 2018). The authors concluded that the older adults with high levels of autistic traits may have an overly-negative view of their own cognition (Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022). In addition, this difference disappeared when controlling for depression symptoms, suggesting a role of poor mental health in SCD in this population (Stewart et al., 2022a). These recent findings also correspond with prior research indicating that autistic older adults and those with higher levels of autistic traits report significantly more problems with daily executive functioning (Davids et al., 2016; Geurts et al., 2020; Stewart et al., 2018; Wallace et al., 2016), which correlate well with informant-reports (indicating sufficient insight by autistic older adults into their own cognitive abilities), but which did not generally correspond with objective performance (Davids et al., 2016; Geurts et al., 2020). This initial suggestion of a disconnect between the daily problems experienced by older adults on the autism spectrum, and objective abilities measured using tests of cognitive functioning, mirror problems found in the field of SCD research in general populations (Tales et al., 2014, 2015). Finally, some other studies in the field have examined Subjective Cognitive Impairment (SCI; a feeling that one's cognitive abilities are impaired (i.e., not necessarily that these have declined over time). One such study indicated that those with BAP aged in their mid-sixties showed a greater degree of SCI compared to their non-BAP counterparts, but this was not associated with declined objective cognitive functioning, nor with informant-reports of cognitive change (Caselli et al., 2018).

It can be difficult to recruit older adults with a formal autism diagnosis as research participants in sufficient numbers (Niekerk et al., 2011; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Charlton et al., 2022; Stewart et al., 2018, 2020), especially when directly testing, in-person, a range of cognitive functions using methods analogous to those applied in real-world clinical contexts such as memory clinics, and with a participant group of an appropriate age (i.e., older adults aged 70 +). As autism is heritable, autistic traits are continuously distributed in the general population, and are elevated in first-degree biological relatives of autistic people (Constantino & Todd, 2003; Hoekstra et al., 2007; Lundström et al., 2012; Robinson et al., 2011), much of the emerging evidence with older adults has utilised data from non-autistic populations by investigating the impact of autistic traits on cognition and outcomes (Caselli et al., 2018; Losh et al., 2009; Mason et al., 2021, 2022; Piven, 2001; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Stewart et al., 2018, 2020; Wallace et al., 2016).

The current study therefore aimed to a) examine the relationships between SCD, clinically-relevant objective cognitive performance, autistic traits, and depression and anxiety symptomology in a group of older adults aged 50 + . We will utilise the Montreal Cognitive Assessment (MoCA), which has been indicated as a more sensitive screener for cognitive impairment in adults on the autism spectrum compared with tasks used in prior studies (e.g., MMSE; Groot et al., 2021); and b), as sex differences in cognition in autism are well documented, with studies of younger autistic adults finding neurobiological sex differences (Lai et al., 2013), and recent research indicating possible sex differences in ageing in older autistic adults and those with high levels of autistic traits, as well as in their experiences of SCD (Abbott et al., 2018; Klein et al., 2022; Koolschijn & Geurts, 2016; Norris, Tales et al., 2024; Walsh et al., 2019), this study will also examine the impact of sex on the relationships between SCD, objective cognitive abilities, autistic traits, and mood.[4]

[4] This study requested participant sex in an initial questionnaire (i.e., gender was not specified). However, responses were free-text such that participants could write their preferred response, with none identifying with a gender different to their sex assigned at birth.

2. Methods

2.1. Participants

Participants aged 50 and over were recruited for an in-person study using opportunistic sampling, including recruitment from the Older Adults Research Participant Database at Swansea University, university-wide emails, and various community outreach events in order to increase the diversity of our sample (e.g., those who do not have access to/use the internet). Participants were eligible should they be in fair general health, speak English as their first language, with no history of neurological, psychiatric or psychological disorder,[5] serious head injury, or uncorrected vision or hearing problems. Autism was not an explicit inclusion/exclusion criteria, in order to reduce any potential bias in the recruited sample (e.g., those identifying with autism due to individual/family circumstances being more likely to take part, etc). None of the participants reported taking medication likely to significantly affect information processing or cognitive function. Data for 97 participants in total were included in the current study (35 males, 62 females, mean age = 65.32 years, SD = 6.42, range = 50–78; see Table 1). Participants were invited to the School of Psychology for an appointment of around 2.5 hours, including frequent breaks. The data were collected as part of a wider research project assessing cognitive abilities and autistic traits in a large cohort of older adults. This study was approved by the Department of Psychology Ethics Committee at Swansea University, UK. All participants provided written informed consent and were fully debriefed at the end of their participation.

