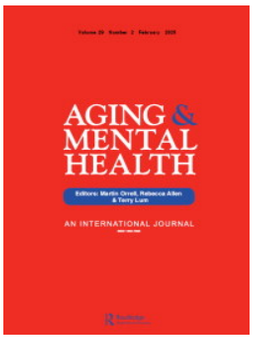

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Anne C. Krendl & Colleen S. Hughes

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Mindsets over matter: priming theory of mind improves older adults' mental state attributions about naturalistic social interactions

Anne C. Krendl and Colleen S. Hughes

Department of Psychological & Brain Sciences, Indiana University, Bloomington, IN, USA

ABSTRACT

Objectives: Aging is associated with declines in theory of mind – the ability to infer the mental states of others. We examined whether priming theory of mind mindsets actively (Study 1) and passively (Study 2) improved older adults' performance.

Method: Across two studies, participants completed a novel question-and-answer theory of mind task using the television show *Nathan for You*® in a mindset or no mindset condition. In Study 1, participants ($N = 324$, 18–84 years) completed a similar task related to a different show prior to the *Nathan for You* task (active mindset). In Study 2, young ($N = 235$; $M_{Age} = 20.47$) and older ($N = 193$, $M_{Age} = 74.48$) adults made continuous ratings of awkwardness of different episodes of *Nathan for You* before completing the question-and-answer task (passive mindset). We also measured executive function and episodic memory. In both studies, the same tasks were performed in reverse order for the control conditions (no mindset).

Results: Mindsets were associated with small-to-medium increases in theory of mind performance. Cognitive ability did not explain these improvements.

Conclusion: These findings suggest that theory of mind performance can be improved through motivation (e.g. mindsets); cognitive function (e.g. ability) does not moderate this relationship.

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Theory of mind; intervention; older adults; episodic memory; naturalistic video

Theory of mind, the ability of infer the mental and emotional states of others, is critical for forming and maintaining social relationships. Theory of mind is comprised of multiple distinct subcomponents, including the ability to infer other people's thoughts and motivations, detect deception, understand emotions, and identify faux pas (Baron-Cohen, 2001; Quesque & Rossetti, 2020). Numerous studies have shown that theory of mind abilities decline over the lifespan (Henry et al., 2013). These declines may have implications for older adults' cognitive and emotional well-being (Hamilton et al. under review; A. C. Krendl, Mannering, et al. 2023). A small body of work has identified interventions that are generally effective in improving older adults' theory of mind performance (Cavallini et al. 2015, 2021; Lecce et al. 2015, 2019; Rosi et al. 2016), but they are time-intensive and yield heterogenous effects (Roheger et al. 2022), thus limiting their scalability and potential impact. Critically, it remains unclear why these interventions are effective. The goal of the current study was to determine whether active and passive theory of mind engagement improved theory of mind performance, and, if so, why that might be.

Theory of mind is a complex construct (Apperly, 2012) that is generally separated into two key domains: cognitive (e.g. inferring beliefs or motivations, detecting deception) and affective (detecting faux pas, understanding emotions) (Bottiroli et al. 2016; Fischer et al. 2017; Ruitenberg et al. 2020; Shamay-Tsoory & Aharon-Peretz, 2007). Interventions train and evaluate performance on a single domain of theory of mind (e.g. cognitive theory of mind) (Cavallini et al. 2015, 2021; Lecce et al. 2015, 2019; Rosi et al. 2016), which may not generalize to other domains. Indeed, cognitive and affective theory of mind engage activity in dissociable brain regions (Schurz et al. 2014, 2021), suggesting that training one domain might not necessarily generalize to another.

Theory of mind interventions also involve having older adults practice using theory of mind through extensive facilitator-led trainings and adjusting their performance based on feedback (Cavallini et al. 2015, 2021; Lecce et al. 2015, 2019; Rosi et al. 2016). These interventions rely on the assumption that older adults need to learn how to properly engage in theory of mind. Alternatively, these interventions may be effective because they put older adults in the motivational mindset to engage theory of mind. For example, reading literary fiction may boost theory of mind (Kidd et al. 2016) by temporarily activating theory of mind mindsets (Mumper & Gerrig, 2019). Finally, because theory of mind requires individuals to maintain multiple pieces of information in working memory, inhibit the incorrect prediction, and engage episodic memory (Bottiroli et al. 2016; Fernandes et al. 2021; Laillier et al. 2019; Leslie et al. 2004; Rabin & Rosenbaum, 2012), intensive interventions may only be effective for individuals with relatively high cognitive ability.

Across two studies, we examined whether actively (Study 1) and passively (Study 2) activating theory of mind mindsets improved performance. We conducted these studies in an online lifespan sample (Study 1) and in-lab with groups of young and older adults (Study 2). We operationalized active mindsets as having participants track multiple domains of theory of mind. They did this in the same format that was used to assess theory of mind performance. Conversely, passive mindsets were operationalized as having participants dynamically track a single domain of theory of mind (awkwardness) during a video task. Because this was completed in a different format

CONTACT Anne C. Krendl akrendl@indiana.edu

than was used to assess theory of mind performance, theory of mind engagement here was relatively passive. An important benefit of awkwardness judgements, however, is that recent work suggests that detecting awkwardness in these videos engages both cognitive and affective theory of mind (French et al. under review). Thus, in both cases, we anticipated that active and passive mindset engagement would generalize to improved performance across multiple theory of mind domains. Our outcome was theory of mind performance based on a naturalistic video-based task. Videos of social interactions are particularly useful measures of theory of mind because they are dynamic (i.e. unfolding over time like real-life interactions), can assess multiple domains of theory of mind, and integrate multiple types of cues (e.g. verbal, nonverbal). Altogether, video of social interactions better capture how older adults use theory of mind in real-world interactions (Grainger et al. 2019; Krendl et al. 2022; Krendl, Mannering, et al. 2023; Laillier et al. 2019; Phillips et al. 2015) and predict real-world outcomes (Krendl et al. 2022).

Hypothesis 1 predicted that activating theory of mind mindsets would boost subsequent performance for young and older adults, and was tested in Studies 1 and 2. Our second question examined whether cognitive ability moderated the effect of mindset on performance (Study 2). To investigate this, we separately measured executive function and episodic memory in Study 2. We predicted that older adults' executive function and/or episodic memory would relate to better theory of mind performance, but that these individual differences would not explain the mindset-related improvements. If, as predicted, actively and passively engaging theory of mind mindsets boosts older adults' performance, then older adults' motivations (vs. ability) to engage in theory of mind may serve as an additional type of intervention.

Study 1

Prior theory of mind interventions with older adults have generally trained and evaluated performance on a single domain of theory of mind (e.g. cognitive theory of mind) and then measured their performance on a similar domain (Cavallini et al. 2015, 2021; Lecce et al. 2015, 2019; Rosi et al. 2016). Here, we examined the benefit of actively engaging multiple domains of theory of mind on subsequent theory of mind performance. To do so, we used two similarly-structured question-and-answer style tasks about naturalistic social interactions: one based on a relatively familiar television show (*The Office*®), the other based on a relatively unfamiliar television show (*Nathan for You*). Both tasks assessed the same domains of cognitive (inferring intentions, understanding beliefs, and detecting deception) and affective (understanding emotions, detecting faux pas) theory of mind. Prior work has shown that such shows elicit theory of mind (Krendl, Hugenberg, et al. 2023), and they have been successfully used with older adult samples (Krendl, Hugenberg, et al. 2023; Krendl et al. 2022; Krendl, Mannering, et al. 2023). Because prior work has shown that familiarity with *The* Office, but not *Nathan for You*, is associated with better performance (Krendl, Hugenberg, et al. 2023), *The Office* task served as an active mindset manipulation rather than the outcome of interest.

