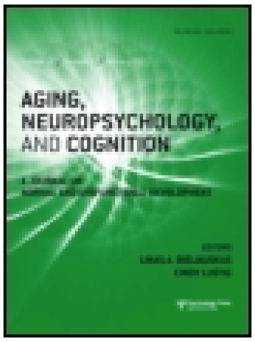

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Evidence for the role of affective theory of mind in face-name associative memory

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ABSTRACT

Poor face-name recall has been associated with age-related impairments in cognitive functioning, namely declines in episodic memory and executive control. However, the role of social cognitive function – the ability to remember, process, and store information about others – has been largely overlooked in this work. Extensive work has shown that social and nonsocial cognitive processes rely on unique, albeit overlapping, mechanisms. In the current study, we explored whether social cognitive functioning – specifically the ability to infer other people's mental states (i.e., theory of mind) – facilitates better face-name learning. To do this, a sample of 289 older and young adults completed a face-name learning paradigm along with standard assessments of episodic memory and executive control alongside two theory of mind measures, one static and one dynamic. In addition to expected age differences, several key effects emerged. Age-related differences in recognition were explained by episodic memory, not social cognition. However, age effects in recall were explained by both episodic memory and social cognition, specifically affective theory of mind in the dynamic task. Altogether, we contend that face-name recall can be supported by social cognitive functioning, namely understanding emotions. While acknowledging the influence of task characteristics (i.e., lures, target ages), we interpret these findings in light of existing accounts of age differences in face-name associative memory.

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Face-name learning; aging; social memory; theory of mind; lures

Memory declines with age (e.g., Salthouse, 2019), and an abundance of work has shown that associative memory is particularly sensitive to this decline (see Naveh Benjamin & Mayr, 2018). Associative memory refers to the process of encoding, storing, and retrieving paired information, such as word pairs (e.g., Naveh Benjamin et al., 2007) or face-landscape sets (e.g., Greene & Naveh Benjamin, 2020). Irrespective of the association to be learned, age-related deficits are often attributed to deficiencies in the ability to bind new information together (see MacKay & Burke, 1990 or Naveh Benjamin, 2000), inhibit irrelevant information (e.g., Hasher & Zacks, 1988), or spontaneously engage in deep-level processing (see Craik & Rose, 2012). Because these mechanisms are not mutually exclusive, associative memory across adulthood is generally thought to be dictated by the availability of cognitive resources more generally. However, it is also possible that additional mechanisms support associative memory, particularly when the paired information

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contains social stimuli (e.g., face-name pairs). In the current study, we explore this possibility by considering how social cognitive function – the ability to process, store, and remember information about others – uniquely contributes to face-name associative memory performance in a sample of older and young adults.

Associative memory deficits are well-documented across myriad stimuli (i.e., words, objects, pictures) whereby associations are harder to remember than the individual items in the association (Naveh Benjamin & Mayr, 2018). Associative memory has important diagnostic value. For example, differences between cognitively normal and pathological decline are better predicted when face-name pairs are used than when words or space-object pairs are used (Weissberger et al., 2017). One reason for this is that dissociable neural pathways support social (i.e., face-name) versus nonsocial (i.e., word pairs) associative learning (e.g., Metoki et al., 2017). Indeed, because the fusiform gyrus has been widely implicated in face processing (Kanwisher & Yovel, 2006), face-name social associative memory may be particularly sensitive to aging due to its reliance upon multiple neurological mechanisms. Consistent with this assertion, prior work has shown that older adults have reduced activation in the fusiform gyrus than young adults when encoding faces or face-based associations (Dennis et al., 2008). Other work suggests that the fusiform gyrus becomes less-efficient for face-based processing (e.g., Zebrowitz et al., 2016), and this may be due to the fact that people automatically derive myriad inferences from facial characteristics (e.g., trait judgments: Willis & Todorov, 2006; sexual orientation: Rule & Ambady, 2008; emotion: Adams et al., 2012; see Hugenberg & Wilson, 2013 for a review).

Face-name memory is a well-studied phenomenon that is a challenge at all ages, but more difficult in later life (Horn et al., 2018; Naveh Benjamin & Mayr, 2018), particularly face-name recall (S. Rhodes et al., 2019). Recall processes may be more ecologically valid as they better reflect daily contexts in which a face is seen, and a name must be retrieved. This could be why face-name recall is more sensitive than face-name recognition for detecting cognitive decline (e.g., Amariglio et al., 2012; Rentz et al., 2011; Sanabria et al., 2018; Weissberger et al., 2017). For instance, lower hippocampal activity during face-name recall is associated with having mild cognitive impairment (O'Brien et al., 2010) and greater risk factors for brain pathology related to Alzheimer's disease (Sanabria et al., 2018; Toepper, 2017).

One potential reason that face-name associative memory, particularly recall performance, may be sensitive in detecting cognitive decline is its association with several core cognitive functions, including episodic memory and executive control (e.g., Amariglio et al., 2012; Rentz et al., 2011; Sanabria et al., 2018; Weissberger et al., 2017). However, each plays a unique role in face-name memory. For example, performance on episodic memory tasks (i.e., learning a list of words) is related to face-name associative memory, especially when retrieval is delayed (e.g., Amariglio et al., 2012; Rentz et al., 2011). Having poor executive control disrupts older adults' ability to filter out task-irrelevant information for encoding (Deiber et al., 2010), which presents barriers to associative binding when switching between face-based tasks (e.g., Weeks et al., 2016). Consistent with this assertion, older adults are more susceptible to memory intrusions than young adults (Healey & Kahana, 2015) and more disrupted by distractors (e.g.,Tse et al., 2010; Zanesco et al., 2020). These effects have been commonly observed using *lures*—incorrect stimuli that are related to correct stimulus (Greene & Naveh Benjamin, 2020; Pantelis et al., 2008; Papp et al., 2021). However, although face-name associative memory indisputably requires episodic memory and executive control (e.g.,Dennis et al., 2008; Monge et al., 2018; Rentz et al., 2011), unexplained variance remains. We contend that social cognition – the process of learning, remembering, and applying details about people (i.e., Fiske & Taylor, 1991) – may support face-name memory, particularly when memory demands are high (i.e., delayed recall).