3. Materials

3.1. Autism-spectrum related measures

3.1.1. Autism Spectrum Quotient (AQ-50; Baron-Cohen et al., 2001)

The AQ-50 is a paper-based questionnaire providing a self-reported measure of levels of autistic traits (Ruzich et al., 2015), including 50 questions assessing social skill, attention switching, attention to detail, communication, and imagination. Participants were asked to rate their level of agreement with items such as 'I prefer to do things with others rather than on my own' on a 4 point scale from 'definitely disagree' to 'definitely agree'. Participants were scored with one point for each item when they endorsed a behaviour associated with autism either mildly or strongly (e.g., 'strongly disagree' or 'disagree' in response to the item 'I can easily keep track of several different people's conversations'). A cut-off of 32 is used to indicate possible autism. Test-retest reliability for the AQ-50 is reported at $r = .7$ (Baron-Cohen et al., 2001).

3.1.2. Empathising quotient (EQ; Baron-Cohen & Wheelwright, 2004)

The EQ is a paper-based questionnaire providing a self-reported measure of empathising behaviour. The EQ comprises 60 items (40 questions relevant to empathy and 20 filler questions). Participants were scored with one point for each item when they endorsed an empathic behaviour mildly, or two points if they endorsed the behaviour strongly (e.g., 'agree' or 'strongly agree' in response to the item 'I really enjoy caring for other people'). A higher total score indicates a 'strong empathiser' (test-retest reliability $r = .835$; Lawrence et al., 2004).

3.1.3. Systemising quotient (SQ; Baron-Cohen et al., 2003)

The SQ is a paper-based questionnaire providing a self-reported measure of systemising behaviour. The SQ comprises 60 items (40 questions relevant to systemising and 20 filler questions). Participants were scored with one point for each item when they endorsed a systemising behaviour mildly, or two points if they endorsed the behaviour strongly (e.g., 'disagree' or 'strongly disagree' in response to 'I find it difficult to understand instruction manuals for putting appliances together'). A higher total score indicates a 'strong systemiser' (internal consistency $\alpha = .903$; Wheelwright et al., 2006).

3.2. Cognitive ability measures

3.2.1. Montreal cognitive assessment (MoCA; Freitas et al., 2012; Gilewski et al., 1990)

The paper-based MoCA provided an index of cognitive functioning. The MoCA is a 30 item experimenter-administered cognitive screening tool measuring short-term and working memory, visuospatial ability, executive function, language, attention, concentration, abstract reasoning, and orientation to time and place. Normal cognitive function is indicated by a score = >26/30 (Gilewski et al., 1990). The MoCA has been indicated as a more sensitive screener for cognitive impairment in adults on the autism spectrum when compared with other tasks (e.g., Mini-Mental State Exam; MMSE; Groot et al., 2021). Internal consistency for the MoCA has been found to be $\alpha = .84$ (Costa et al., 2012).

[5] 'no history of neurological, psychiatric, or psychological disorder' refers to e.g., age-related disease including diagnosed dementia, mild cognitive impairment, stroke, transient ischaemic attack (TIA), subarachnoid haemorrhage (SAH), etc, as well as diagnosed major psychiatric conditions such as psychosis, schizophrenia, etc). This criterion was checked with potential participants in a conversation with the researcher, such that the participant was not required to make a judgement about whether conditions constituted one of these excluding factors (e.g., autism, ADHD, or common mental health conditions such as anxiety and depression, which were not exclusionary). N.b. no participants disclosed autism diagnoses.

Table 1
Participants' educational attainment and occupation status.

	Category	Overall Percentage % (N) N = 97	Female Percentage % (N) N = 62	Male Percentage % (N) N = 35
Highest education level	*None*	2.1 (2)	3.2 (2)	0 (0)
	GCSEs/O Levels	9.3 (9)	9.7 (6)	8.6 (3)
	A Levels/Technical Exams	14.4 (14)	16.1 (10)	11.4 (4)
	Degree/Cert. Ed	38.1 (37)	35.5 % (22)	42.9 (15)
	Masters/Professional Qualifications	30.9 (30)	32.2 (20)	28.6 (10)
	PhD	1 (1.0)	1.6 (1)	0 (0)
		Missing data 4.1 (4)	Missing data 1.6 (1)	Missing data 8.6 (3)
Occupation[a]	*Managers, Directors and Senior Officials*	14.4 (14)	11.3 (7)	20.0 (7)
	Professional Occupations	49.5 (48)	48.4 (30)	51.4 (18)
	Associate Professional and Technical Occupations	1.0 (1)	0.0 (0)	2.9 (1)
	Administrative and Secretarial Occupations	15.5 (15)	22.6 (14)	2.9 (1)
	Skilled Trades Occupations	7.2 (7)	4.8 (3)	11.4 (4)
	Caring, Leisure and Other Service Occupations	5.2 (5)	8.1 (5)	0.0 (0)
	Sales and Customer Service Occupations	3.1 (3)	4.8 (3)	0.0 (0)
	Process, Plant and Machine Operatives	2.1 (2)	0.0 (0)	5.7 (2)
	Elementary Occupations	0.0 (0)	0.0 (0)	2.9 (1)
		Missing data 1.0 (1)	Missing data (0)	Missing data 2.9 (1)
Retired?	*Y*	78.4 (76)	80.6 (50)	
	N	19.6 (19)	17.7 (11)	

