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Age differences in social cognition: when does decline begin?

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Abstract
Normal ageing is often accompanied by a variety of changes in cognitive abilities, including the interpersonal aspects of cognition (i.e. social cognition). The domain of social cognition includes at least three dimensions: theory of mind, emotion recognition, and empathy. To date, it is not entirely clear how ageing affects social cognition and whether all or only some of these abilities decline in older people. The present study therefore sought to clarify the possible existence of age-related differences in social cognition by examining different age groups. A total of 159 participants were eligible for the study (young adults: 36; adults: 37; middle-aged adults: 45; older adults: 41) and completed a series of validated instruments to assess social cognition. A one-way analysis of covariance for continuous variables was conducted to compare the four age groups on social cognition measures, controlling for the effect of sex. The results showed that older people reported significantly lower scores on all of these measures compared to the other age groups, with the sole exception of empathy. Furthermore, no effect of sex was found. Overall, the present results emphasise the importance of an in-depth examination of social cognitive abilities, particularly in older people.

Keywords Theory of mind · Facial emotion recognition · Empathy · Aging

Introduction

Normal ageing is often associated with a variety of changes in cognitive abilities, such as processing speed, memory, visuospatial abilities and executive functions (e.g., Murman, 2015; Salthouse, 2010). More recently, researchers have also begun to look at social and interpersonal aspects of cognition (i.e., social cognition) in normal ageing. The domain of social cognition encompasses a range of abilities that enable individuals to construct mental representations of the relationships between oneself and others and to use these representations flexibly to carry out appropriate social interactions (Adolphs, 2001). Among its key components, three sub-domains of social cognition essential for mental state inference and affective processing were selected: emotion recognition, Theory of Mind (ToM), and empathy. These represent related but conceptually distinct dimensions that contribute to successful interpersonal functioning (Adolphs, 2009; Frith & Frith, 2007).

Emotion recognition is the ability to identify and interpret emotional states from perceptual cues such as facial expressions, vocal tone, and body posture. This process is often considered a foundational perceptual component of social cognition, as it provides critical information about others' affective states. Neuroimaging and lesion studies have consistently implicated a network including the amygdala, fusiform gyrus, and superior temporal sulcus in the processing of emotional facial expressions and socially relevant perceptual cues (Adolphs, 2002; Haxby et al., 2000).

In contrast, ToM involves higher-order cognitive processes that enable individuals to attribute mental states to others and use this information to explain and predict human behaviour (Frith & Frith, 2005). ToM has been conceptualised as comprising two main components: affective and cognitive ToM (Shamay-Tsoory et al., 2010). Cognitive ToM is defined as the ability to infer another individual's thoughts, intentions, and beliefs. Affective ToM refers to the ability to understand what another person is feeling (Shamay-Tsoory et al., 2010). The neural correlates of ToM have been consistently associated with a distributed network including the medial prefrontal cortex, temporo-parietal junction,

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posterior superior temporal sulcus, and precuneus, which are thought to support mental state attribution and perspective taking (Frith & Frith, 2006; Saxe & Kanwisher, 2003).

Empathy, in turn, has been defined as "the ability to experience and understand what others feel without confusing oneself with others" (Decety & Lamm, 2006, p. 1146) and is commonly categorised into two main dimensions: affective empathy and cognitive empathy (Baron-Cohen & Wheelwright, 2004). Affective, or emotional, empathy refers to the ability to emotionally resonate with another person's feelings; this involves automatic emotional responses such as emotional contagion, sympathy, and compassion (Decety & Jackson, 2004). Cognitive empathy, by contrast, is closely related to ToM and represents the ability to understand another person's perspective or mental state and use this understanding to respond appropriately in social situations (Decety & Jackson, 2004; Singer & Klimecki, 2014). Affective empathy has been linked to brain regions involved in affective processing and emotional resonance, including the anterior insula and anterior cingulate cortex, whereas cognitive empathy overlaps with brain regions implicated in mentalising processes, particularly the medial prefrontal cortex and temporo-parietal junction (Decety & Jackson, 2004; Shamay-Tsoory, 2011).