We predicted that theory of mind performance on the *Nathan for You* task would be higher when participants, regardless of age, first completed *The Office* task (active mindset condition) versus when they completed the *Nathan for You* task first (no mindset condition) (Hypothesis 1a). We also predicted that the mindset boost would generalize to both cognitive and affective theory of mind (Hypothesis 1b).

Methods

Participants

Data were collected through the online platform Prolific Academic (www.prolific.ac) (Palan & Schitter, 2018) as part of a separate study (Krendl, Hugenberg, et al. 2023) with distinct goals and analyses from the current study. A total of 347 participants were recruited from Prolific for a one-hour study; each received $12. Data collection was approved by the Indiana University Institutional Review Board. Participants were selected to reflect a representative sample of the U.S. population. The same group of participants completed both tasks, with 160 seeing *Nathan for You* first (no mindset condition) and 187 seeing *The Office* first (mindset condition). Participants ranged from 18–84 years old (M_{Age} = 45.8 years, SD = 15.7). See Table 1 for sample demographics. As reported in Krendl, Hugenberg, et al. (2023), data from four participants were removed because they reported having difficulty watching the video clips, and 19 additional participants were excluded due to *an priori* criterion to exclude participants whose performance on any task was more than 3 standard deviations from the mean.

Because power analyses were based on the predictions of Krendl, Hugenberg, et al. (2023), we conducted sensitivity analyses to ensure the achieved sample (N = 324) was sufficient to detect effects in the current study. Sensitivity analyses were conducted in G*Power (Faul et al. 2007) using one within-subject factor (question type) and one within-subject factor (condition). The sample size was sufficient to detect a small effect size (f = 0.077) with moderate predicted correlation between within subject variables (r = 0.4), 80% power, and targeted α = 0.05.

Table 1. Demographics for Study 1 and Study 2.

		Study 1		Study 2			
				Young adults (N = 235)		Older adults (N = 193)	
		No mindset (N = 45)	Mindset (N = 179)	No mindset (N = 92)	Mindset (N = 143)	No mindset (N = 88)	Mindset (N = 105)
Mean age (years)		45.840 (16.110)	45.730 (15.681)	18.66 (.929)	21.64 (4.05)	74.90 (6.46)	74.13 (6.60)
Gender	Male	69 (47.6%)	83 (46.4%)	29 (31.5)	49 (34.3)	35 (39.8%)	43 (41.0)
	Female	72 (49.7%)	93 (52.0%)	62 (67.4)	90 (62.9)	53 (60.2%)	62 (59.0)
	Other/NB	4 (2.8 %)	3 (1.7%)	1 (1.1)	4 (2.8)	–	–
Race	White	117 (80.7%)	137 (76.5%)	69 (75.0)	98 (68.5)	86 (97.7%)	97 (92.4)

For age, SD (). for all other demographics, data reflect the total N of the sample in each category with the percent of the sample in ().

Materials

Participants completed two similar theory of mind tasks, each of which was based on a U.S. mockumentary-style television shows: *The Office*® and *Nathan for You*®. *The Office* task has been used with older adults in prior work (Krendl et al. 2022; A. C. Krendl, Mannering, et al. 2023). *Nathan for You* was selected because familiarity with this show is comparatively low in the samples of interest in the current study (Krendl, Hugenberg, et al. 2023). The task design was the same for both *The Office* and *Nathan for You*: participants viewed multiple short clips (25 clips ranging from 9 to 55 s for *The Office*; 18 clips ranging from 15 to 45 s for *Nathan for You*) in sequential order of a single episode. Following each clip, participants responded to 1–6 multiple-choice questions about what they had just seen. The questions assessed different components of theory of mind: inferring beliefs (e.g. 'What does Nathan think about some of the items in Emily's store?'), detecting deception (e.g. 'Why did Nathan want his glass to be refilled with apple juice?'), understanding emotions (e.g. 'How does Emily feel about having bars and nightclubs in the areas?'), inferring motivations (e.g. 'Why does Nathan want Emily to extend her hours?'), and detecting faux pas (e.g. 'Did someone say or do something inappropriate in this clip?'). Respondents needed to use contextual or nonverbal cues to make inferences about characters' internal states to correctly answer these questions.

Control questions were also included that did not rely on theory of mind; rather, they were factually related to what a character had said or done (e.g. 'When is Meredith's birthday?'). These questions thus controlled for older adults' abilities to understand and remember the details of the show. Questions were presented in a fixed order, but the order of the answer options was randomized. This task structure allowed participants to follow the basic narrative of the episode. There were a total of 65 questions for *The Office* task and 64 for *Nathan for You*. At the end of each task, participants were asked if they had ever seen the show before (response options: yes or no). The full list of questions and response options for both *The Office* and *Nathan for You* tasks has been published (Krendl, Hugenberg, et al. 2023). Data are available upon request to the first author.

Scoring

Performance was calculated as the number of questions answered correctly divided by the total number of items. We created the composite affective theory of mind score by averaging together performance on the understanding emotion and detecting faux pas items (Cronbach's α = .549). We created the composite cognitive theory of mind score by averaging together performance on the inferring beliefs, understanding intentions, and detecting deception items (Cronbach's α = 0.679). See (Hamilton et al., 2023) for a similar approach.

Results

As expected, familiarity with *The Office* was high, with two-thirds ($N = 218$; 67.5%) reporting that they had seen the show before. However, only about 1 out of 10 ($N = 38$; 11.7%) participants reported having seen *Nathan for You* before, reflecting a significantly lower familiarity rate, $\chi^2(323) = 14.570$, $p < .001$. Consistent with prior work showing that familiarity is associated with better performance (Krendl, Hugenberg, et al. 2023), participants performed better overall on *The Office* ($M = 0.902$, SD = 0.081) than *Nathan for You* ($M = 0.875$, SD = 0.070), $t(324) = 6.469$, $p < 0.001$.

Hypothesis 1a: Theory of mind performance is higher in mindset versus no mindset condition

We tested Hypothesis 1 by conducting a 3 (*Nathan for You* question type: affective theory of mind, cognitive theory of mind, control) × 2 (condition: mindset or no mindset) mixed-model ANOVA with age (modeled continuously) as a covariate. Question type was a within-subject factor and condition was a between-subject factor. There was a main effect of question type, $F(2,642) = 59.085$, $p < 0.001$, $\eta^2_{partial} = 0.155$ because performance was highest on control questions ($M = 0.912$, SD = 0.095), followed the cognitive theory of mind questions ($M = 0.937$, SD = 0.068), then the affective theory of mind questions ($M = 0.763$, SD = 0.129). Consistent with Hypothesis 1a, there was a main effect of condition, $F(1,321) = 7.320$, $p = 0.007$, $\eta^2_{partial} = 0.022$, because theory of mind performance was higher for *Nathan for You* in the mindset versus no mindset condition, $t(322) = 2.562$, $p = 0.011$, Cohen's $d = .286$. See Table 2 for means by question and condition type. This small-to-medium effect supports the prediction that engaging mindsets boosts performance. There was no main effect of age or interactions with age, all $Fs < 1.160$, $ps > .3284$. See Figure 1.