[a] Participants were categorised into occupational groups based on the Standard Occupational Classification 2010 (Office for National Statistics). Each major classification has detailed lists of occupations that fall within that classification.

3.2.2. National adult reading test (NART; Nelson & Willison, 1991)

The NART was administered as a measure of cognitive reserve (Dykiert & Deary, 2013; Grober et al., 1991; Nelson & O'Connell, 1978; Stern, 2009). Participants were provided with a card with 50 words (e.g., 'SUPERFLUOUS', 'DEPOT', 'PSALM') to be read aloud to the experimenter. Participants were informed that some words may be unfamiliar, but that they should pronounce all the words as best as they could. The experimenter followed their own word scoring card and scored errors during the test. The NART has a high internal consistency ($\alpha = 0.90$; Crawford et al., 1988) and test-retest reliability ($r = 0.98$; Crawford et al., 1989).

3.2.3. Trails A and B (Leiter, 1949)

The Trails A and B paper-based test was administered as a measure of speed of processing, attention, and cognitive flexibility (Reitan, 1958; Salthouse et al., 2000). For Trails A, participants were asked to draw one continuous line joining a series of circled numbers in ascending order as quickly but as accurately as possible. For Trails B, participants were asked to draw one continuous line joining a series of alternating circled numbers and letters in ascending and alphabetical order (A -> 1 -> B -> 2, etc) as quickly but as accurately as possible. In each trail, the experimenter immediately indicated to the participant if they made a mistake, asking the participant to rectify the mistake before continuing. Brief practice trials were provided for both trails A and B. The dependent variable was time taken in seconds to complete each trail B (note that this included any time taken to rectify errors), as a measure of executive control (Arbuthnott & Frank, 2000). Test-retest reliability of the TMT A and B have been reported at $r = .81$ and.86 respectively (Wagner et al., 2011).

3.2.4. Spatial working memory (WM; Corsi, 1973; Wechsler, 2010)

The Corsi Block-Tapping Task (Corsi, 1973) is measure of spatial working memory (WM) consisting of a forwards and backwards span (Wechsler, 2010). Participants watch the experimenter tap the Corsi-blocks at a rate of one block per second, in a sequence, which they must try to replicate in serial order (forwards span) and in backwards order (backwards span). In up to eight trials of increasing spans by + 1. As forward and backward spans of spatial WM are thought to rely upon similar cognitive processes (Donolato et al., 2017; Kessels et al., 2008; Wilde et al., 2004), each participant's total mean score for forwards and backwards spans were used to index WM. Reliability for the Corsi-blocks task has been reported at $r = .753$ (forwards span) and $r = .782$ (backwards span; de Paula et al., 2016).

3.3. Mood measures

3.3.1. Beck anxiety inventory (BAI; Beck et al., 1988)

The BAI is a measure of self-reported symptoms of anxiety spanning the past week. The BAI is a paper-based questionnaire consisting of 21 items regarding physical and cognitive symptoms of anxiety (e.g., heart pounding, fear of the worst), which participants rate on a four-point scale ranging from 0 (not at all) to 3 (severely, I could barely stand it) in relation to how much they are bothered by each symptom. A higher score indicates higher symptoms of anxiety (internal consistency $\alpha = .92$; test-retest reliability $r = .75$; Fydrich et al., 1992).

3.3.2. Beck depression inventory (BDI; Beck et al., 1987)

The BDI is a measure of self-reported symptoms of depression spanning the past two weeks. The BDI is a paper-based questionnaire consisting of 21 items regarding cognitive, behavioural, affective, and somatic symptoms of depression which participants rate on a four-point scale ranging from 0 to 3. For example, for the topic of sadness, choices range from 0 – 'I do not feel sad' to 3 – 'I am so sad and unhappy that I can't stand it'. A higher score indicates higher levels of depression symptoms (internal consistency α = .85; Beck, 1976).