Although these constructs are theoretically distinguishable, they are also functionally and neurally interconnected. For example, the superior temporal sulcus and medial prefrontal cortex have been implicated in both emotion processing and mental state inference, highlighting the partially shared neural architecture underlying different components of social cognition (Adolphs, 2009; Becchio et al. 2006; Frith & Frith, 2007). Emotion recognition may provide the perceptual input necessary for mental state inference, while ToM enables a more complex representation of others' internal experiences beyond observable cues. Empathy integrates these processes by linking the understanding of another person's emotional state with an affective response. Therefore, examining emotion recognition, ToM, and empathy together may offer a more comprehensive characterisation of social cognitive functioning.

Regarding the study of these components in relation to ageing, ToM is one of the most extensively studied aspects of social cognition in healthy ageing (Kemp et al., 2012). Age-related differences have been found in cognitive ToM tests such as Happé's Strange Stories (Happé, 1994), Faux Pas (Gregory et al., 2002) and ad hoc constructed perspective-taking tasks, with older adults performing worse than young participants (e.g., Baksh et al., 2018; Bottiroli et al., 2016; Duval et al., 2011; Rosi et al., 2016). In affective ToM tasks, such as the Reading the Mind in the Eyes test (Baron-Cohen et al., 2001), some studies have also found poorer performance in older adults compared to younger adults (e.g., Baksh et al., 2018; Bottiroli et al., 2016; Fischer et al., 2017). However, not all evidence is consistent, and other studies have found age-related improvements in favour of older adults, equivalent performance between younger and older adults, or circumstance-related changes in older adults in both affective and cognitive ToM (e.g., Castelli et al., 2010; Keightley et al., 2006; McKinnon & Moscovitch, 2007).

Similarly inconsistent results have been obtained in relation to emotion recognition, which is an essential skill for adaptive social behaviour as it guides reactions and actions towards potentially friendly or threatening individuals (Stolier & Freeman, 2016). Most studies have focused on the investigation of facial emotion recognition, with two meta-analyses showing that age-related differences in the accuracy of facial emotion recognition are not consistent (Ruffman et al., 2008; Hayes et al., 2020). A preliminary meta-analysis by Ruffman et al. (2008) has shown that these differences are greatest for the emotions anger, fear and sadness compared to happiness and surprise, although no age effect was found for disgust. Similarly, the results of the updated meta-analysis by Hayes et al. (2020) showed that when combining task types (e.g.,, photos vs. videos), the pattern of age effects for all emotions was largely consistent with the previous meta-analysis (i.e., largest age effects for anger, fear, sadness; no effect for disgust). However, the magnitude and direction of the age effects were strongly influenced by the task design elements. In particular, relatively moderate age effects were found for all emotions in videos, suggesting that older adults may not show an effect in recognising positive facial emotions.

The final component of the social cognition domain that has received much attention in the context of normal ageing is empathy (e.g., Jarvis et al., 2024). While previous studies seem to suggest that cognitive empathy declines with age (Henry et al., 2013), the evidence for age-related changes in affective empathy is more conflicting. For example, some studies have found that emotional empathy declines in later life (e.g.,, Albouy & Décaudin, 2018; Sommerlad et al., 2021), others that it increases (e.g.,, Kelly et al., 2022; Yaghoubi Jami et al., 2021), and still others that affective empathy does not change (e.g.,, Beadle et al., 2015; Stietz et al., 2021). A recent meta-analysis summarised the results of these studies and showed that emotional empathy can even increase in adulthood (Jarvis et al., 2024).

Overall, it is not yet entirely clear how ageing affects social cognitive abilities and whether all or only some of these abilities decline in older people. Several reasons could explain why contradictory results on age-related differences in social cognition have been found in the literature. So far, most studies have investigated possible differences by comparing the performance of young adults with that of older

adults. Conversely, only a few studies have examined social cognitive abilities by looking at individuals from different age groups (e.g., Baksh et al., 2018; Grainger et al., 2023). The inclusion of different age groups could make it possible to obtain important information about the development of social cognitive abilities in older adulthood. Similarly, most previous studies were limited by looking at only one aspect of the domain of social cognition (e.g., emotion recognition but not mental state understanding). Different components of social cognition might be affected differently by age (with difficulties in one domain possibly being compensated for in other domains), so it is important to use multiple instruments to assess all domains of social cognition in the same individuals. Finally, older studies have mostly used static stimuli to investigate facial emotion recognition or ToM (e.g., Ruffman et al., 2008). The use of video stimuli that better reflect the interactions that take place in everyday interpersonal relationships could allow for a better investigation of complex abilities such as social cognition.