Hypothesis 1b: Active mindset engagement boosts performance across domains

Hypothesis 1b was also supported. There was no two-way interaction between question type × condition, $F < 1$, $p = 0.608$, suggesting that the mindset condition had similar impact across domain of theory of mind (affective, cognitive). Specifically, performance was higher in the mindset than no mindset condition for the affective theory of mind questions, $t(322) = 2.029$, $p = 0.043$, Cohen's $d = 0.227$, as well as the cognitive theory of mind questions, $t(322) = 2.313$, $p = 0.021$, Cohen's $d = .258$. Performance on the control questions did not differ between the mindset and no mindset condition for *Nathan for You*, $t(322) = 1.181$, $p = 0.071$, Cohen's $d = .202$. See Table 2 for means, also Figure 1.

Table 2. Mean (SD) performance – proportion correct – based on the condition (mindset or no mindset) and type of theory of mind questions, and (for Study 2 only) age group.

	Study 1		Study 1			
	Nathan for You		Young adults		Older adults	
	No mindset ($N = 145$)	Mindset ($N = 179$)	No mindset ($N = 81$)	Mindset ($N = 128$)	No mindset ($N = 86$)	Mindset ($N = 102$)
Cognitive	.917 (.086)	.939 (.072)	.950 (.058)	.961 (.048)	.901 (.090)	.923 (.079)
Affective	.747 (.128)	.776 (.129)	.731 (.136)	.795 (.119)	.723 (.143)	.755 (.134)
Control	.867 (.195)	.907 (.145)	.921 (.096)	.935 (.091)	.912 (.091)	.920 (.088)
Overall	.852 (.087)	.879 (.081)	.872 (.070)	.901 (.062)	.843 (.092)	.867 (.083)

The overall theory of mind score was derived by averaging across cognitive (inferring beliefs, inferring motivations, detecting deception) and affective (understanding emotions, detecting faux pas) questions.

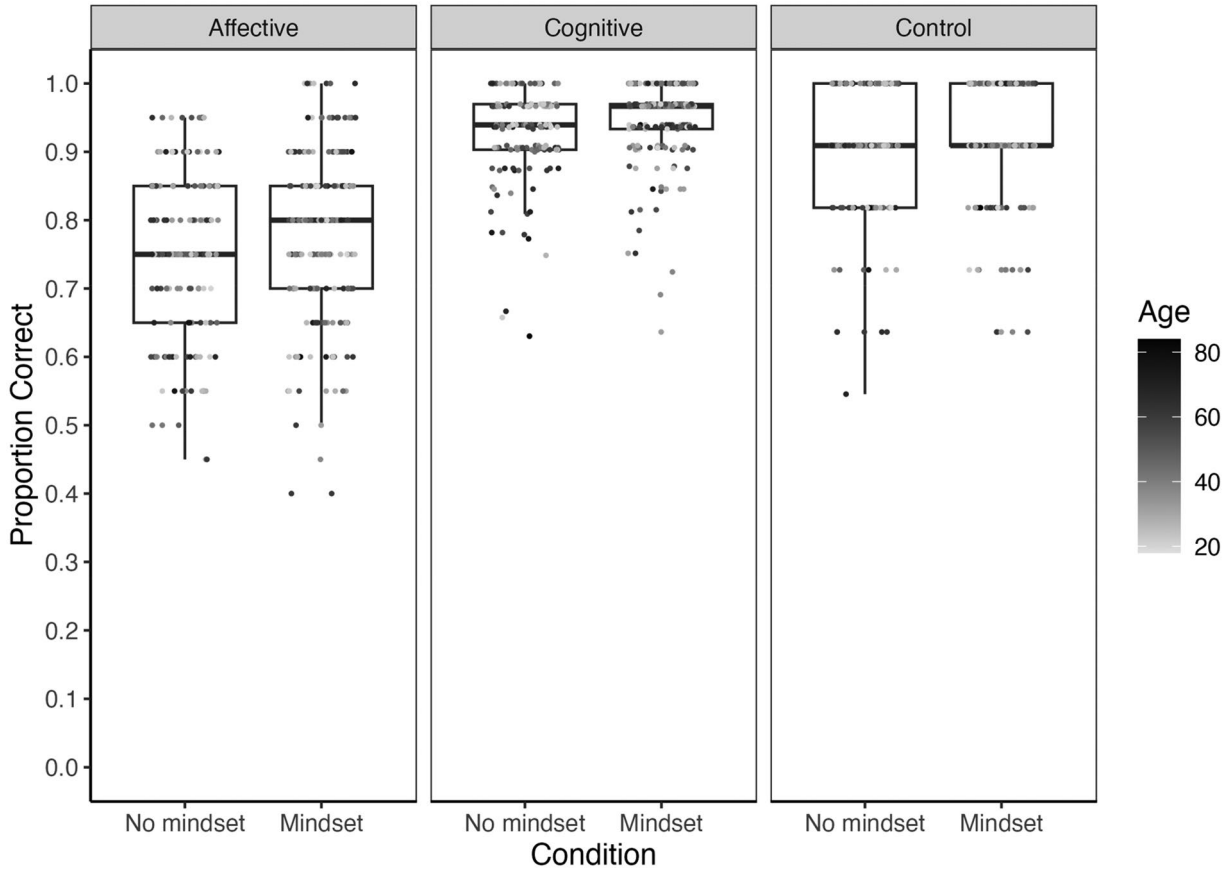

Figure 1. The mindset (vs. no mindset) condition improved both cognitive and affective theory of mind performance regardless of age.
Note. Box plots show the median and upper/lower quartiles, with whiskers drawn ± 1.5x the interquartile range. Data points representing individual participant scores are overlaid.

Study 2

In Study 2, we used a passive manipulation to activate theory of mind (*via* awkwardness judgments) using a different modality (continuous joystick ratings) than the outcome measure (the question-and-answer task from Study 1). Of interest was whether passive mindset engagement also improved theory of mind performance. As in Study 1, we predicted that theory of mind performance would be higher for young and older adults in the mindset versus no mindset condition (Hypothesis 1a). Because identifying social awkwardness engages multiple aspects of theory of mind, including belief inferences, emotion recognition, and social gaffes detection (French et al. under review; Heavey et al. 2000; Pantelis et al. 2015), we predicted that the boost would generalize to both cognitive and affective theory of mind, but not to control questions (Hypothesis 1b).

The second goal of Study 2 was to determine whether cognitive ability predicts mindset-related improvements in theory of mind. This is an important issue because it may explain why an intervention works or for whom it is well-suited. Indeed, older adults with worse executive function (Bailey & Henry, 2008; Charlton et al. 2009; Wang & Su, 2013) and episodic memory (Fernandes et al. 2021; Jarvis & Miller, 2017) have poorer theory of mind. However, only one study has explored the cognitive mechanisms (focusing specifically on executive function) related to improvements in theory of mind (Lecce et al. 2019). Thus, additional work assessing multiple cognitive domains is needed. If, however, the mindset-related improvements in theory of mind are unrelated to cognitive ability then it may be particularly well-suited for groups (e.g. older versus younger adults) with low cognitive ability. We therefore measured both cognitive abilities and assessed their relationship with theory of mind performance. We hypothesized, in line with prior work, that older adults' better executive function and/or episodic memory would relate to their better theory of mind performance (Hypothesis 2a), but would not moderate performance boosts following the mindset manipulation (Hypothesis 2b).