Because faces are rich in social information (see Hugenberg & Wilson, 2013 for a review), they likely require deeper encoding than nonsocial cues (e.g., words, pictures of objects), which may enhance subsequent memory. Indeed, prior work has shown that memory for faces is aided by the ability to detect and integrate subtle facial cues such as eye gaze (e.g., Lopis et al., 2019). People who have difficulty detecting these cues (i.e., people on the autism spectrum; Fedor et al., 2018) often have poorer face-name memory (Boucher et al., 2012). Within the context of aging, Chan et al. (2018) showed that older adults engaged in less analytic patterns of face processing (i.e., fixating less on eye regions) than young adults, which related to poorer face recognition. This effect was exacerbated among older adults with lower executive function.

Counteracting these face processing differences, remembering information paired with faces is positively related to more complex social cognitive abilities (e.g., Franklin & Adams, 2010). Specifically, older adults are better at remembering to whom they told something (i.e., face-information binding) if they are better at inferring the thoughts and emotions of others, also referred to as theory of mind (El Haj et al., 2016). This could be due to the fact that theory of mind requires spontaneous decoding of facial cues, possibly facilitating deeper encoding in any face-based task. In fact, a classic theory of mind task is the Reading the Mind in the Eyes test (RMET; Baron-Cohen et al., 2001) which has people decode mental states from photographs displaying only someone's eyes. Crucially, El Haj et al. (2016) found that older adults were significantly worse than young adults at several theory of mind tasks including RMET, partially contributing to age differences in face-information memory. Thus, age-related differences in attending to, decoding, and applying facial cues (i.e., using theory of mind) may provide another explanatory mechanism for age effects in face-name associative memory.

Theory of mind is conceptually complex (Apperly, 2012) and includes a wide range of functions, including, but not limited to, the ability to infer beliefs, understand others' emotions, detect deception, and identify social faux pas (Baron-Cohen, 2001; Quesque & Rossetti, 2020). Theory of mind is generally examined in two subcomponents: cognitive (i.e., understanding beliefs, thoughts, and motivations of others) and affective (i.e., understanding feelings and emotions of others). Older adults tend to perform worse than young adults on cognitive theory of mind tasks (see Henry et al., 2013 for a review) whereas these age differences are attenuated on affective tasks (e.g., Bottiroli et al., 2016; Charlton et al., 2009; Duval et al., 2011) or sometimes not present at all (e.g., Castelli et al., 2010; Li et al., 2013). This pattern holds true even in the face of pathological impairments (e.g., Demichelis et al., 2020).

Prior work suggests that cognitive theory of mind may predict better social associative memory (e.g., El Haj et al., 2016). Critically, the cognitive and affective tasks in that study used static stimuli that have been critiqued for their lack of specificity (Quesque & Rossetti, 2020; Schaafsma et al., 2015). In fact, theory of mind research has shifted toward using dynamic stimuli to better reflect the complexity of real-world social interactions (e.g., Byom & Mutlu, 2013; Dziobek et al., 2006; Feyerabend et al., 2018; Grainger et al., 2019; Johansson Nolaker et al., 2018). Dynamic tasks better represent how theory of mind unfolds in daily life (see Hamilton et al., 2022 for discussion) and usually elicit stronger age differences (e.g., Grainger et al., 2019, 2021; Henry et al., 2013). Recent work using a mockumentary-style television show measuring multiple aspects of each subcomponent shows that specific abilities (i.e., inferring beliefs, inferring emotions) have unique relationships to different aspects of social connectedness in later life (Krendl, Kennedy, et al., 2022). This suggests that unique types of theory of mind (e.g., inferring beliefs, understanding emotions) may aide in comprehending nuanced situational cues that could contribute to real-world social outcomes. Therefore, face-name associative memory could relate to specific domains of theory of mind when measured via a dynamic task.

The present study

In the present study, we examined whether social cognitive function uniquely contributed to older adults' face-name memory. In doing so, we hope to extend past literature that exclusively focuses on cognitive decline as the mechanism behind age deficits in face-name associative memory. Recall is more sensitive to cross-sectional age effects (S. Rhodes et al., 2019) and has higher diagnostic value (e.g., Amariglio et al., 2012; Rentz et al., 2011; Sanabria et al., 2018; Weissberger et al., 2017). Therefore, we were primarily concerned with how age effects in recall could be explained by cognitive and/or social cognitive factors. However, because delayed recognition performance can also bear diagnostic importance (e.g., Weissberger et al., 2017), we examined both to establish whether social cognitive functioning is related to only the more difficult process (i.e., recall) or face-name memory altogether (i.e., recall and recognition).