On these bases, the main aim of the present exploratory study was to elucidate the possible presence of age-related differences in various domains of social cognition by examining different age groups (young adults, adults, middle-aged adults and older adults). Three aspects of social cognition were examined: (1) recognition of dynamic facial expressions; (2) representation of other people's mental states (both affective and cognitive ToM); (3) empathy (both affective and cognitive). Through a comprehensive assessment of social cognitive abilities, we therefore wanted to explore whether and when a decline in these abilities begins.

Table 1 Baseline sociodemographic characteristics of the four age groups ($N=159$)

	Young adults* ($n=36$)	Adults ($n=37$)	Middle-aged adults ($n=45$)	Older adults ($n=41$)
Sociodemographic information				
Age (years)	22.97 (1.30)	29.78 (4.20)	53.42 (4.19)	69.76 (7.34)
Sex[#]				
Female	17 (47.2%)	21 (56.8%)	27 (60%)	25 (61%)
Male	19 (52.8%)	16 (43.2%)	18 (40%)	16 (39%)
Education				
Primary/Secondary/ High school diploma	21 (58.4%)	15 (40.5%)	21 (46.6%)	23 (56.1%)
B.Sc. or M.Sc. Degree/Postgraduate qualification	15 (41.6%)	22 (59.5%)	24 (53.4%)	18 (43.9%)
Profession				
Student	27 (75%)	7 (18.9%)	2 (4.4%)	-
Employed	7 (19.4%)	26 (70.3%)	39 (86.7%)	5 (12.2%)
Unemployed	2 (5.6%)	4 (10.8%)	4 (8.9%)	4 (9.8%)
Retired	-	-	-	32 (78%)
Marital status				
Single	35 (97.2%)	29 (78.4%)	5 (11.1%)	1 (2.4%)
Cohabitant	1 (2.8%)	8 (21.6%)	5 (11.1%)	-
Married	-	-	27 (60%)	23 (56.1%)
Separated/divorced	-	-	8 (17.8%)	7 (17.1%)
Widower	-	-	-	10 (24.4%)

*Young adults: 18–25 years; adults: 26–40 years; middle-aged adults: 41–60 years; older adults: 61 years and older

[#]Participants' sex was determined by asking them to indicate their biological sex, i.e. the set of biological characteristics associated with physical and physiological traits such as chromosomal genotype, hormone levels, and internal and external anatomy

Materials and methods

Participants

The data were collected from March 2022 to March 2025 as part of an anonymous survey. Two hundred participants were recruited for the present study via advertisements. The exclusion criteria were: under 18 years of age, low educational level (<primary school) or insufficient knowledge of the Italian language, performance on the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) below the normative values determined for the Italian population (Santangelo et al., 2015), and the presence or history of a neurological or severe psychiatric disorder. Participants were recruited to be representative of the identified age groups, with sex balance within each age group. The following age groups were selected to ensure broad representativeness across all major stages of the adult life course: young adults: 18–25 years; adults: 26–40 years; middle-aged adults: 41–60 years; older adults: 61 years and older. A total of 159 participants were eligible for the study (young adults: 36; adults: 37; middle-aged adults: 45; older adults: 41). The sociodemographic characteristics for the four age groups are presented in Table 1.

The sample size was determined based on an a priori power analysis, using the software G*Power 3.1 (Faul et al., 2009), where a medium effect size, a power of over 0.80 and an alpha level of 0.05 were considered sufficient for one-way Analysis of covariance (ANCOVA) with four groups and one covariate.

