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Dissociable brain activity for high-stakes deception detection in young and older adults

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Abstract

While anyone can fall victim to deception with deleterious impact, age-related changes in financial, cognitive, socioemotional, and neurobiological factors convey greater risk to older adults. Neural responses underlying deception detection may elucidate age-related vulnerability or resilience to deception. Here, we examined 53 young (18–33 years) and 50 older (55–78 years) adults who underwent functional magnetic resonance imaging while aiming to detect deception in naturalistic, high-stakes videos (i.e. pleas for information about a missing relative, where later some of the pleaders were found guilty in the murder of the missing relative). Behaviourally, young and older adults had comparably poor performance at detecting deceptive pleas. Further, we observed a multivariate pattern of brain activity, including visual and parietal areas that differentiated genuine from deceptive pleas across age groups. Reflecting individual variation, older adults with higher sensitivity to deception had stronger activation of brain regions associated with mentalizing (e.g. medial prefrontal cortex) and cognitive control (e.g. anterior cingulate cortex, dorsolateral prefrontal cortex) during deception detection. Together, our findings build on extant models of decision-making in ageing to show that age differences in brain function may facilitate compensation among some older adults to identify deception.

Keywords: deception detection; aging; functional neuroimaging; medial prefrontal cortex; dorsolateral prefrontal cortex

Introduction

Exploitation arising from deception can deleteriously impact individuals' finances, health, and well-being (Wood and Lichtenberg 2017, Nguyen *et al.* 2021). While anyone can fall victim to deception, age-related changes in financial, cognitive, socioemotional, and neurobiological factors convey greater risk to older adults (Lachs and Han 2015, Spreng *et al.* 2016, Ebner *et al.* 2023). Understanding how individuals detect deception is paramount to developing effective interventions. One challenge to this work is that experimental laboratory tasks investigating social interactions have limited fidelity to real-world contexts (Redcay and Moraczewski 2020). For instance, different social-cognitive skills may underlie deception detection based on context [e.g. during face-to-face social interactions vs. online phishing attempts (Ebner *et al.* 2023)] or the multiplicity of cues available in task stimuli (Hartwig and Bond 2014). Also, extant research showing older adults' poorer understanding of others' intentions largely relies on stimuli derived from low arousal and/or low-stakes contexts (e.g. reading or watching fictitious vignettes; Hughes *et al.* 2019, Krendl *et al.* 2023). Age differences may be attenuated in high-arousal contexts—i.e. older adults may engage their decision-making resources more selectively (Porter and ten Brinke 2010, Spreng and Turner 2019).

This possibility is supported by findings from a task in which participants viewed videos of family members pleading for the safe return of a missing relative and were asked to determine the veracity of the plea (ten Brinke and Porter 2012). The speaker was subsequently convicted of the kidnapping/murder of the missing person (deceptive plea), or someone else was convicted (genuine plea). Prior

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behavioural reports described two patterns of age effects in this task (Gunderson and ten Brinke 2022). First, young and older adults had similar, above-chance sensitivity to deception (i.e. correctly identifying deceptive pleas while rarely mistaking genuine pleas as lies). Second, older (vs. young) adults had a greater propensity to say that a speaker was telling the truth (truth bias) to both plea types. Older adults' greater truth bias may reflect the social nature of interpersonal (vs. virtual; Pehlivanoglu *et al.* 2023) paradigms. That is, age-related prioritization of positive emotional and social experience (Charles and Carstensen 2010) blunts the salience of negative emotion and information (Charles and Carstensen 2010, Carstensen *et al.* 2011, Reed *et al.* 2014) and increases propensity to trust (Castle *et al.* 2012). While both facets of performance were related to hypothetical monetary donations to deceptive pleaders, truth bias more strongly related to donations among older adults (Gunderson and ten Brinke 2022). These facets reflect different mechanisms of deception, not just in this paradigm but in the broader literature, which may (or may not) be exacerbated with older age (Hamilton *et al.* 2022, Ebner *et al.* 2023).