3.3.3. Cognitive change index (CCI; Saykin et al., 2006)

The CCI is a paper-based questionnaire consisting of 20 items regarding perceptions of one's own memory, executive function, and language abilities (e.g., "recalling information when I really try, "focusing on goals and carrying out a plan", "understanding conversations"). Participants were asked to consider their cognitive function compared to the previous five years on when rating each item a 1 to 5 Likert scale (1 = no change or normal ability, 5 = much worse or severe problem). A higher total score indicates greater feelings of subjective cognitive decline compared to five years ago (reliability α = .94; Rodriguez et al., 2023).

3.4. Design

The study is cross-sectional, assessing the impact of, and difference between sexes on measures of objective and subjective cognitive ability, mood, and autistic traits.

3.5. Procedure

Demographic questions (date of birth, sex, current and/or previous occupation/s, formal qualifications), and the AQ, EQ, and SQ were sent to participants by post prior to the study. Participants completed these at home (taking around 20 min), and then brought these with them to their appointment. Testing took place in a quiet laboratory, where the remainder of the tasks as above were administered in a set order, with a minimum of one break in the middle of the appointment. The running order was as follows: MoCA, NART, Trials A & B, Spatial Span, Visual Search (reported elsewhere; Norris et al., 2024), BAI, BDI, and CCI, in addition to other tasks not reported for the purposes of the current study. The appointment took place with a member of the research team at the Department of Psychology at Swansea University.

3.6. Analytic plan

To address the first aim of the study in examining relationships between subjective cognitive ability (CCI), objective cognitive performance (MoCA), premorbid cognitive ability (NART), working memory (spatial span), executive functioning (Trails A and B), autistic traits (AQ, EQ, SQ), depression and anxiety symptomology (BAI and BDI), and age, correlational analyses will be conducted between these factors. For the second aim of investigating the impact of sex on the relationships between SCD, objective cognitive abilities, autistic traits, mood, and age as above, correlational analyses will also be conducted separately for the male and female groups.

4. Results

Probability plots and stem and leaf plots for each variable were examined in order to assess assumptions of normality. Two outlying data points were removed from the analyses: one high-scoring outlier was removed from the BAI data (4.43 SDs above the mean), and one high-scoring outlier was removed for CCI (4.70 SDs above the mean). Missing data were excluded pairwise.

4.1. Correlations

Due to multiple correlations being conducted, Bonferroni correction was applied to the following correlational analyses, yielding a p value of $p = .004$.

Correlations were first conducted for the whole sample (see Table 2). As anticipated by previous research, older age was significantly associated with measures of objective cognition in terms of slower Trail Making test performance: A RT (i.e., processing speed); $r = .301$, $p = .003$, and B, $r = .324$, $p = .001$). In addition, more severe depression symptoms were related to greater feelings of SCD; $r = -.357$, $p < .001$. There were no relationships between levels of autistic traits, empathising and systemising quotients, mood, and objective and subjective cognitive abilities across the whole group ($ps > .004$; see Table 2).

4.1.1. Sex differences

As autistic traits are known to be higher in males, and patterns of age-related change in cognitive abilities show gender differences, between-groups analyses were conducted to compare sexes across measures. Female participants had higher symptoms of anxiety, BAI: $t(93) = -2.50$, $p = .014$, and depression: BDI, $t(92.03) = -2.13$, $p = .035$, $d = 0.43$ compared to males, as well as scoring higher on the EQ, $t(94) = -3.82$, $p < .001$. Males displayed higher levels of autistic traits: AQ, $t(92) = 3.19$, $p = .002$, and also scored higher on the SQ, $t(95) = 3.68$, $p < .001$ (all other differences were non-significant, $ps > .05$, see Table 3).

Table 2

Correlations between age, years in education, depression and anxiety scores, objective and subjective cognitive abilities, autistic traits, and the systemising and empathising quotients.

	Age	Education	MoCA	BAI	BDI	CCI	NART	Trails A RT	Trails B RT	Spatial WM Forward Span	Spatial WM Backward Span	AQ	SQ	EQ
Age	.													
Education	−.160	.												
MoCA	−.266	.015	.											
BAI	.011	−.185	−.012	.										
BDI	−.021	.062	.098	.333*	.									
CCI	.263	−.022	−.137	.259*	.357*	.								
NART	−.220	.382*	.130	−.127	.002	−.134	.							
Trails A RT	.301*	−.163	−.063	.016	.092	.073	−.061	.						
Trails B RT	.324*	−.147	−.192	.066	.156	.166	−.216	.416*	.					
Spatial WM Forward Span	−.126	.060	.090	−.019	−.218	−.161	.172	−.315*	−.355	.				
Spatial WM Backward Span	−.158	.119	.196	−.169	−.059	−.168	.286	−.356*	−.286	.571*	.			
AQ	.025	.007	−.185	−.088	.020	.089	.021	.136	.074	−.114	−.121	.		
SQ	.045	−.102	.082	−.117	−.169	−.113	−.059	−.142	.029	.026	.233	.248	.	
EQ	−.037	−.029	.183	.227	−.031	−.034	.090	−.045	.041	.122	.058	−.634*	.013	.