This study was approved by the Ethics Committee of the University of Turin (protocol number 0623857) and was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants before the start of the study.

Procedure

All measures (with the exception of the MoCA) were administered to participants via online survey software (LimeSurvey, GmbH, Germany) in the laboratory. An anonymised, individual and unique code to complete the survey was provided to those who gave their agreement to take part in the study.

Before completing the questionnaires, participants were first administered a paper-and-pencil cognitive screening tool (MoCA) to assess general cognitive performance. Second, participants were asked to complete self-report questions assessing sociodemographic (i.e., age, sex[1], education level, marital status, and occupation) and clinical information (i.e., history or presence of psychiatric or neurological disorders, assessed using yes/no self-report questions) to determine eligibility for the study.

Participants were seated in a separate, quiet room to complete the assessment. The measures were administered in a counterbalanced order, with half of the participants completing the performance-based tests first and then the self-report questionnaires, and the other half completing the conditions in reverse order.

Measures

Participants filled in a series of measures as part of a broader investigation, but only those instruments relevant to the present research questions are described here.

Recognition of others' prototypical facial expressions

The Amsterdam Dynamic Facial Expression Set – Bath Intensity Variations (ADFES-BIV) comprises standardised stimuli of dynamic, prototypical facial expressions (Wingenbach et al., 2016). The original ADFES (van der Schalk et al., 2011) consists of 12 Northern European encoders (7 male, 5 female) and 10 Mediterranean encoders (5 male, 5 female) that mimic six basic emotions (anger, disgust, fear, happiness, sadness, surprise) and three complex emotions (contempt, pride, embarrassment) as well as neutral expressions. More recently, the ADFES stimuli were adapted to include both high-intensity and more subtle expressions, resulting in three levels of intensity of emotional facial expressions: low, medium and high (Wingenbach et al., 2016).

For the present study, we selected 60 stimuli (from a total of 360 videos of the ADFES-BIV): 9 basic and complex emotions and 1 neutral control expression, 3 female and 3 male actors, presented at medium intensity. The clips were presented one at a time in random order. A black screen was displayed to the participants at the end of each clip, to avoid a possible facilitation effect in the recognition of the facial expressions, due to the last static frame of the videos.

Participants were asked to choose one of ten options displayed below each video, using the criterion of which word best describes the emotion of the person shown in the video. The number of correct answers for each expression was summed to obtain an overall score (emotion recognition total score) for all emotions (all expressions except neutral).

In our sample, Cronbach's alpha good for the ADFES-BIV emotion recognition score was 0.96.

Recognition of other people's mental states (ToM)

The Movie for the Assessment of Social Cognition (MASC) assesses ToM (both affective and cognitive processes) by presenting scenes of social interactions that resemble those of everyday life (Dziobek et al., 2006; Fossati et al., 2018). The task is presented in the form of a 15-minute film divided into 43 segments representing the test items, followed by a question on various mental state modalities. Participants are instructed that the film shows four people meeting on a Saturday evening and that the film is paused at various points and questions are asked. Participants are asked to try to imagine what the characters are thinking or feeling at the moment the film is paused.

The Italian version of the scale has shown good internal consistency (Cronbach's alpha coefficient ranging from 0.70 to 0.78) and test-retest reliability (Fossati et al., 2018). In our sample, Cronbach's alpha was 0.74.

The Italian version of the Reading the Mind in the Eyes Test (RMET) was used to assess the ability to recognise the affective mental states of others (Baron-Cohen et al., 2001; Serafin & Surian, 2004). Participants viewed 36 photographs of the eye region of various human faces and were asked to choose one of four words, using the criterion of which word best describes the mental state of the person depicted in the photograph. Participants received a score of 1 for every correct answer, with a maximum possible score of 36. The Italian version of the scale has shown good internal consistency (Cronbach's alpha coefficient = 0.61) and test-retest reliability (Vellante et al., 2013). In our sample, Cronbach's alpha was 0.50.

[1] Participants' sex was determined by asking them to indicate their biological sex, i.e. the set of biological characteristics associated with physical and physiological traits such as chromosomal genotype, hormone levels, and internal and external anatomy.