With this theoretical rationale in mind, we predicted that age effects in face-name learning could be explained by cognitive *and* social cognitive performance. With regard to overall performance, young adults were expected to outperform older adults on recall and less dramatically on recognition, replicating past research (e.g., Danckert & Craik, 2013; seeS. Rhodes et al., 2019 for meta-analysis). Consistent with prior work, we focused on theory of mind (El Haj et al., 2016) and controlled for demographic factors and cognitive function (episodic memory, executive function). Critically, we measure cognitive and affective theory of mind using a dynamic task with specific subtypes of each component to extend and build on prior work (e.g., El Haj et al., 2016; Krendl, Kennedy, et al., 2022; Krendl, Mannering, et al., 2022).

An exploratory goal of the current investigation was to evaluate whether perceptual biases contribute to older adults' face-name associative memory. Specifically, face-name pairs for in-group (i.e., same-age) targets are better remembered than outgroup (i.e., other age) targets by older and young adults (Strickland-Hughes et al., 2020). Thus, we were concerned with how the *own-age bias* (e.g., M. Rhodes & Anastasi, 2012) might influence the degree to which age effects in face-name associative memory emerge. We used old and young age faces to evaluate this bias; however, we also implemented critical lures (i.e., previously learned, but incorrect names) with same and different age faces. Critical lures have been shown to lead to poorer associative memory (e.g., Greene & Naveh Benjamin, 2020; Papp et al., 2021), though it remains unknown whether it extends to age differences in face-name memory. Prior work has shown that older adults' susceptibility to lures may be related to their poorer executive control and/or episodic memory (e.g., Healey & Kahana, 2015; Weeks et al., 2016; Zanesco et al., 2020). It could be that the presence of lures minimizes the own-age bias such that age differences in cognitive resources contribute to greater susceptibility to lures in older adulthood. However, if lures strengthen the magnitude of the bias, this could suggest that perceptual biases may be protective against face-name memory decline for ingroup targets. This exploratory aim will test if the own-age bias is moderated by task characteristics (i.e., target age, presence of lures), which will provide additional context for understanding age differences in face-name memory beyond cognitive and social cognitive abilities.

Method

Participants

A total of 153 cognitively normal older adults (M_{age} = 74.04, SD = 7.02; 61% female) and 136 young adult participants (M_{age} = 18.97, SD =.92; 63% female) were recruited from August 2021 to April 2022 from the Bloomington, IN area. Older adults were recruited via community-based methods (i.e., outreach, ads) and were pre-screened for cognitive impairment via telephone using the well-validated, six-item screener (Callahan et al., 2002). Young adults were undergraduate students at Indiana University and completed the study for partial course credit. Table 1 contains demographics by age group[1]. This study was approved by the Institutional Review Board at Indiana University.

Table 1. Demographic information by cohort.

	Young Adults (*n* = 136)	Older Adults (*n* = 153)
Age	19.0 (.92)	74.0 (7.02)
Sex		
Men	34 (25%)	52 (34%)
Women	86 (63%)	101 (66%)
Undisclosed	2 (1%)	–
Race		
AAPI	9 (7%)	2 (1%)
Black	8 (6%)	1 (1%)
White	93 (68%)	149 (97%)
Other (i.e., mixed)	12 (9%)	1 (1%)
Relationship Status		
Single	88 (65%)	8 (5%)
In a Relationship	34 (25%)	–
Married	–	84 (55%)
Divorced	–	36 (24%)
Separated	–	–
Widowed	–	17 (16%)
Years of Education		
High School	43 (32%)	9 (6%)
Some College	77 (57%)	23 (15%)
College Graduate	2 (1%)	46 (30%)
Advanced Degree	–	67 (44%)

Note. For age, means are reported with standard deviations in parentheses. For all other variables, frequencies are reported with percentages in parentheses. 14 young adults did not complete demographic questionnaires due to time constraints for testing. AAPI = Asian American/Pacific Islander.

Materials

Face-name learning

Our face-name learning task consisted of 16 face-name pairs, with an equal number of old and young faces as well as male and female faces (see Sperling et al., 2001; Sperling, 2003). This design is similar to related work (Rentz et al., 2011) and has high test-retest reliability (Amariglio et al., 2012). Faces were neutrally expressive and selected from the PAL database (Minear & Park, 2004). Faces were matched for attractiveness and distinctiveness and paired with age- and gender- matched names. Age-matched names were chosen using the United States Social Security Administration database (https://www.ssa.gov/oact/babynames/decades) for the decades of 1930–1940 for older targets and 1990–2000 for young targets. For both target ages, the top 8 names were selected for each gender. Of those, four were used as correct responses and four as incorrect foils. Name and face pairing were counterbalanced using a Latin square design with four versions allowing for each pairing to occur once within target age and gender categories. No version effects emerged for recall or recognition ($F < 2.50$, $ps > .05$).

Participants were told before the task that they would be asked to remember the face-name pair. They then passively viewed each pair for 2 s. Stimuli were presented using DirectRT. After approximately 10 min, participants completed a free recall task (i.e., only faces presented, and participants had to generate the names themselves). This was immediately followed by cued recognition in which one face presented with two name options: one correct and one incorrect. Incorrect names were divided into novel names (i.e., new foils), and the other half used old, but incorrectly paired, names (i.e., lures). Consistent with similar work (Amariglio et al., 2012; Rentz et al., 2011), we calculated raw scores for recall and percent scores for recognition via the number of correct responses divided by the number of total responses.