* Correlation is significant at the 0.004 level (2-tailed).

4.2. Correlations - split by sex

Due to multiple correlations being conducted, Bonferroni correction was applied to the following correlational analyses, yielding a p value of $p = .002$. For males, faster performance on Trails A ($r = -.503$, $p = .002$) and B ($r = -.531$, $p = .001$) were associated with increased levels of education. Finally, males' SCD was positively associated with both their anxiety ($r = .533$, $p = .001$) and depression symptomology ($r = .700$, $p < .001$). Therefore, in males, a higher level of education was associated with faster speed of performance on both Trials A and B. In addition, a greater degree of SCD was associated with more severe anxiety and depression symptoms. All other correlations were non-significant ($ps > .002$, see Table 4).

For females, a greater number of years in formal education were associated with better scores on the NART; $r = .390$, $p = .002$. No other correlations reached Bonferroni-corrected significance ($ps > .002$, see Table 5).

5. Discussion

Research to date, although limited, has begun to indicate that autistic adults and those with high levels of autistic traits may be at an increased risk of SCD, objective cognitive decline, and anxiety and depression in ageing (Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Charlton, et al., 2022; Stewart et al., 2018; Wallace et al., 2016). In addition, sex differences in cognition, including in autistic adults are well documented (Lai et al., 2013), and may extend to cognitive ageing in this population, including experiences of SCD (Abbott et al., 2018; Klein et al., 2022; Koolschijn & Geurts, 2016; Norris, Tales et al., 2024; Walsh et al., 2019). The current study therefore aimed to build upon recent findings by examining whether levels of autistic traits in a non-autistic older adult sample were related to objective measures of cognition used in memory clinics, SCD, and symptoms of anxiety and depression, and whether associations differed depending on sex. Importantly, our study utilised objective measures of cognition that are used in relevant real-world contexts, i.e., memory clinics.

When assessing relationships between the measures across the whole sample, as expected, increasing age was related to poorer objective cognitive performance on Trails A and B (Jenkins et al., 2019; Reisberg & Gauthier, 2008; Tales et al., 2014, 2015). Our findings also reflect prior literature from the non-autistic and autistic populations, in that increased SCD was related to greater depression symptomology (Jenkins et al., 2019; Reid & MacLullich, 2006; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Torenvliet et al., 2024). The current study found no relationships between SCD, objective cognitive abilities, and levels of autistic traits when analysing data for the whole sample (see below for different results based on sex). These findings may be somewhat supportive of prior studies indicating no differences in cognitive abilities between autistic and non-autistic older adults

Table 3
Descriptive and inferential statistics for the dependent variables.