Table 2 Performance on the social cognition tasks (scores as correct answers) for the four age groups, controlling for the effect of sex

	Young adults (n=36)	Adults (n=37)	Middle-aged adults (n=45)	Older adults (n=41)	Test (df)*	p	Effect size η^2
Facial emotion recognition							
ADFES-BIV (emotion recognition total score)	31.08 (7.84)	31.92 (6.04)	31.51 (5.53)	25.49 (6.20)[a]	F(3, 154)=9.55	<0.001	0.157
ToM							
MASC	31.86 (4.09)	32.92 (3.20)	30.42 (3.85)	24.44 (6.28)[a]	F(3, 154)=28.32	<0.001	0.356
RMET	27.06 (2.69)	26.65 (3.10)	26.91 (3.58)	24.37 (3.91)[a]	F(3, 154)=5.78	<0.001	0.101
Empathy							
QCAE Affective	33.61 (5.55)	34.86 (5.35)	34.53 (4.89)	33.61 (5.28)	F(3, 154)=0.55	0.651	0.011
QCAE Cognitive	59.86 (6.37)	60.51 (7.23)	60.38 (7.96)	59.56 (7.31)	F(2, 154)=0.15	0.930	0.003
QCAE Total	93.47 (9.61)	95.38 (10.55)	94.91 (9.57)	93.17 (9.14)	F(3, 154)=0.47	0.706	0.009

* Covariate: sex

[a] Significant differences: Older adults vs. all other age groups, p <.05

df degrees of freedom, *ADFES-BIV* Amsterdam dynamic facial expression set - bath intensity variations, *ToM* theory of mind, *MASC* movie for the assessment of social cognition, *RMET* reading the mind in the eyes test, *QCAE* questionnaire of cognitive and affective empathy

Empathy

The Italian version of the Questionnaire of Cognitive and Affective Empathy (QCAE) (Di Girolamo et al., 2019; Reniers et al., 2011) was used to assess self-reported empathy. The QCAE comprises 31 items, rated on a 4-point Likert scale (from 1 "strongly agree" to 4 "strongly disagree") and examine two main dimensions of empathy: Cognitive Empathy and Affective Empathy.

The scale has shown good internal consistency (Cronbach's α≥0.77) and test-retest reliability (Di Girolamo et al., 2019; Reniers et al., 2011). In line with these results, in our sample the Cronbach's alpha was good for the QCAE (α score Affective QCAE = 0.83; α score Cognitive QCAE = 0.71).

Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 28.0 (IBM SPSS Statistics for Windows, Armonk, NY, USA: IBM Corp.).

The normal distribution was assessed using the indices for asymmetry and kurtosis. All variables were normally distributed.

Firstly, the descriptive data was examined to obtain an overview of the sociodemographic characteristics of the respondents. The descriptive data were presented as means with standard deviations for continuous variables or as frequencies with percentages for categorical variables.

Secondly, comparisons were made between the four age groups on measures of social cognition using a one-way analysis of covariance (ANCOVA) for continuous variables, controlling for the possible effect of sex. Bonferroni post-hoc analyses were calculated to evaluate the pairwise comparisons between the four groups. The effect size was determined by calculating the partial eta-squared (η^2). In addition to the main analyses based on age group comparisons, we conducted sensitivity analyses by modelling age as a centred continuous variable in linear regression models. A quadratic age term was also included to test for potential non-linear age-related trends. Measures of social cognition were used as dependent variables in each regression model tested.

The level of significance for all statistical analyses was set at p <.05.

Results

Assessment of social cognition

Regarding the recognition of emotional facial expressions, the results of the univariate ANCOVA showed a significant difference between the four groups in the emotion recognition total score, after controlling for sex (p <.001; partial η^2=0.157). The ANCOVA also revealed a non-significant effect of sex on the emotion recognition total score [F (1, 154)=3.85, p =.052, η^2=0.024]. Notably, Bonferroni post hoc tests showed a statistically significant difference between older adults and all other three age groups [young adults: −5.87, 95% CI (−9.76; −1.98), p <.001; adults: −6.52, 95% CI (−10.36; −2.67), p <.001; middle-aged adults: −6.04, 95% CI (−9.70; −2.38), p <.001] (Table 2). The results of the ANCOVAs for the individual emotions (anger, disgust, fear, happiness, sadness, surprise, contempt, pride, embarrassment, neutral) are shown in Supplementary Material 1.