Methods

Participants

Participants in Study 2 completed all tasks in person and in private testing rooms. *A priori* power analyses were conducted in G*Power (Faul et al. 2007) using six regressors (age, gender, condition, control task performance, executive function, episodic memory) and a small effect size ($f = 0.15$) targeted an N of 98 for 80% power at α=.05. Young ($N = 235$; $M_{Age} = 20.47$, SD = 3.52) and older adults ($N = 193$, $M_{Age} = 74.48$, SD = 6.53) were recruited for the current study, which well exceeded the minimum power needed. Participants were pseudorandomized to the control (92 young adults, 88 older adults) and intervention conditions (143 young adults, 105 older adults). Older adults were primarily female ($N = 115$; 59.6%), White ($N = 183$; 94.8%), and well-educated ($N = 138$, 71.5%, had a college degree or higher). Young adults were also primarily female ($N = 152$; 64.7%; $N = 5$ non-binary) and White ($N = 167$; 71.1%). See Table 1 for demographics. Participants who reported having previously seen any episodes of *Nathan for You* or did not provide a response indicating their familiarity with the show

were excluded from analysis (Young adults: no mindset, $N = 11$, mindset, $N = 15$; Older adults: no mindset: $N = 2$, mindset: $N = 3$).

Procedure

Older adults were recruited from the Bloomington, Indiana community, and young adults were undergraduates enrolled at Indiana University, Bloomington. Older adults received monetary compensation for participating, and young adults either received monetary compensation or partial course credit in exchange for their participation. Data collection was approved by the Indiana University Institutional Review Board and participants provided written informed consent. Older adults completed testing across two sessions. In the first session, they completed the neuropsychological battery from the Uniform Data Set 3.0 (UDS) (Weintraub et al., 2018) along with unrelated measures on their social networks and computer-based questionnaires. In the second session, they completed the mindset manipulation, as well as several measures of social cognition that are not directly relevant to the current investigation. Young adults completed a subset of the same tasks across one or two sessions. Young and older adults in the mindset condition completed the same tasks (e.g. neuropsychological testing during the first session and the theory of mind tasks in the second session), whereas young adults in the no mindset condition did not complete the neuropsychological testing.

Materials

Passive mindset manipulation

For the mindset manipulation, participants watched two episodes of *Nathan for You*—Season 2, Episode 2 ('Souvenir Shop') and Season 1, Episode 2 ('Petting Zoo')—that were different than the episodes they viewed for the performance task. While watching each episode, participants used a Logitech Extreme 3D Pro joystick to make continuous ratings indicating how awkward they thought the plotline was at any given moment, similar to previous work (French et al. under review; Pantelis et al. 2015). The videos were displayed in MATLAB (version R2020a), and Psychophysics Toolbox Version 3 (Brainard & Vision, 1997; Kleiner et al. 2007) was used to record the movement of the joystick. Participants first completed a calibration task for two minutes in which they tracked luminance as it varied across a matrix of greyscale tiles. Young and older adults were both successful in completing the joystick task, and provided ratings with sufficient and similar variability patterns (French et al. under review). Subsequent theory of mind performance was measured using the *Nathan for You* task described in Study 1.

Neuropsychological measures

Executive function and episodic memory were measured using the Uniform Data Set 3.0 (UDS) (Weintraub et al., 2018). Consistent with prior work, executive function was operationalized using the total number of correct trials from the digit span forward and backward tasks, and the standardized residuals generated from regressing Part A completion time of the Trail Making Test on Part B completion time (MacPherson et al. 2017; Salthouse, 2011). Episodic memory was measured using the number of total items in the delayed recall for the Craft Story 2, Benson Complex Figure Copy, and the Rey Auditory Verbal Learning. Though not a core UDS measure, the Rey Auditory Verbal Learning is sensitive to memory decline (Rabin et al. 2009), and its exclusion from the UDS has been noted as a

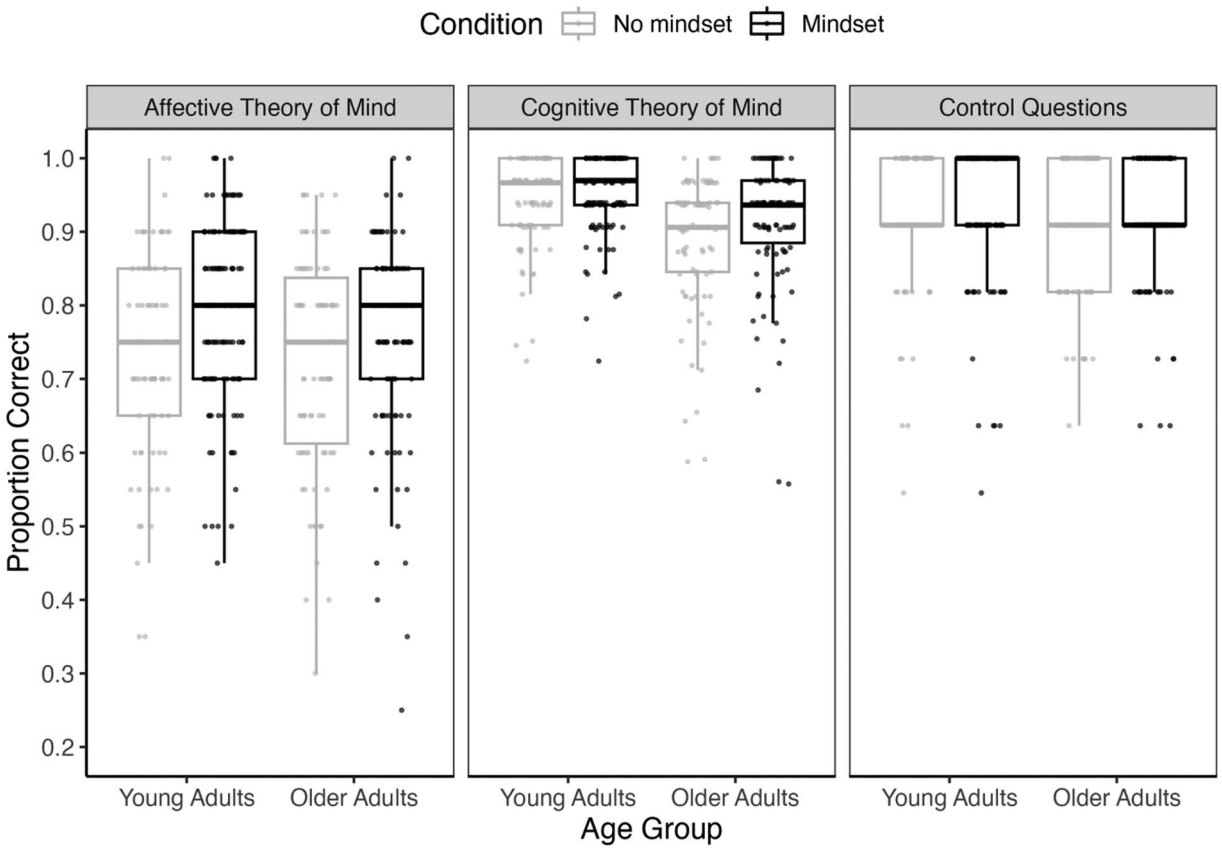

Figure 2. The mindset (vs. no mindset) condition improved both cognitive and affective theory of mind performance across age groups.
Note. Box plots show the median and upper/lower quartiles, with whiskers drawn ± 1.5x the interquartile range. Data points representing individual participant scores are overlaid.