	Overall (N = 97)	Male (N = 35)	Female (N = 62)	t tests
Age	M = 65.32 (SD = 6.42); Range = 50 –78; n = 96	M = 66.15 (SD = 6.04); Range = 51 –78; n = 34	M = 64.87 (SD = 6.63); Range = 50 –77; n = 62	$t(94) = 0.93$, $p = .354$, $d = 0.20$
Years in education	M = 15.56 (SD = 3.11); Range = 10 –27; n = 94	M = 15.82 (SD = 2.83); Range = 10 –22; n = 34	M = 15.41 (SD = 3.27); Range = 10 –27; n = 60	$t(92) = 0.62$, $p = .537$, $d = 0.13$
MoCA	M = 27.89 (SD = 1.87); Range = 22 –30; n = 97	M = 27.46 (SD = 1.79); Range = 24 –30; n = 35	M = 28.13 (SD = 1.88); Range = 22 –30; n = 62	$t(95) = -1.72$, $p = .088$, $d = 0.37$
BAI	M = 4.47 (SD = 3.90); Range = 0 –16; n = 95	M = 3.20 (SD = 3.18); Range = 0 –13; n = 35	M = 5.22 (SD = 4.11); Range = 0 –16; n = 60	$t(93) = -2.50$, $p = .014$*, $d = 0.55$
BDI	M = 5.59 (SD = 4.87); Range = 0 –20; n = 97	M = 4.34 (SD = 3.60); Range = 0 –12; n = 35	M = 6.29 (SD = 5.36); Range = 0 –20; n = 62	$t(92.03) = -2.13$, $p = .035$*, $d = 0.43$
CCI	M = 12.11 (SD = 10.18); Range = 0 –41; n = 96	M = 10.91 (SD = 10.45); Range = 0 –41; n = 35	M = 12.80 (SD = 10.05); Range = 0 –39; n = 61	$t(94) = -0.87$, $p = .385$, $d = 0.18$
NART	M = 39.22 (SD = 6.46); Range = 10 –49; n = 97	M = 38.31 (SD = 7.43); Range = 10 –49; n = 35	M = 39.73 (SD = 5.85); Range = 27 –49; n = 62	$t(95) = -1.03$, $p = .304$, $d = 0.21$
Trail Making: A	M = 33.22 (SD = 9.94); Range = 15 –61; n = 97	M = 33.25 (SD = 10.62); Range = 16 –61; n = 35	M = 33.20 (SD = 9.62); Range = 15 –61; n = 62	$t(95) = 0.24$, $p = .981$, $d = 0.00$
Trail Making: B	M = 73.35 (SD = 24.65); Range = 31 –154; n = 96	M = 75.00 (SD = 23.52); Range = 38 –130; n = 35	M = 72.40 (SD = 25.42); Range = 31 –154; n = 61	$t(94) = 0.50$, $p = .622$, $d = 0.11$
Spatial WM Forward Span	M = 7.55 (SD = 1.81); Range = 3 –11; n = 97	M = 7.71 (SD = 1.82); Range = 3 –11; n = 35	M = 7.45 (SD = 1.81); Range = 4 –10; n = 62	$t(95) = 0.69$, $p = .495$, $d = 0.14$
Spatial WM Backward Span	M = 7.40 (SD = 1.66); Range = 4 –12; n = 97	M = 7.57 (SD = 1.91); Range = 4 –12; n = 35	M = 7.31 (SD = 1.51); Range = 4 –11; n = 62	$t(95) = 0.75$, $p = .454$, $d = 0.15$
AQ[a]	M = 18.15 (SD = 6.91); Range = 6 –36; n = 94	M = 21.03 (SD = 6.48); Range = 11 –34; n = 34	M = 16.52 (SD = 6.65); Range = 6 –36; n = 60	t(92) = 3.19, $p = .002$**, d = 0.69
SQ	M = 62.56 (SD = 18.92); Range = 23 –109; n = 97	M = 71.40 (SD = 15.69); Range = 36 –102; n = 35	M = 57.56 (SD = 18.87); Range = 23 –109; n = 62	t(95) = 3.68, $p < .001$***, d = 0.80
EQ	M = 45.77 (SD = 12.53); Range = 15 –68; n = 96	M = 39.74 (SD = 12.62); Range = 15 –63; n = 35	M = 49.23 (SD = 11.18); Range = 23 –68; n = 61	t(94) = −3.82, $p < .001$***, d = 0.80

$p < .05$*, $p < .01$**, $p < .001$***

[a] Although it is noted that 16 participants scored above the cut-off score of 26, and 6 above a cut-off score of 32 on the AQ, caution is recommended in the use of cut-offs based on this measure, as the AQ is intended as a descriptive measure of autistic traits, rather than being diagnostic per se. (Ruzich et al., 2015).

Table 4
Correlations in the male group between age, years in education, depression and anxiety scores, objective and subjective cognitive abilities, autistic traits, and the systemising and empathising quotients.

	Age	Education	MoCA	BAI	BDI	CCI	NART	Trails A RT	Trails B RT	Spatial WM Forward Span	Spatial WM Backward Span	AQ	SQ	EQ
Age	.													
Education	−.312	.												
MoCA	−.300	−.101	.											
BAI	.340	−.329	−.053	.										
BDI	.188	−.030	−.053	.472*	.									
CCI	.275	−.176	−.287	.533*	.700*	.								
NART	−.233	.415	.175	−.085	−.119	−.214	.							
Trails A RT	.335	−.503	−.191	.170	.162	.170	−.253	.						
Trails B RT	.235	−.531*	−.028	.264	.096	.180	−.210	.635*	.					
Spatial WM Forward Span	.013	.172	.059	.061	.020	.025	.219	−.292	−.406*	.				
Spatial WM Backward Span	−.090	.170	.386	−.131	−.098	.001	.308	−.481*	−.342	.469*	.			
AQ	−.072	.072	−.366	−.156	−.058	−.093	−.153	.215	.038	−.172	−.297	.		
SQ	−.306	.272	.151	−.314	−.247	−.292	.241	−.492	−.175	.084	.476	.047	.	
EQ	−.152	.029	.363	.009	−.073	−.072	.332	−.159	−.022	.357	.239	−.727*	.178	.

[*] Correlation is significant at the 0.002 level (2-tailed).

Table 5
Correlations in the female group between age, years in education, depression and anxiety scores, objective and subjective cognitive abilities, autistic traits, and the systemising and empathising quotients.