Cognitive abilities

We measured episodic memory using an auditory verbal learning test (Rey, 1964) and executive control using the Trail Making test (Bowie & Harvey, 2006; Sánchez-Cubillo et al., 2009). For episodic memory, we used the number of words correctly recalled after an interference trial and retention delay (15–20 min), which may be a more sensitive measure of cognitive decline (e.g., Dias et al., 2021). For the Trail Making test, we created a standardized residual score by using linear regression to predict Part B completion time from Part A completion time to isolate executive functioning from processing speed (e.g., Salthouse, 2011). Differences between actual and predicted scores were calculated for each participant which equals the error in prediction (i.e., residual variance) which was then standardized. This effectively models age effects in executive control, namely task switching abilities (e.g., Salthouse, 2011), and has been previously related to social associative memory and theory of mind in older adulthood (El Haj et al., 2016). Moreover, this approach is commensurate with findings that Part B shows greater sensitivity to cognitive decline (Ashendorf et al., 2008; MacPherson et al., 2017).

Theory of mind

We measured theory of mind in a dynamic video task whereby participants viewed 25 sequentially ordered clips, ranging from 10–60 seconds, from *Season 1, Episode 4* of the sitcom The Office© (see Krendl, Kennedy, et al., 2022 for a similar approach; see Krendl, Mannering, et al., 2022 for psychometric properties). Participants answered 2–4 questions after each clip with each question evaluating one distinct aspect of theory of mind. Question generation and categorization procedures are described in Krendl, Mannering, et al. (2022). Cognitive theory of mind had three subcomponents: inferring motivation (10 items), inferring others' beliefs (nine items), and detecting deception (10 items). Affective theory of mind had two subcomponents: understanding emotions (10 items) and recognizing a faux pas (10 items). There were also 15 control items interspersed throughout the task to check for overall clip comprehension. For all 64 questions, response time was unconstrained. Afterward, participants answered several questions about the show including whether they had seen the show before (*Yes* = 1 or *No* = 0)[2]. This task is modeled after research on social comprehension among individuals with autism (Byrge et al., 2015; also see Halberstadt et al., 2011 for a similar approach). Although there is some statistical overlap with significant correlations emerging across all categories ($r = .36$ to $.70$, all $ps < .001$; see Table 2), these subcomponents are theoretically distinct and variance inflation factors from the regression modeling indicated no issues of multicollinearity[3]. Accuracy was calculated for each subcomponent as a proportion correct (number correct/total number of responses).

To remain consistent with past literature, we used the classic Reading the Mind in the Eyes test (RMET; Baron-Cohen et al., 2001) which uses static images. RMET is sometimes referred to as a measure of emotion recognition (e.g., Guastella et al., 2010) as it has a moderate to strong relationship with facial emotion perception tasks (Henry et al., 2009; Petroni et al., 2011). However, this task is widely known as a traditional measure of theory of mind (see Moran, 2013) and has been used in past literature on social associative memory (e.g., El Haj et al., 2016). The task uses 36 trials where a person's eyes are displayed with four emotion words. Participants are asked to select the one correct response from three incorrect foils. Accuracy was calculated as a proportion with the number of correct trials divided by the total number of trials.

Analytic approach

The design and analyses were not preregistered, but a priori power analyses were conducted in G*Power 3.1 (Faul et al., 2007) with parameters of $\alpha = .05$ and $\beta = .80$ used with two-tailed estimates and small to medium effect size estimates (effect size $f^2 = .10$). The highest necessary sample size was 151 participants to detect

Table 2. Correlations between age, social cognitive, and cognitive variables.

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1. Age	––								
2. RMET	.02	––							
3. Deceit Detection	−.49***	.17**	––						
4. Infer Emotion	−.36***	.22***	.51**	––					
5. Detect Faux Pas	−.16**	.34***	.38***	.40***	––				
6. Infer Belief	−.33***	.19**	.70***	.53***	.45***	––			
7. Infer Motivation	−.13*	.25***	.52***	.40***	.37***	.53***	––		
8. Executive Control	−.35***	−.05	−.19**	−.18**	−.19**	−.29***	−.19**	––	
9. Episodic Memory	.18**	.29***	.51***	.30***	.20***	.54***	.32***	−.17**	––

Note. Executive control scores are residuals with higher scores indicating worse performance. RMET = Reading the Mind in the Eyes test. † $p < .10$; * = $p < .05$; ** $p < .01$; *** $p < .001$.

a significant ΔR^2 when adding all social cognitive predictors after controlling for general cognition. Prior to conducting analyses, outliers were identified as being more than 2 SD away from mean recognition scores and over 1.5 times the interquartile range. Eight participants (4 young; 4 older) were identified as outliers and excluded from all analyses. Due to computer-saving errors, data were lost or corrupted for 36 older adults and 6 young adults. Thus, the analytic sample comprised of 130 young and 113 older adults which satisfies all power demands which indicates that any significant effects can be meaningfully interpreted. The primary hypothesis was tested via hierarchical linear regression with demographic variables (i.e., age group, gender, education) included in Step 1, cognitive variables in Step 2 (i.e., executive function, episodic memory), and social cognitive variables in Step 3. The outcomes were face-name recall and recognition, with priority given to the changing in variance explained (i.e., ΔR^2). Analyses were conducted in SPSS 28.0 (IBM Corp, 2021).

Results

Prior to testing differences in face-name performance, we examined age differences in cognitive and social cognitive predictor variables. Using independent-samples *t*-tests, Table 3 shows performance across age group. Except for RMET[4] (*p* = .45), age differences emerged across all variables with young adults outperforming older adults (all *p*s < .01). The differences are generally consistent with past work in theory of mind and cognitive functioning (e.g., Demichelis et al., 2020; Krendl, Kennedy, et al., 2022; Moran, 2013; c.f. Kynast et al., 2020; Lee et al., 2021 for RMET), although there is mixed evidence regarding the magnitude of age differences in affective theory of mind (e.g., Bottiroli et al., 2016; Charlton et al., 2009; Duval et al., 2011). Revisiting the correlations in Table 2, the cognitive and social cognitive variables may appear to be moderately correlated due to the relatively strong age effects across nearly all variables. We examined variance inflation factors to ensure statistical validity which showed no factors over 2.5, and thus multicollinearity is not an issue for the following results.