Table 3. Correlations for covariates and performance on the *Nathan for You* task, including performance on control (non-theory of mind) questions (NFY control) and the affective (NFY affective) and cognitive (NFY cognitive) theory of mind questions. Older adults only.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Age	—					
(2) NFY control	−0.155*	—				
(3) NFY affective	−0.133	.429***	—			
(4) NFY cognitive	−0.205**	.577***	.569***	—		
(5) Executive function	−0.092	.216**	.315***	.316***	—	
(6) Episodic memory	−0.069	.275***	.404***	.381***	.387***	—

*$p < 0.05$, **$p < 0.01$, ***$p \leq 0.001$.

limitation (Besser et al., 2018). For each domain, all data were standardized and we created a composite score in which higher scores indicate better episodic memory and executive function. Data are available upon request to the first author.

Results

Hypothesis 1a: Theory of mind performance is better after passive mindset versus no mindset engagement

To test Hypothesis 1, we entered young and older adults' data into a 3 (question type: control, affective theory of mind, cognitive theory of mind) × 2 (age group: young or older adult) × 2 (condition: mindset or no mindset) mixed-model ANOVA. Question type was a within-subject factor; age group and condition were between-subjects factors. See Table 2 for descriptive statistics. There was a significant question type × age group interaction, $F(2,393) = 3.781$, $p = 0.023$, $\eta^2_{partial} = .010$. Suggesting that task performance was not influenced by practice effects, young and older adults did not differ in their performance on the control questions, $t(395) = 1.438$, $p = 0.151$, Cohen's $d = .145$. See Figure 2. However, young adults outperformed older adults on both the cognitive and affective theory of mind questions, both $ts > 2.20$, $ps < 0.05$, Cohen's $ds > .221$. There were also main effects of age group and question type, both $Fs > 11.222$, $ps < 0.001$, $\eta^2_{partials} > .027$. See Table 2, also Figure 2.

Consistent with Hypothesis 1a, there was a main effect of condition, $F(1,393) = 10.178$, $p < 0.001$, $\eta^2_{partial} = 0.025$ because performance was higher in the mindset ($M_{Correct} = 0.886$, $SD = 0.074$) than no mindset ($M_{Correct} = 0.857$, $SD = 0.083$) condition.

Hypothesis 1b: Passive mindset engagement is associated with better performance on cognitive, affective theory of mind, but not control questions

In support of Hypothesis 1b, the main effect of condition was qualified by a question type × condition interaction, $F(2,393) = 6.289$, $p = 0.002$, $\eta^2_{partial} = .016$. Unpacking this interaction, we found that the mindset condition did not affect performance on the control questions (mindset: $M_{Correct} = 0.928$, SD = 0.090; no mindset: $M_{Correct} = 0.917$, SD = 0.093; $t(395) = 1.222$, $p = 0.222$, Cohen's $d = 0.124$). In contrast, doing the joystick ratings first improved (vs. the no mindset condition) both cognitive theory of mind (mindset: $M_{Correct} = 0.944$, SD = 0.066; no mindset: $M_{Correct} = 0.925$, SD = 0.080; $t(395) = 2.651$, $p = 0.008$, Cohen's $d = 0.270$) and affective theory of mind (mindset: $M_{Correct} = 0.777$, SD = 0.127; no mindset: $M_{Correct} = 0.727$, SD = 0.140; $t(395) = 3.763$, $p < 0.001$, Cohen's $d = 0.383$). There were no other two-way interactions or a three-way interaction, all $Fs < 1.704$, $ps > 0.182$.

Because the passive mindset task involved having participants evaluate moments of awkwardness in the videos in real time, one possibility is that these judgments might have artificially inflated affective theory of mind performance by increasing accuracy on faux pas detection. We examined this possibility by conducting an exploratory analysis for emotion and faux pas (the two affective channels). Because condition did not interact with age group, we did not include age group in this exploratory analysis. The 2 (question type: emotion, faux pas) × 2 (condition: mindset or no mindset) mixed-model ANOVA revealed main effects of question type, $F(1,395) = 60.432$, $p < 0.001$, $\eta^2_{partial} = 0.133$; and condition, $F(1,395) = 14.157$, $p < 0.001$, $\eta^2_{partial} = 0.035$; but no interaction $F < 1$. The fact that there was not a significant interaction suggests that the overall improvement in affective theory of mind was not driven by increased performance on the faux pas questions.

Table 4. Regression analyses for Study 2 examining the contributions of executive function and episodic memory to affective and cognitive theory of mind performance, controlling for covariates. NFY control refers to performance on the non-theory of mind control questions on the *Nathan for You* task.

	Affective theory of mind performance		Cognitive theory of mind performance	
Predictors	Covariates only β	Full model β	Covariates only β	Full model β
Age in years	−0.063	−0.052	−0.135*	−0.126*
Women	.131	.101	0.057	0.032
NFY control	.390***	.290***	0.531***	0.451***
Condition	.105	.153*	.125*	.164**
Episodic memory		.268***		.217***
Executive function		.147*		.115
N	188	188	188	188
Adj. R^2	.199	.303	.344	.409
F	12.61***	14.55***	25.752***	22.60***

Condition refers to whether participants were in the no mindset or mindset condition (dummy coded: no mindset = 0, mindset = 1); males are the reference group for gender. βs are standardized. Analyses conducted among older adults only. The change in R^2 was not increased in models that included the age group × executive function [episodic memory] interactions.
*$p < 0.05$, **$p < 0.01$, ***$p \leq 0.001$.

Hypothesis 2: Older adults' executive function and episodic memory contribute to better performance overall (2a), but do not moderate mindset-related improvement (2b)

To test Hypothesis 2a, we next examined whether older adults' executive function and/or episodic memory predicted their cognitive or affective theory of mind performance. Young adults were not included in this analysis. We conducted separate regression models for affective and cognitive theory of mind performance. Executive function and episodic memory were entered as predictors in both models, and both models also controlled for performance on the control questions, age, gender, and condition. Correlations between these variables are provided in Table 3. Both models were significant, $Fs > 14.50$, $ps < 0.001$, Adjusted $R^2s > .30$. In both models, episodic memory uniquely predicted performance, all ßs > 0.217, $ps \leq 0.001$, $ps < .03$. See Table 4 for full regression statistics.

To test Hypothesis 2b, we repeated the regression analyses described above, but added two interaction terms for condition (dummy coded: 0 = no mindset, 1 = mindset) and cognitive function (condition × executive function; condition × episodic memory). Neither model was significant, (ΔFs < 1.03, ps > 0.36, $\Delta R^2 < 0.01$), suggesting that individual differences in cognitive abilities did not predict the mindset-related boost in performance among older adults.