	Age	Education	MoCA	BAI	BDI	CCI	NART	Trails A RT	Trails B RT	Spatial WM Forward Span	Spatial WM Backward Span	AQ	SQ	EQ
Age	.													
Education	−.100	.												
MoCA	−.195	.010	.											
BAI	−.093	−.120	−.079	.										
BDI	−.065	.114	.110	.247	.									
CCI	.276	.069	−.083	.117	.212	.								
NART	−.204	.390*	.075	−.210	.027	−.095	.							
Trails A RT	.285	.016	.011	−.059	.069	.012	.088	.						
Trails B RT	.362*	.023	−.265	.003	.197	.170	−.218	.293	.					
Spatial WM Forward Span	−.206	.000	.127	−.033	−.300	−.263	.154	−.330	−.336	.				
Spatial WM Backward Span	−.219	.085	.101	−.174	−.023	−.285	.286	−.262	−.265	.645	.			
AQ	.038	−.057	−.017	.044	.155	.246	.208	.096	.075	−.120	−.055	.		
SQ	.142	−.289	.159	.069	−.068	.012	−.180	.019	.093	−.038	.077	.210	.	
EQ	.077	−.026	−.007	.226	−.132	−.080	−.167	.031	.112	.037	−.026	−.505	.163	.

* Correlation is significant at the 0.002 level (2-tailed).

(Koolschijn & Geurts, 2016; Torenvliet et al., 2022), although this is in contrast to other previous findings of a greater degree of SCD in those with higher levels of autistic traits (Caselli et al., 2018; Klein et al., 2022; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Torenvliet et al., 2022, but see Torenvliet et al., 2024). As we did not directly recruit a sample of older adults with high levels of autistic traits, and focused on analysing the effects of AQ, SQ, and EQ scores across a standard, community-dwelling sample, this may go some way to explaining these differences between studies (see also *Limitations* section).

Our second aim was to examine the relationships between the above measures for males and females separately. As expected, males scored higher on the AQ and SQ (Baron-Cohen et al., 2003; Baron-Cohen & Wheelwright, 2004; Ruzich et al., 2015). Females had higher levels of anxiety and depression (Beekman et al., 1998; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022), and higher EQ scores. Correlational results indicate that for males, a higher level of formal education was associated with better performance on both Trails A and B. In addition, higher levels of SCD in males was associated with a greater degree of anxiety and depression symptomology. Such evidence indicates a need to consider an individual's sex when assessing subjective and objective cognitive decline in older adults, in particular with regard to subjective feelings of cognitive decline and mental health in males. For females, no correlations between factors of interest reached significance.

The current findings therefore highlight the complex relationship between subjective and objective cognitive functioning in ageing, and the impact of mental health (Jenkins et al., 2019; Reid & MacLullich, 2006), which has important implications for ageing autistic adults and those with high levels of autistic traits (Bishop-Fitzpatrick & Rubenstein, 2019; Hofvander et al., 2009; Lever & Geurts, 2016; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Stewart et al., 2018; Torenvliet et al., 2022). Our findings also indicate that these relationships differ depending on sex (Torenvliet et al., 2024), although sex differences indicated here may be somewhat in contrast with Stewart et al. (2022), who found that gender was not associated with cognitive performance in their high autistic traits group. It should be noted however that our studies differ significantly in terms of sample, as we did not over-sample for individuals with high levels of autistic traits.

There was also a relationship between higher levels of formal education and faster performance on Trails A and B for males, and future research should endeavour to investigate further the relationship between type and duration of formal of education and systemizing (see e.g., Kidron et al., 2018). In addition, the current study highlights that having a feeling that one's own cognition may be declining is associated with poorer mental health in males, but SCD was not associated with objectively-measured cognitive abilities. This finding has particular implications for treating clinicians, who should consider the impact of mental health on an individual's feelings of SCD in ageing, particularly for males.