Similarly, the results of the univariate ANCOVAs showed a significant difference between the four groups on

the two ToM tasks we administered, after controlling for sex (MASC: p <.001; partial η^2 = 0.356; RMET: p <.001; partial η^2 = 0.101). The ANCOVA also showed a non-significant effect of sex on both ToM scores [MASC: F (1, 154) = 2.00, p =.159, η^2 = 0.013; RMET: F (1, 154) = 0.88, p =.351, η^2 = 0.006]. For MASC in particular, Bonferroni post-hoc tests showed a statistically significant difference between older adults and all other three age groups [young adults: −7.56, 95% CI (−10.33; −4.79), p <.001; adults: −8.52, 95% CI (−11.26; −4.78), p <.001; middle-aged adults: −5.99, 95% CI (−8.69; −3.39), p <.001]. For RMET, Bonferroni post-hoc tests also showed a statistically significant difference between older adults and all other three age groups [young adults: −2.76, 95% CI (−4.84; −0.68), p =.003; adults: −2.30, 95% CI (−4.36; −0.25), p =.019; middle-aged adults: −2.55, 95% CI (−4.50; −0.60), p =.004] (Table 2).

Conversely, different results were obtained for empathy. Indeed, univariate ANCOVAs revealed a non-significant difference between the four age groups on all QCAE scores (cognitive empathy: p =.930; affective empathy: p =.651; total empathy score: p =.706) (Table 2).

Sensitivity analyses using linear regression models with centred age and a quadratic age term yielded a pattern of findings broadly consistent with the main age-group analyses. Full results are reported in Supplementary Material 2.

Discussion

The main aim of the present study was to shed light on the possible presence of age differences across multiple areas of social cognition, namely facial emotion recognition, ToM and empathy.

The results showed that older people reported lower scores on all of these measures compared to the other age groups (young adults, adults, and middle-aged adults). The only exception was empathy, where no significant differences were found between the four age groups in either the affective or cognitive dimensions. Importantly, supplementary analyses modelling age as a continuous variable, with an additional quadratic term, yielded results broadly consistent with the main age-group comparisons, supporting the robustness of the observed age-related patterns. Furthermore, the possible effect of sex on age differences was also analysed. Previous research has reported a female advantage in social cognitive abilities, with women performing significantly better than men on these measures (e.g., Baron-Cohen, 2003; Courtain & Glowacz, 2019). However, in the present study no effect of sex was found for any of the social cognitive abilities examined, in line with part of the literature showing no significant sex differences in most of these abilities (e.g., Di Tella et al., 2020).

The pattern of findings we found is consistent with previous findings showing a decline in social cognitive abilities in older age. In particular, several studies have emphasised the presence of difficulties in ToM, with older adults performing worse than younger adults regardless of task types, domains and modalities (Henry et al., 2013). Accordingly, our results showed poorer performance of older adults on the two ToM tasks we used (i.e., RMET and MASC) compared to the other three age groups, with changes extending to both the affective and cognitive components of ToM.

Similarly, previous systematic reviews and meta-analyses have shown that there appear to be age-related differences in facial emotion recognition, although these are not uniform (Hayes et al., 2020; Gonçalves et al., 2018; Ruffman et al., 2008). The largest effects were found for anger, fear and sadness, while smaller effects were found for happiness and surprise, with older adults being significantly less accurate at recognising these emotions than young adults. The present study supports these findings and shows that older participants have greater difficulty recognising facial expressions of emotion. They performed worse compared to younger individuals for both negative (i.e., anger, fear, contempt, and sadness) and positive emotions (i.e., happiness and pride).