Discussion

The current study showed that active and passive engagement in theory of mind mindsets improved theory of mind performance in a lifespan sample (Study 1), and in both young and older adults (Study 2). This finding suggests that mindset engagement and motivation may contribute to improved theory of mind performance. Study 2 also demonstrated that neither episodic memory nor executive function moderated the mindset-related boost in performance among older adults. Instead, episodic memory benefited theory of mind performance regardless of the manipulation. The current study provides the key insight that training theory of mind can be effective and generalizable in a brief format.

An important consideration in the current study is that active and passive mindsets improved both cognitive and affective theory of mind performance. This is likely because both mindset tasks engaged cognitive and affective theory of mind. Indeed, *The Office* task in Study 1 explicitly focused on both domains of theory of mind. Interestingly, though Study 2 involved only making awkwardness judgments, it still yielded improvements in both cognitive and affective theory of mind. Though some work has suggested that awkwardness measures affective theory of mind; (Baron-Cohen et al. 1999; Stone et al. 1998), other work suggests that identifying social awkwardness engages multiple aspects of theory of mind, including belief inferences, emotion recognition, and social gaffes detection (French et al. under review; Heavey et al. 2000; Pantelis et al. 2015). This may be particularly relevant when participants evaluate social awkwardness from dynamic videos. That is, dynamic theory of mind judgments may engage a wider range of theory of mind subdomains. Indeed, a recent study using these videos found that joystick performance was associated with both cognitive and affective theory of mind performance (French et al. under review).

The current study builds on prior work showing that older adults' theory of mind performance can be improved (Cavallini et al. 2015, 2021; Lecce et al. 2015, 2019; Rosi et al. 2016). However, the current study addresses several limitations in these prior approaches, notably that are time-intensive, yield heterogenous effects, and lack a mechanistic explanation (Roheger et al. 2022). First, both mindset manipulations were relatively brief (about 15 min) and completed independently. Second, both active (Study 1) and passive (Study 2) mindset engagement generalized to improved performance in both cognitive and affective theory of mind. Third, they addressed potential concerns about practice effects underlying improved performance. Specifically, in Study 1, our use of *The Office* task, rather than another *Nathan for You* task, to activate theory of mind mindsets allowed us to rule out the possibility that improved performance was due to familiarity with the show. This is important because prior work has measured theory of mind performance by assessing change before and after the training (Cavallini et al. 2015, 2021; Lecce et al. 2019), raising concerns about potential practice effects. Moreover, our finding in Study 2 that the passive mindset manipulation boosted performance in affective and cognitive theory of mind, but not the control questions, ruled out the possibility that task familiarity boosts performance.

Our finding that executive function predicted affective theory of mind performance, but predicted performance on both cognitive and affective theory of mind in Study 2 contributes to the growing literature examining the cognitive mechanisms underlying theory of mind. This finding contributes to a large body of work that has implicated poor episodic memory and executive function in older adults' worse theory of mind performance (Bailey & Henry, 2008; Charlton et al. 2009; Fischer et al. 2014; Wang & Su, 2013). Importantly, this work has not typically disentangled the unique roles of executive function and episodic memory in theory of mind performance, but see (Fischer et al. 2017; Wang & Su, 2013). This is important because deficits in executive function can contribute to deficits in episodic memory (Baudic et al. 2006), thus confounding the relationship between episodic memory or executive function and theory of mind performance.

Prior work has implicated episodic memory and executive function in unique aspects of theory of mind. For example, poor episodic memory is related to the use of different, less effective strategies on theory of mind tasks among older versus young adults (Krendl, Mannering, et al. 2023). However, accurately engaging theory of mind requires executive function, including maintaining multiple pieces of information in working memory and inhibiting the incorrect prediction (Bottiroli et al. 2016; Fernandes et al. 2021; Laillier et al. 2019; Leslie et al. 2004; Rabin & Rosenbaum, 2012). However, an import caveat to the finding that episodic memory predicted theory of mind performance is that performance on the control questions was included in the regression models. These questions control for general attention and understanding of the show, but were modestly correlated with executive function and episodic memory (rs = 0.22 & 0.27, respectively). Thus, it is possible that the inclusion of these questions might have slightly obfuscated the relationship between executive function and episodic memory to cognitive and affective theory of mind.

We may also infer that the mechanisms that explain age-related declines in theory of mind are not the mechanisms that explain better performance associated with the mindset condition. Rather, the mindset condition may have altered participants' motivations during movie-watching by attuning participants to theory of mind cues either actively (Study 1) or passively (Study 2). Indeed, motivation and familiarity affect overall theory of mind performance (Zhang et al. 2013, 2018). Multiple interventions that draw attention to theory of mind (e.g. discussing theory of mind; Caputi et al. 2021; Lecce et al. 2019; fiction-reading; Mumper & Gerrig, 2019) boost theory of mind performance, suggesting that merely putting people in the mindset is effective. The current study further demonstrates that this possibility does not necessarily rely on feedback about individuals' accuracy at understanding theory of mind or cognitive effort. Moreover, this finding suggests that thinking about awkwardness may engage theory of mind in a more multifaceted way. Future work should explore whether other ratings (e.g. thinking about deception) shows similar beneficial effects.

Limitations and conclusions

Together, the findings from the current study contribute to the growing literature on theory of mind intervention trainings.

Specifically, the study demonstrated that brief (~15 min) interventions that engage theory of mind mindsets actively (Study 1) or passively (Study 2) transfer to better cognitive and affective theory of mind performance. Though the current intervention was effective in increasing theory of mind performance, it is worth noting that the effect sizes were small-to-medium in both Studies 1 and 2, whereas prior theory of mind trainings with older adults have yielded larger effects sizes (Roheger et al. 2022). Though this could suggest that longer interventions may be robust, it is important to note that prior studies have not examined the duration of the boosts observed from the trainings. Moreover, it is unclear whether these interventions transfer beyond lab-based tasks and to real-world contexts. Given that recent work has shown that dynamic, rather than static, measures of theory of mind better capture how older adults and others engage theory of mind in real-world scenarios (Grainger et al. 2019; Krendl et al. 2022; Krendl, Mannering, et al. 2023; Laillier et al. 2019), this is an important area of future work.

The results of this study suggest that motivation may play an important role in boosting older adults' theory of mind performance. This work has implications for improving older adult's cognitive, mental, and emotional well-being. Indeed, theory of mind plays a key role in facilitating social interactions (Bishop-Fitzpatrick et al. 2017; Watson et al. 1999), and recent work shows that it predicts certain aspects of the structure and function of older adults' social networks (Krendl et al. 2022; A. C. Krendl et al., 2022). Because theory of mind plays a key role in facilitating older adults' social interactions, developing effective and scalable interventions that can attenuate the negative impact of aging on this core social cognitive skill are important for protecting older adults' emotional, mental, and physical well-being. The results from the current study suggest that engaging older adults' motivations (vs. ability) to engage in theory of mind may be a streamlined and scalable approach to improving their theory of mind.

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The authors report there are no competing interests to declare.

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References

Apperly, I. A. (2012). What is "theory of mind"? Concepts, cognitive processes and individual differences. *Quarterly Journal of Experimental Psychology (2006)*, *65*(5), 825–839. https://doi.org/10.1080/17470218.2012.676055

Bailey, P. E., & Henry, J. D. (2008). Growing less empathic with age: Disinhibition of the self-perspective. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *63*(4), P219–P226. https://doi.org/10.1093/geronb/63.4.p219

Baron-Cohen, S. (2001). Theory of mind in normal development and autism. *Prisme*, *34*(1), 74–183.