Table 3. Age effects on predictor variables for the analytic sample.

Variable	Young Adults (*n* = 130)	Older Adults (*n* = 113)	*t*	*p*	*d*
Executive Control	−.17 (.65)	.20 (1.26)	2.94	.002	.38
Episodic Memory	11.12 (2.53)	8.60 (3.80)	6.12	<.001	.79
RMET	.71 (.11)	.71 (.13)	.13	.45	.02
The Office® Task					
Control Items	.96 (.06)	.88 (.13)	5.86	<.001	.77
Deceit Detection	.94 (.08)	.76 (.25)	7.76	<.001	1.01
Inferring Beliefs	.95 (.08)	.85 (.16)	6.02	<.001	.79
Inferring Motivation	.93 (.09	.89 (.13)	3.07	.001	.40
Faux Pas Detection	.92 (.10)	.88 (.11)	2.67	.004	.35
Inferring Emotion	.83 (.14)	.71 (.18)	6.07	<.001	.79

Note. Means are reported with standard deviations in parentheses. Executive Control is the standardized residual variance from predicting Trails B from Trails A with lower scores being better. Episodic Memory is the number of correctly recalled items on the Rey learning task from the delayed recall trial. RMET = Reading the Mind in the Eyes test. Cohen's *d* is reported in the final column as an indicator of effect size.

Primary hypothesis: explaining age effects via general and social cognitive functioning

First, we confirmed that there were age effects in recall and recognition using independent samples *t*-tests. As expected, age effects were significant for recall ($t(241) = 4.10$, $p < .001$, Cohen's $d = .53$) and recognition ($t(241) = 4.27$, $p < .001$, Cohen's $d = .55$) with young adults ($M = 4.37$, $SE = .22$ for recall; $M = 12.11$, $SE = .19$ for recognition) performing better than older adults ($M = 3.03$, $SE = .24$ for recall; $M = 10.92$, $SE = .21$ for recognition). Next, hierarchical linear regression analyses were used to evaluate whether age effects in could be attributed executive control, episodic memory, and/or social cognitive abilities. As shown in Table 4, age effects were eliminated after controlling for cognition with the overall model being significant for recall ($\Delta F(2,219) = 19.72$, $p < .001$, $R^2 = .24$) and recognition ($\Delta F(4,219) = 4.76$, $p = .009$, $R^2 = .12$). For both models, Step 2 showed significant improvement in the amount of variance explained with only episodic memory predicting age differences in face-name memory whereas executive control had no association.

When adding social cognitive predictors in Step 3, model fit was not significantly increased for recognition ($\Delta F(7,212) = .76$, $p = .61$, $\Delta R^2 = .02$), but it was for recall ($\Delta F(7,212) = 2.23$, $p = .033$, $\Delta R^2 = .05$). Aligning with predictions, inferring emotions in The Office® task (β = .22, SE =.07, 95 CIs [.07, .36]) was driving this model fit increase whereas RMET was not significantly associated (β = .12, SE =.07, 95% CIs [–.00, .26], $p = .06$). No aspects of cognitive theory of mind predicted face-name recall (all *p*s > .10). More importantly, in these full models, all variance inflation factors were less than 2.5 indicating no issues of multicollinearity. Our use of hierarchical modeling allows us to assert that the effects of affective theory of mind, namely the ability to infer emotions, are present even after modeling the influence of general cognition. Thus, while age effects in face-name recall and cued recognition were sufficiently explained by episodic memory, the ability to

Table 4. Hierarchical regression models for predicting social associative memory.

	Recall			Recognition		
Variables	*Step 1*	*Step 2*	*Step 3*	*Step 1*	*Step 2*	*Step 3*
Demographics						
Gender	.18**	.08	.06	.03	−.02	−.04
Education	.08	.04	−.01	−.05	−.06	−.09
Age Group	−.31***	−.13	−.09	−.23*	−.16	−.10
Cognition						
Executive Control		−.07	−.05		.02	.04
Episodic Memory		.40***	.37***		.22**	.16†
Social Cognition						
RMET			.12†			.05
The Office®						
Control Items			−.01			−.06
Deceit Detection			−.08			.08
Inferring Beliefs			.07			.13
Inferring Motivation			−.11			−.08
Faux Pas Detection			−.02			.02
Inferring Emotion			.22**			.04
Total R^2	.10	.24	.29	.08	.12	.14
ΔF	8.54	19.72	2.23	6.13	4.76	.78
ΔR^2	.10	.14	.05	.08	.04	.02
p	<.001	<.001	.033	.001	.017	.61

Note. Standardized β-weights are presented by step. RMET = Reading the Mind in the Eyes test. † $p < .10$; * = $p < .05$; ** $p < .01$; *** $p < .001$.

infer emotions is still significantly associated with greater face-name recall. See Figure 1 for a visualization of this effect.