Overall, the current results seem to emphasise the presence of changes in social cognition with age that extend at least to ToM and facial emotion recognition. There are at least two possible explanations for these results. The first explanation relates to the networks in the brain that are recruited by these two components of social cognition and their patterns of change with age. Although ageing in adulthood leads to widespread gradual atrophy of the brain, it is generally recognised that the frontal and temporal regions undergo significant age-related changes (e.g., Di Domenico et al., 2025; Raz et al., 2005). In particular, loss of brain volume appears to occur earlier and more rapidly in frontal areas (e.g., Bettcher, 2018; Phillips & Henry, 2005; Ruffman et al., 2008), so it is possible that changes in these brain areas are responsible for older adults' difficulties with ToM and emotion recognition. For example, previous studies have shown that patients with lesions of the ventromedial prefrontal cortex exhibit alterations in the affective components of social cognition, whereas patients with lesions of the dorsolateral prefrontal cortex were impaired in the cognitive dimension of this domain (Shamay-Tsoory et al., 2007; Xi et al., 2011).

A second possible explanation for the present findings, which is not mutually exclusive from the first, relates to the role of executive functions, which may play a role in the decline of social cognition in old age. Executive functions, particularly working memory, inhibitory control, and cognitive flexibility, are thought to support the inferential and

regulatory processes necessary for successful ToM reasoning (Devine & Hughes, 2014). Notably, this group of abilities appears to be more involved in cognitive ToM, while results on the relationship between affective ToM and executive functions are more mixed (e.g., Bottiroli et al., 2016; Duval et al., 2011; Otsuka et al., 2021). This is not surprising, as many cognitive ToM tasks place higher demands on executive control than the corresponding control tasks (Bull et al., 2008), especially on working memory and cognitive flexibility. Conversely, affective ToM appears to rely heavily on the inhibitory control subcomponent of the executive functions. Some studies have found this to be a significant predictor of reduced performance on affective ToM tasks such as the RMET (Henry et al., 2013; Otsuka et al., 2021). Thus, while these domains can be partially separated, executive processes appear to support ToM, particularly when emotional or cognitive inference is complex, ambiguous, or context-dependent (Ahmed & Miller, 2011).

A different pattern of results was found for empathy. There were no significant differences between the four age groups in either the affective or the cognitive dimension of empathy. These results are partly contrary to previous findings, which have shown a decline in cognitive empathy (e.g., the facet of perspective-taking) with increasing age (Beadle & de la Vega 2019; Sun et al., 2018), while the more affective facets of empathy (e.g., empathic concern or personal distress) appear to remain stable or even improve (O'Brien et al., 2013; Sun et al., 2018).

The stability or improvement of affective empathy in older people could be due to several reasons. In particular, socioemotional selectivity theory (Carstensen, 2006) posits that older adults prioritise emotionally meaningful goals and invest more resources in improving the quality of social relationships compared to younger adults. Older adults have also been found to regulate their emotions more effectively than middle-aged and younger individuals (Gross et al., 1997). The combination of good emotion regulation skills and increased motivation for social interaction may promote affective empathy. Furthermore, neuroimaging studies have shown that at least some of the central brain areas involved in emotional processing (e.g., amygdala, thalamus, cingulate gyrus) show only modest structural and functional decline with increasing age (e.g., Mather, 2016; Wager et al., 2008).