Baron-Cohen, S., O'riordan, M., Stone, V., Jones, R., & Plaisted, K. (1999). Recognition of faux pas by normally developing children and children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders*, *29*(5), 407–418. https://doi.org/10.1023/a:1023035012436

Baudic, S., Dalla Barba, G., Thibaudet, M. C., Smagghe, A., Remy, P., & Traykov, L. (2006). Executive function deficits in early Alzheimer's disease and their relations with episodic memory. *Archives of Clinical Neuropsychology: The Official Journal of the National Academy of Neuropsychologists*, *21*(1), 15–21. https://doi.org/10.1016/j.acn.2005.07.002

Besser, L., Kukull, W., Knopman, D. S., Chui, H., Galasko, D., Weintraub, S., Jicha, G., Carlsson, C., Burns, J., Quinn, J., Sweet, R. A., Rascovsky, K., Teylan, M., Beekly, D., Thomas, G., Bollenbeck, M., Monsell, S., Mock, C., Zhou, X. H., & Morris, J. C, Neuropsychology Work Group, Directors, and Clinical Core leaders of the National Institute on Aging-funded US Alzheimer's Disease Centers. (2018). Version 3 of the national Alzheimer's coordinating center's uniform data set. *Alzheimer Disease and Associated Disorders*, *32*(4), 351–358. https://doi.org/10.1097/WAD.0000000000000279

Bishop-Fitzpatrick, L., Mazefsky, C. A., Eack, S. M., & Minshew, N. J. (2017). Correlates of social functioning in autism spectrum disorder: The role of social cognition. *Research in Autism Spectrum Disorders*, *35*, 25–34. https://doi.org/10.1016/j.rasd.2016.11.013

Bottiroli, S., Cavallini, E., Ceccato, I., Vecchi, T., & Lecce, S. (2016). Theory of mind in aging: Comparing cognitive and affective components in the faux pas test. *Archives of Gerontology and Geriatrics*, *62*, 152–162. https://doi.org/10.1016/j.archger.2015.09.009

Brainard, D. H., & Vision, S. (1997). The psychophysics toolbox. *Spatial Vision*, *10*(4), 433–436. https://doi.org/10.1163/156856897X00357

Caputi, M., Cugnata, F., & Brombin, C. (2021). Theory of mind and loneliness: Effects of a conversation-based training at school. *International Journal of Psychology*, *56*(2), 257–265.

Cavallini, E., Bianco, F., Bottiroli, S., Rosi, A., Vecchi, T., & Lecce, S. (2015). Training for generalization in theory of mind: A study with older adults. *Frontiers in Psychology*, *6*, 1123. https://doi.org/10.3389/fpsyg.2015.01123

Cavallini, E., Ceccato, I., Bertoglio, S., Francescani, A., Vigato, F., Ianes, A. B., & Lecce, S. (2021). Can theory of mind of healthy older adults living in a nursing home be improved? A randomized controlled trial. *Aging Clinical and Experimental Research*, *33*(11), 3029–3037. https://doi.org/10.1007/s40520-021-01811-4

Charlton, R. A., Barrick, T. R., Markus, H. S., & Morris, R. G. (2009). Theory of mind associations with other cognitive functions and brain imaging in normal aging. *Psychology and Aging*, *24*(2), 338–348. https://doi.org/10.1037/a0015225

Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

Fernandes, C., Barbosa, F., Martins, I. P., & Marques-Teixeira, J. (2021). Aging and social cognition: A comprehensive review of the literature. *Psychology & Neuroscience*, *14*(1), 1–15. https://doi.org/10.1037/pne0000251

Fischer, A. L., Bernstein, D. M., & Thornton, W. L. (2014). Vascular health modifies theory of mind performance in older adults. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *69*(2), 219–227. https://doi.org/10.1093/geronb/gbs120

Fischer, A. L., O'Rourke, N., & Loken Thornton, W. (2017). Age differences in cognitive and affective theory of mind: Concurrent contributions of neurocognitive performance, sex, and pulse pressure. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *72*(1), 71–81. https://doi.org/10.1093/geronb/gbw088

French, R., Kennedy, D. P., & Krendl, A. C. (under review). Establishing construct validity for dynamic measures of behavior using naturalistic study designs.

Grainger, S. A., Steinvik, H. R., Henry, J. D., & Phillips, L. H. (2019). The role of social attention in older adults' ability to interpret naturalistic social scenes. *Quarterly Journal of Experimental Psychology (2006)*, *72*(6), 1328–1343. https://doi.org/10.1177/1747021818791774

Hamilton, L. J., Krendl, A. C., Hamilton, L. J., & Krendl, A. C. (2023). Evidence for the role of affective theory of mind in face-name associative memory. *Aging, Neuropsychology, and Cognition*, *31*(3), 417–437. https://doi.org/10.1080/13825585.2023.2194607

Hamilton, L. J., Peng, S., Coleman, M., Krendl, A. C., & Perry, B. L. (under review). Tight knit social networks support mental health, but large and diverse networks protect against cognitive decline and Alzheimer's disease.

Heavey, L., Phillips, W., Baron-Cohen, S., & Rutter, M. (2000). The awkward moments test: A naturalistic measure of social understanding in autism. *Journal of Autism and Developmental Disorders*, *30*(3), 225–236. https://doi.org/10.1023/a:1005544518785

Henry, J. D., Phillips, L. H., Ruffman, T., & Bailey, P. E. (2013). A meta-analytic review of age differences in theory of mind. *Psychology and Aging*, *28*(3), 826–839. https://doi.org/10.1037/a0030677

Jarvis, S. N., & Miller, J. K. (2017). Self-projection in younger and older adults: A study of episodic memory, prospection, and theory of mind. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, *24*(4), 387–407. https://doi.org/10.1080/13825585.2016.1219314

Kidd, D., Ongis, M., & Castano, E. (2016). On literary fiction and its effects on theory of mind. *Scientific Study of Literature*, *6*(1), 42–58. https://doi.org/10.1075/ssol.6.1.04kid

Kleiner, M., Brainard, D., & Pelli, D. (2007). What's new in Psychtoolbox-3?.