5.1. Limitations

A limitation of the current study was that the sample was majority female, a common problem in adulthood psychological research more broadly. Future research should therefore endeavour to recruit samples with more equally-sized sex groups in order to further examine how levels of autistic traits may influence ageing, and whether this differs depending on sex. Further, in the current study we were not able to over-sample participants with high levels of autistic traits, and did not directly examine autistic older adults. Studies of autistic traits in the general population should not replace those conducted with diagnosed older adults. However, as recruiting autistic older adults in sufficient numbers can be a significant challenge (Niekerk et al., 2011; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Charlton, et al., 2022; Stewart et al., 2018, 2020), particularly when engaging participants in oftentimes lengthy in-person testing of a range of cognitive functions most applicable to memory clinics, investigating autistic traits can be appropriate (Caselli et al., 2018; Mason et al., 2022; Norris, Tales et al., 2024; Piven, 2001; Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022; Stewart et al., 2018, 2020; Wallace et al., 2016). In addition, there are possible limitations of the AQ as a definitive screening tool for the presence or absence of autism, especially within some groups (e.g., autistic women), where the AQ may under-report autistic traits (Baron-Cohen et al., 2014; Brown et al., 2020). Finally, information about the profile of cognitive ageing in older adults with high levels of autistic traits can provide important information about autistic ageing, and may be particularly helpful when investigating under-researched groups such as older women (Stewart, Corbett, Ballard, Creese, Aarsland, Hampshire, & Brooker et al., 2022), as well as in examining individual differences in typical and atypical ageing relevant to clinical practice. Indeed, the current findings highlight that examining autistic traits in males and females in the general population reveals important factors in the relationships between SCD, objective cognition, and mood.

5.2. Implications

Our findings add to emerging evidence which indicates a need to identify autistic people and those with high levels of autistic traits prior to Memory Clinic assessment, followed by considering the use of more tailored investigations (Norris, Tales et al., 2024). This is likely to be preferable when compared to relying on normative data that may not be appropriate to this population, and may contribute to misdiagnosis and/or misinterpretation of reported symptoms, test results, and behaviour. Evidence-based service and task adaptations are required to ensure self-report of SCD and related factors is facilitated, and that objective functioning is appropriately measured in autistic and high-traits older adults (Stewart, 2012). Service-providers dealing with older adults should therefore consider screening for autistic traits (Mason et al., 2021), and interpreting interactions between measures with caution, whilst also considering the potential influence of sex. Further, recent evidence indicates significant overlap between the presentations of autism-related behaviours and dementia (Caselli et al., 2018; Rhodus et al., 2020, 2022), and that higher levels of autistic traits may be related to steeper cognitive and brain ageing, as well as dementia (Crawford et al., 2014; Croen et al., 2015; Hand et al., 2020; Norris, Tales et al., 2024;

Rhodus et al., 2020, 2022; Starkstein et al., 2015; Vivanti et al., 2021, 2025). The current findings also provide data on the relationship between autistic traits and MoCA scores, a crucial tool used clinically which has received little autism research attention to date compared to other, more outdated measures such as the MMSE (Powell et al., 2017). Further research should seek to understand whether performance on the MoCA is sensitive to MCI/dementia in autistic adults and those with high levels of autistic traits.

5.3. Future research

Lifestyle factors may also play a crucial role in patterns of age-related change in those with varying levels of autistic traits. Indeed, alongside genetic and biological factors, social isolation and loneliness (more common in autistic people) could go some way to explaining findings of a faster pace of physical ageing (self-, informant-, and interviewer-reported) in older autistic adults and those with high levels of autistic traits (Mason et al., 2021), even over and above the influence of IQ and socio-economic status. This is supported by recent findings indicating that one of the most commonly-endorsed SCD-related problems in older autistic adults was a *reduced interest in leisure activities* (Klein et al., 2022). Future research should therefore consider the social circumstances of individuals, including social connectedness and loneliness, in order to elucidate their influence on objective and subjective cognition. The current findings of a relationship between poorer mental health in males and SCD provide further evidence for the importance of this investigation. Further evidence is required to inform service adaptations that facilitate self-report of subjective cognitive concerns by older autistic adults and those with high levels of autistic traits, as well as into the appropriate measurement of objective functioning in this group (Farley & McMahon, 2014; Hand et al., 2020; Happé & Charlton, 2011; Turcotte et al., 2016). Indeed, a recent study indicates that normative data for the types of tests used in Memory Clinics may not be appropriate for this population (Norris, Tales et al., 2024).

CRediT authorship contribution statement

Jade Eloise Norris: Writing – original draft, Methodology, Formal analysis, Resources, Investigation, Data curation, Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Andrea Tales:** Resources, Investigation, Data curation, Writing – review & editing, Project administration, Funding acquisition, Conceptualization, Writing – original draft, Methodology, Formal analysis. **Emma Richards:** Resources, Data curation, Writing – review & editing, Investigation, Writing – original draft, Formal analysis. **Alecia L. Cousins:** Resources, Data curation, Writing – review & editing, Investigation, Writing – original draft, Formal analysis. **Julia R. Badger:** Writing – original draft, Investigation, Conceptualization, Project administration, Funding acquisition, Writing – review & editing, Methodology, Formal analysis.

Funding statement

This work was supported by the Realising Potential Trust (B1760), and BRACE Dementia Research (Registered Charity Number: 297965).

Declaration of Competing Interest

The authors have no competing interests to declare that are relevant to the content of this article.

Data availability

Data will be made available on request.

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