Conversely, areas of the brain involved in cognitive empathy processes, such as the dorsolateral prefrontal cortex, appear to be impaired by ageing (Leclerc & Kensinger, 2010; Moran et al., 2012). Indeed, cognitive empathy is linked to executive functions and reasoning supported by prefrontal networks that are susceptible to age-related decline (Moran et al., 2012). However, in the present study, in contrast to the decline in ToM abilities, we did not find any significant differences in cognitive empathy between age groups. This apparent discrepancy may be partly explained by the different nature of the assessment tools used. While ToM was measured by performance-based tasks requiring real-time interpretation of social cues and mental states (i.e., RMET and MASC), cognitive empathy was measured by self-report (QCAE), which reflects an individual's perceived ability rather than actual performance. Indeed, self-report instruments rely on individuals' subjective evaluation of their empathic tendencies and may therefore be influenced by factors such as self-awareness, response biases, or socially desirable responding. As a result, they may be less sensitive to subtle or context-dependent changes in actual social cognitive functioning. In contrast, performance-based tasks directly assess the ability to decode emotional expressions and infer others' mental states in structured situations, which may make them more sensitive to emerging difficulties in social cognitive processing (Murphy & Lilienfeld, 2019). Previous research suggests that self-perceptions of social cognitive ability do not always match objective measures, particularly in older adults who may maintain positive self-assessment despite functional decline (Sun et al., 2018). More generally, the discrepancies observed between self-report and performance-based measures of social cognition may reflect the distinction between perceived empathic disposition and actual social cognitive performance during real-time social interactions (Keysers & Gazzola, 2014). In addition, the ToM tasks in our study likely place greater demands on working memory, attention, and cognitive flexibility — components of executive function that are known to decline with age (Salthouse, 2010). Conversely, answering a self-report questionnaire such as the QCAE requires minimal cognitive effort and may be less sensitive to subtle age-related changes.

In this context, self-report measures may capture the propensity or self-perceived tendency to empathise, whereas performance-based tasks assess the ability to accurately interpret others' emotions and mental states. Therefore, the apparent stability of empathy observed in the present study should be interpreted with caution, as it may reflect the limited sensitivity of self-report measures to detect subtle changes in social cognitive functioning. Future research combining self-report with more ecologically valid, performance-based tasks for empathy would be essential to clarify these patterns.

The study has some limitations. First, we used self-report instruments to assess some components of social cognition (i.e., empathy). Performance-based instruments or structured interviews, which depend less on individuals' awareness, should be used in addition to traditional self-report. Second, cross-sectional studies do not allow reliable conclusions about causal direction. Longitudinal studies are

needed to observe the trajectory of decline in social cognitive abilities over the life course. Third, the RMET in our sample has a low Cronbach's alpha, which may partially limit the reliability of our results. Although the RMET has been widely used as a measure of mental state inference from subtle facial cues, previous research has noted that the test often shows modest internal consistency estimates, which may reflect the heterogeneity of items and the limited number of stimuli included in the task (Higgins et al., 2026; Oakley et al., 2016). Low internal consistency introduces measurement error that can attenuate observed effect sizes and reduce statistical power (Nunnally & Bernstein, 1994). Consequently, the ability of the RMET to detect subtle differences between groups may be diminished. In the context of the present study, this limitation may have influenced the pairwise comparisons involving the RMET, potentially leading to an underestimation of the magnitude of group differences or increasing the likelihood of Type II errors. Therefore, the RMET findings should be interpreted with some caution. However, to address these issues, we used the MASC in conjunction with the RMET, which supports the conclusions regarding the ToM. The MASC has demonstrated strong psychometric properties and provides a more ecologically valid, dynamic assessment of ToM in both clinical and non-clinical populations (Dziobeck et al., 2006). Finally, although we assessed the general cognitive functioning of our participants to exclude those who showed poor cognitive performance, we did not include specific measures of executive function in the assessment, which may have played a role in the lower performance of older participants on social cognition tasks compared to the other age groups (e.g., Bottiroli et al., 2016).

Despite these limitations, the present study is among the few available studies that have investigated possible differences in social cognitive abilities among individuals of different age groups (e.g., Baksh et al., 2018; Grainger et al., 2023). In addition, we used a comprehensive battery of measures that capture key components of the social cognition domain and provide evidence that older participants may show alterations in most of these skills. A more in-depth examination of social cognition abilities is therefore of paramount importance, as difficulties with these skills have been associated with poor interpersonal functioning, reduced quality of life and inappropriate social behaviour, particularly in older people (Bath & Deeg, 2005; Fry & Debats, 2006).

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Data availability The data are available on request from the corresponding author.

Declarations

Research involving human participants and/or animals The present study was approved by the Ethics Committee of the University of Turin (protocol number 0623857) and was conducted in accordance with the Declaration of Helsinki.

Informed consent Informed consent was obtained from all participants before the start of the study.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent to publish Not applicable for the study.

Competing interests The authors have declared that no competing interests exist.

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