Exploratory hypothesis: task effects on face-name associative memory

Omnibus analyses for recall performance utilized a 2 (Perceiver Age; Young, Older) × 2 (Target Age; Young, Older) mixed ANOVA. As expected, a significant main effect of Perceiver Age emerged ($F(1,241) = 17.39$, $p < .001$, $\eta_p^2 = .07$) as well as the main effect of Target Age ($F(1,241) = 5.89$, $p = .016$, $\eta_p^2 = .02$); however, the interaction was not statistically significant ($F(1,241) = 2.79$, $p = .096$).[5] Older adults ($M = 2.89$, 95% CIs [2.43, 3.33]) correctly recalled fewer names than young adults ($M = 4.33$, 95% CIs [3.89, 4.74]). Names for older faces ($M = 1.98$, 95% CIs [1.77, 2.17]) were correctly recalled more often than names for young faces ($M = 1.72$, 95% CIs [1.54, 1.89]). It should be noted that average recall performance was low (below 50% on average), but this is not inconsistent with prior work (e.g., Amariglio et al., 2012; Papp et al., 2014; Rentz et al., 2011 c.f. Strickland-Hughes et al., 2020). With no significant interaction, there is no indication of an own-age bias for recall.

Examining recognition performance with added element of critical lures via name cues, we used a 2 (Perceiver Age; Young, Older) × 2 (Target Age; Young, Older) × 2 (Cue Type; Critical Lure, New Foil) mixed ANOVA. The dependent variable was the proportion of correct trials whereby a correct trial was marked by recognizing the correct name rather than the foil. The main effect of Target Age ($p = .37$) and its interaction with Perceiver Age ($p = .83$) and Cue Type ($p = .17$) were not statistically significant. Conversely, the main effect of Cue Type was significant ($F(1,241) = 19.12$, $p < .001$, $\eta_p^2 = .07$) along with the Perceiver Age main effect ($F(1,241) = 18,48$, $p < .001$, $\eta_p^2 = .07$) and the Perceiver Age ×

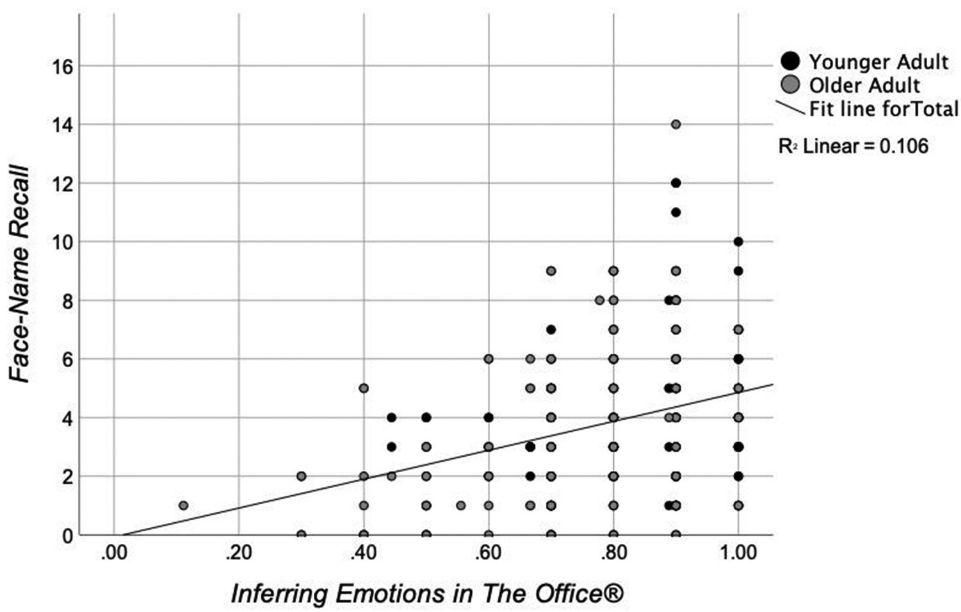

Figure 1. The linear association between face-name recall and inferring emotions.

Cue Type ($F(1,241) = 24.67$, $p < .001$, $\eta_p^2 = .09$) interaction. However, these effects were all qualified by a significant 3-way interaction ($F(1,241) = 6.70$, $p = .01$, $\eta_p^2 = .03$).

We deconstructed this 3-way interaction using a simple interactions approach to isolate the Target Age × Cue Type interaction for each age group and pairwise mean difference tests with Bonferroni corrections for multiple comparisons. Young adults showed a significant interaction ($F(1,129) = 9.59$, $p = .002$, $\eta_p^2 = .07$) whereas older adults did not ($p = .44$), only showing a significant main effect of Cue Type ($F(1,112) = 34.62$, $p < .001$, $\eta_p^2 = .24$). As shown in Figure 2, young adults were worse ($p = .022$) at recognizing names for older faces that used critical lures (*M* = .73, 95% CIs [.69, .77]) when compared to young faces with lures (*M* = .79, 95% CIs [.76, .83]) but did not show this effect for new foils ($p = .19$). On the other hand, older adults were worse ($p < .001$) at recognizing names paired with critical lures (*M* = .62, 95% CIs [.58, .65]) versus new foils (*M* = .75, 95% CIs [.72, .78]), but they did not differ in performance based on the age of target faces ($p > .30$). Moreover, simple main effects of Perceiver Age only emerged for critical lure trials (*F*s>12.50, *p*s < .001), although more strongly for young faces ($\eta_p^2 = .14$) than older faces ($\eta_p^2 = .05$). Altogether, it appears that the own-age bias manifested in cued recognition, but only for young adults when viewing critical lure trials. Older adults were more susceptible to lures overall with no moderation by target age.