Krendl, A. C., Hugenberg, K., & Kennedy, D. P. (2023). Comparing data quality from an online and in-person lab sample on dynamic theory of mind tasks. *Behavior Research Methods*, *56*(3), 2353–2375. https://doi.org/10.3758/s13428-023-02152-y

Krendl, A. C., Kennedy, D. P., Hugenberg, K., & Perry, B. L. (2022). Social cognitive abilities predict unique aspects of older adults' personal social networks. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *77*(1), 18–28. https://doi.org/10.1093/geronb/gbab048

Krendl, A. C., Mannering, W., Jones, M. N., Hugenberg, K., & Kennedy, D. P. (2023). Determining whether older adults use similar strategies to young adults in theory of mind tasks. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *78*(6), 969–976. https://doi.org/10.1093/geronb/gbac187

Krendl, A. C., Peng, S., Hamilton, L. J., & Perry, B. L. (in press). Social and general cognition are uniquely associated with social connectedness in later life. *Psychology and Aging*, *39*(6), 644–657. https://doi.org/10.1037/pag0000831

Laillier, R., Viard, A., Caillaud, M., Duclos, H., Bejanin, A., de La Sayette, V., Eustache, F., Desgranges, B., & Laisney, M. (2019). Neurocognitive determinants of theory of mind across the adult lifespan. *Brain and Cognition*, *136*, 103588. https://doi.org/10.1016/j.bandc.2019.103588

Lecce, S., Bottiroli, S., Bianco, F., Rosi, A., & Cavallini, E. (2015). Training older adults on theory of mind (ToM): Transfer on metamemory. *Archives of Gerontology and Geriatrics*, *60*(1), 217–226. https://doi.org/10.1016/j.archger.2014.10.001

Lecce, S., Ceccato, I., Rosi, A., Bianco, F., Bottiroli, S., & Cavallini, E. (2019). Theory of mind plasticity in aging: The role of baseline, verbal knowledge, and executive functions. *Neuropsychological Rehabilitation*, *29*(3), 440–455. https://doi.org/10.1080/09602011.2017.1308871

Leslie, A. M., Friedman, O., & German, T. P. (2004). Core mechanisms in 'theory of mind'. *Trends in Cognitive Sciences*, *8*(12), 528–533. https://doi.org/10.1016/j.tics.2004.10.001

MacPherson, S. E., Cox, S. R., Dickie, D. A., Karama, S., Starr, J. M., Evans, A. C., & Deary, I. J. (2017). Processing speed and the relationship between trail making test-B performance, cortical thinning and white matter microstructure in older adults. *Cortex*, *95*, 92–103. https://doi.org/10.1016/j.cortex.2017.07.021

Mumper, M. L., & Gerrig, R. J. (2019). How does leisure reading affect social cognitive abilities? *Poetics Today*, *40*(3), 453–473. https://doi.org/10.1215/03335372-7558080

Palan, S., & Schitter, C. (2018). Prolific.ac—A subject pool for online experiments. *Journal of Behavioral and Experimental Finance*, *17*, 22–27. https://doi.org/10.1016/j.jbef.2017.12.004

Pantelis, P. C., Byrge, L., Tyszka, J. M., Adolphs, R., & Kennedy, D. P. (2015). A specific hypoactivation of right temporo-parietal junction/posterior superior temporal sulcus in response to socially awkward situations in autism. *Social Cognitive and Affective Neuroscience*, *10*(10), 1348–1356. https://doi.org/10.1093/scan/nsv021

Phillips, L. H., Allen, R., Bull, R., Hering, A., Kliegel, M., & Channon, S. (2015). Older adults have difficulty in decoding sarcasm. *Developmental Psychology*, *51*(12), 1840. https://doi.org/10.1037/dev0000063

Quesque, F., & Rossetti, Y. (2020). What do theory-of-mind tasks actually measure? Theory and practice. *Perspectives on Psychological Science*, *15*(2), 384–396. https://doi.org/10.1177/1745691619896607

Rabin, J. S., & Rosenbaum, R. S. (2012). Familiarity modulates the functional relationship between theory of mind and autobiographical memory. *Neuroimage*, *62*(1), 520–529. https://doi.org/10.1016/j.neuroimage.2012.05.002

Rabin, L. A., Paré, N., Saykin, A. J., Brown, M. J., Wishart, H. A., Flashman, L. A., & Santulli, R. B. (2009). Differential memory test sensitivity for diagnosing amnestic mild cognitive impairment and predicting conversion to Alzheimer's disease. *Aging, Neuropsychology, and Cognition*, *16*(3), 357–376. https://doi.org/10.1080/13825580902825220

Roheger, M., Hranovska, K., Martin, A. K., & Meinzer, M. (2022). A systematic review and meta-analysis of social cognition training success across the healthy lifespan. *Scientific Reports*, *12*(1), 3544. https://doi.org/10.1038/s41598-022-07420-z

Rosi, A., Cavallini, E., Bottiroli, S., Bianco, F., & Lecce, S. (2016). Promoting theory of mind in older adults: Does age play a role? *Aging & Mental Health*, *20*(1), 22–28. https://doi.org/10.1080/13607863.2015.1049118

Ruitenberg, M. F., Santens, P., & Notebaert, W. (2020). Cognitive and affective theory of mind in healthy aging. *Experimental Aging Research*, *46*(5), 382–395. https://doi.org/10.1080/0361073X.2020.1802980

Salthouse, T. A. (2011). What cognitive abilities are involved in trail-making performance? *Intelligence*, *39*(4), 222–232. https://doi.org/10.1016/j.intell.2011.03.001

Schurz, M., Radua, J., Aichhorn, M., Richlan, F., & Perner, J. (2014). Fractionating theory of mind: A meta-analysis of functional brain imaging studies. *Neuroscience & Biobehavioral Reviews*, *42*, 9–34. https://doi.org/10.1016/j.neubiorev.2014.01.009

Schurz, M., Radua, J., Tholen, M. G., Maliske, L., Margulies, D. S., Mars, R. B., … Kanske, P. (2021). Toward a hierarchical model of social cognition: A neuroimaging meta-analysis and integrative review of empathy and theory of mind. *Psychological Bulletin*, *147*(3), 293. https://doi.org/10.1037/bul0000303

Shamay-Tsoory, S. G., & Aharon-Peretz, J. (2007). Dissociable prefrontal networks for cognitive and affective theory of mind: A lesion study. *Neuropsychologia*, *45*(13), 3054–3067. https://doi.org/10.1016/j.neuropsychologia.2007.05.021

Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience*, *10*(5), 640–656. https://doi.org/10.1162/089892998562942

Wang, Z., & Su, Y. (2013). Age-related differences in the performance of theory of mind in older adults: A dissociation of cognitive and affective components. *Psychology and Aging*, *28*(1), 284. https://doi.org/10.1037/a0030876

Watson, A. C., Nixon, C. L., Wilson, A., & Capage, L. (1999). Social interaction skills and theory of mind in young children. *Developmental Psychology*, *35*(2), 386. https://doi.org/10.1037/0012-1649.35.2.386

Weintraub, S., Besser, L., Dodge, H. H., Teylan, M., Ferris, S., Goldstein, F. C., Giordani, B., Kramer, J., Loewenstein, D., Marson, D., Mungas, D., Salmon, D., Welsh-Bohmer, K., Zhou, X.-H., Shirk, S. D., Atri, A., Kukull, W. A., Phelps, C., & Morris, J. C. (2018). Version 3 of the Alzheimer disease centers' neuropsychological test battery in the Uniform Data Set (UDS). *Alzheimer Disease and Associated Disorders*, *32*(1), 10–17. https://doi.org/10.1097/WAD.0000000000000223

Zhang, X., Fung, H. H., Stanley, J. T., Isaacowitz, D. M., & Ho, M. Y. (2013). Perspective taking in older age revisited: A motivational perspective. *Developmental Psychology*, *49*(10), 1848–1858. https://doi.org/10.1037/a0031211

Zhang, X., Lecce, S., Ceccato, I., Cavallini, E., Zhang, L., & Chen, T. (2018). Plasticity in older adults' theory of mind performance: The impact of motivation. *Aging & Mental Health*, *22*(12), 1592–1599. https://doi.org/10.1080/13607863.2017.1376313