Discussion

The main goal of this study was to further extend our understanding of age differences face-name learning. We replicated age differences in face-name recall and face-name recognition but found a unique role for social cognitive function. Specifically, we found that although episodic memory adequately explained age differences in recognition, the ability to infer emotions also predicted older adults' recall performance. This finding suggests that, in addition to general cognitive

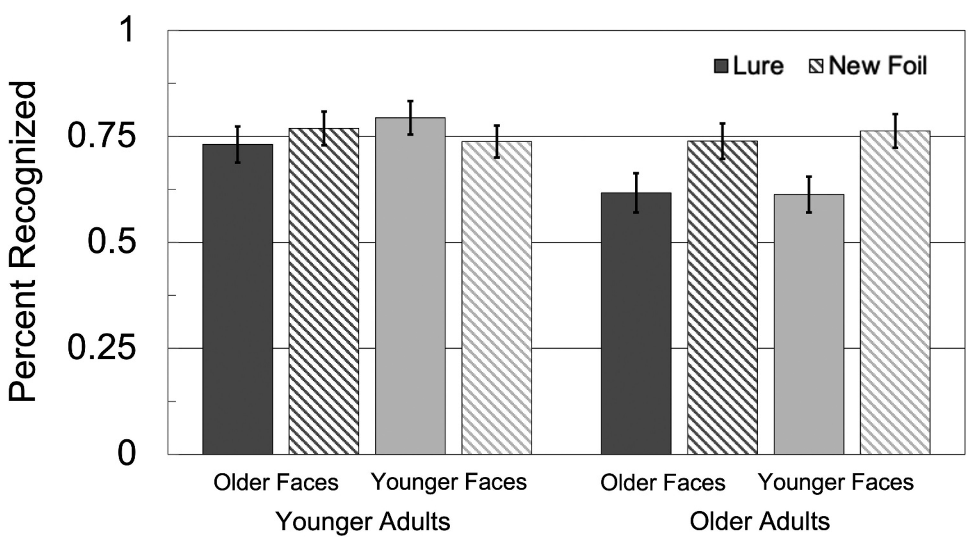

Figure 2. Visualizing the 3-way interaction for face-name recognition.

function, social cognitive function also contributes to some aspects of associative memory, notably face-name recall. A secondary finding from the current study was that there was an own-age bias for face-name recognition, however, this was only the case for young adults. Here we found that, when deciding between two previously presented names (i.e., critical lure trials), young adults performed worse with opposite-age faces whereas older adults performed worse irrespective of the target face age. Conversely, there were no differences when viewing faces novel distractor cues.

Inferring emotions is associated with recall, but not recognition

To begin interpreting these results, it is not surprising that age differences in face-name associative memory emerged in recall and recognition. Existing work shows that both types of performance can be useful as a diagnostic tool for cognitive decline when using memory retention intervals (e.g., Amariglio et al., 2012; Rentz et al., 2011; Sanabria et al., 2018; Weissberger et al., 2017). Yet, it is well-documented that age effects in recall are larger than those detected in recognition (e.g., Danckert & Craik, 2013; S. Rhodes et al., 2019). Moreover, successful free recall is contingent upon self-initiated retrieval processes which have been implicated in older adults' poor associative memory overall (e.g., Craik & Rose, 2012; Hargis & Castel, 2017; Troyer et al., 2006). Therefore, we assert that there is added theoretical value to theory of mind being associated with recall given that it is a more demanding type of memory.

The ability to infer the emotional states of others may support face-name recall through relatively automatic processes associated with face processing. Using a two-systems account of theory of mind, inferences about others' feelings operates through relatively automatic sensory channels (e.g., face perception) and effortful processes requiring cognitive resources (Frith & Frith, 2008). Although affective theory of mind seems to be less impacted by aging than cognitive subcomponents (e.g., Bottiroli et al., 2016; Charlton et al., 2009; Demichelis et al., 2020; Duval et al., 2011), both young and older adults performed worse on the inferring emotions items from *The Office*® task relative to all other subcomponents (see Table 3). Given its difficulty, face-name recall may be uniquely associated with this aspect of theory of mind precisely because additional mechanisms are necessary for successful performance. This raises the possibility that deficits in the ability to infer emotions could detract from associative binding and produce more errors, which appears to be the case in our study.

It is important to note that the dynamic measure from *The Office*® was significantly associated with face-name recall whereas the static measure was not (see Table 3). Dynamic measures of social cognition may elicit stronger differences (e.g., Grainger et al., 2019, 2021; Henry et al., 2013), and this was indeed the case within our sample (see Table 2). Moreover, dynamic measures have been shown to be stronger predictors of social connectedness in later life (Krendl, Kennedy, et al., 2022). Consequently, the significant association between dynamic, and not static, social cognitive processes suggests that face-name recall is more strongly connected to the efficacy of extracting task-relevant information in real-time. In general, people who have difficulty recognizing and applying information about others are worse at associating social information together (e.g., Boucher et al., 2012) which also emerges in older adults (e.g., El Haj et al., 2016). Thus, it remains plausible that theory of mind, namely the ability to infer emotions, can support face-name learning, due to its automatic *and* context-dependent nature.

Automatically extracting and contextualizing facial information on a person-specific basis (i.e., using theory of mind) is a socially desirable ability that has important downstream consequences. Indeed, the ability to infer emotions is related to having more distant, non-close relationships in older adulthood (Krendl, Kennedy, et al., 2022), and being able to detect socially inappropriate behavior (i.e., faux pas) is associated with being less lonely (Radecki et al., 2019). Regarding face-name associative memory, remembering a name of a new acquaintance likely aides in future interactions by promoting perceptions of intrapersonal closeness or relationship importance (e.g., Ray et al., 2019). Therefore, we contend that these findings add to the growing body of literature that demonstrate the importance of theory of mind, particularly the ability to infer emotions, for a variety of social behaviors including face-name learning.

Critical lures and the own-age bias

As shown in Figure 1, the own-age bias was demonstrated by a deficit in recognizing names for opposite age faces, but only for young adults on critical lure trials. While this is partially consistent with past work (e.g., He et al., 2011; M. Rhodes & Anastasi, 2012; Strickland-Hughes et al., 2020), it is unclear why the own-age bias did not emerge in older adults. Indeed, only the main effect of Cue Type was evident for older adults (see Figure 2). One possibility is that this discrepancy reflects older adults' increased sensitivity to lures in general. Recent work has shown how older adults, relative to young adults, may have difficulties with highly specific information while retaining more gist-level aspects of face-based associations (Greene & Naveh Benjamin, 2020). Therefore, lures that are specifically designed to be related to the correct response are particularly attuned to their processing biases. Thus, older adults in our study might not have shown an own-age bias due to poor specificity for name encoding for a particular face, irrespective of the target age. This interpretation appears to align with an executive control account of age differences in associative memory whereby the allure of incorrect but familiar responses is greater for older adults.

There are two important caveats for this interpretation. First, older adults performed equally as well as young adults on our measure of executive control (see Table 3), and this was entirely unrelated to face-name recall and recognition overall (see Table 4). Therefore, executive control differences may seem to be an implausible justification for the differences in own-age biases. Though it is possible that our measure of executive control was not sufficiently sensitive to detect differences, the Trail Making test has been shown to be related to theory of mind (see Table 2) and social associative memory in prior work (see Table 2; see also El Haj et al., 2016). Regardless, future work should utilize a more comprehensive battery of executive functioning (i.e., Stroop test; Backwards Digit Span) to probe this further. It is important to note that past research also shows that older adults may simply display the own-age bias to a lesser degree (e.g., M. Rhodes & Anastasi, 2012). Thus, the non-apparent own-age bias here may simply be due to the overpowering effect of lures, and future work should explore how own-age biases are affected by these task features to address these discrepancies.

Future directions and concluding remarks

One limitation to the current study is that we intentionally omitted facial expressions of emotion from the target faces to be learned. Using emotional faces can reduce the magnitude of the own-age bias in young adults (Cronin et al., 2018), and emotional expressions aide facial recognition more broadly (Denkinger & Kinn, 2018). Moreover, the role of inferring emotions could possibly be strengthened with increased perceptual overlap by using emotional faces (see Stewart et al., 2019 for an example). This could also connect to broader age-related processing biases with regard to emotion perception (i.e., age-related positivity: see Reed et al., 2014) such that affective theory of mind only predicts face-name recall for faces with positive expressions. Since we used neutral faces, we can only speculate on how our findings would change if facial expressions of emotion were included. Future work can investigate whether these associations are strengthened or weakened by certain types of emotional faces. Nevertheless, our results still demonstrate that the ability to infer emotion clearly relates to face-name recall above and beyond cognitive theory of mind as well as the effects of general cognition.

Given that our findings center around the use of a relatively novel and dynamic measure, we implore fellow social cognitive aging researchers to develop other techniques that require more context-driven judgments and increase representative design (see Hamilton et al., 2022 for a discussion). While some materials exist (e.g.,Baksh et al., 2020; Breil et al., 2021), we hope that our findings provide impetus for further creation (e.g., a full database of video clips that engage various aspects of theory of mind) and refinement (e.g., age norms for performance). As a final note, we remind the readers (and ourselves) that our science will only improve with the development and implementation of more rigorous measurements.

Altogether, we have shown that inferring emotions may encapsulate highly desirable skills that aid in social information processing such as successful pairing a name to a face. Although a relatively modest starting point, we contend that these results reinforce the importance of disentangling cognitive and social cognitive components of social behavior. Ultimately, we hope that future research will continue to make strides toward identifying the distinct influence of both general and social cognition on social connectedness.

Note

1. It should be noted that there were significant differences in education ($x^2 = 159.4$, $p < .001$) as many of our older adults had completed bachelor's or advanced degrees. This is driven by recruitment of alumni and former faculty members still living in the community and surrounding area. Nevertheless, normative age differences were still evident in cognitive and social cognitive variables of interest (see Table 3) and education was unrelated to associative memory (see Table 4).
2. Familiarity significantly differed between age groups. In fact, 82% of young adults reported having seen at least one episode which was significantly more than the 36% of older adults ($x^2 = 63.24$, $p < .001$). However, when included in the regression analyses, this did not influence the direction or significance of any reported coefficients (ps > .10).
3. We considered consolidating predictors by calculating reliability estimates for a single cognitive and single affective composite. Inferring motivation, inferring beliefs, and detecting deception had good reliability (Cronbach's α = .78) with interitem correlations around or

above .50. However, inferring emotions and faux pas recognition were substantially less reliable (Cronbach's α = .58) with all interitem correlations below .40, indicating insufficient shared variance for pooling. Nevertheless, a priori power analysis accounted for the five subcomponents as independent predictors, and we opted to keep these variables separate as a result.

4. The lack of age differences in the RMET is surprising. However, sociodemographic influences have been documented with more highly educated, White, and female participants performing better (see Dodell-Feder et al., 2020; Greenberg et al., 2023) which comprise a majority of our older adult sample (see Table 1 and footnote 1).
5. Statistical sensitivity may be an issue here due to range restriction. There was poor performance overall, irrespective of age group, with all but 14 participants recalling 8 or less names (i.e., 50% recall rate) with over half of the sample having recalled 4 or less (i.e., 25% recall rate). This can be seen in Figure 1.

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