More work is needed to understand if contexts that are motivating (e.g. naturalistic, high-stakes, or affectively arousing) ameliorate age differences in deception detection. Suggesting context-independent effects, much prior work attributes age differences to declines in multiple cognitive (e.g. processing speed, working memory; Park and Reuter-Lorenz 2009) and social cognitive (e.g. less accurate emotion recognition; Ebner and Johnson 2009) abilities. For example, older adults with such impairments exhibit poorer deception detection and greater scam susceptibility on cartoon- and survey-based measures, respectively (James *et al.* 2014; Calso *et al.* 2020). Naturalistic paradigms afford context but also greater complexity—referring to the multiple types of social, cognitive, sensory, and integrative processing elicited by the stimuli and corresponding decision-making processes (Redcay and Moraczewski 2020, Lee Masson *et al.* 2024). Perhaps for this reason, one study found worse deception detection among older (vs. young) adults using naturalistic viewing of deceptive statements in a TV show (Krendl *et al.* 2023). This finding indicates a mixed literature for age deficits in naturalistic deception detection and motivates further exploration of the factors that contribute to successful deception detection in some, but not all, older adults (i.e. individual variability within age groups). For instance, some, but not all, older adults may do worse at deception detection due to the cognitive demands associated with integrating information in a complex decision context (Frazier *et al.* 2019, Horta *et al.* 2024). Patterns of neural recruitment during decision-making may reveal how older versus young adults (or more vs. less successful older adults) make decisions.

Decision-making relies on multiple, distributed brain regions (for a review, see Frazier *et al.* 2019, Lighthall 2020). Inferring others' intentions, for instance, activates regions within the default network of the brain comprising the medial prefrontal cortex, posterior cingulate cortex, and lateral temporoparietal regions (e.g. temporoparietal junction, temporal pole; Hughes *et al.* 2019, 2024b). In contrast, tasks measuring cognitive control (e.g. the ability to inhibit distracting information) activate the dorsolateral prefrontal cortex and anterior cingulate cortex (Friedman and Robbins 2022). Older adults with impairments in these domains have weaker activation of corresponding brain regions compared to young adults (Moran *et al.* 2012, Cassidy *et al.* 2021). Yet, a hallmark feature of ageing brain function is less differentiated or specific activation of individual brain regions, potentially reflecting a loss of functional specialization (Koen and Rugg 2019). For complex deception detection, older (vs. young) adults may thus rely on more distributed neural correlates of integrating information in the course of decision-making (Frazier *et al.* 2019). Indeed, older adults exhibit more heterogeneity in behaviour and brain function when viewing naturalistic social interactions than young adults (Geerligs and Campbell 2018, Krendl *et al.* 2023, Hughes *et al.* 2025), suggesting that individual variation within age groups may add unique explanatory insight (beyond age group comparison) about age-specific deception detection strategies.

To directly address these possibilities, we investigated deception detection among young and cognitively healthy older adults while they underwent functional magnetic resonance imaging (fMRI). Complementing past behavioural reports (Gunderson and ten Brinke 2022), we aimed to discover how individuals make deception detection judgements in naturalistic, context-rich (i.e. having dynamic facial, vocal, paralinguistic, and bodily cues of the speaker), high-stakes (i.e. about serious and affectively arousing) scenarios. Poor deception detection accuracy could result from poor sensitivity to deception, a response/motivational bias to say the pleader was telling the truth (Levine 2014, Heemskerk *et al.* 2024), or both. Thus, we decomposed task responses into these facets—d′ and *criterion*, respectively—using Signal Detection Theory (SDT; Stanislaw and Todorov 1999). Given Gunderson and ten Brinke (2022), we hypothesized that older and young adults would have similar, above-chance sensitivity to deception (Hypothesis 1A), but older adults would have a higher truth bias than young adults (Hypothesis 1B). We then examined multivariate patterns of brain activity contrasting deceptive and genuine pleas in young and older adults. We hypothesized that brain activity in regions associated with socioemotional (e.g. temporoparietal junction) and cognitive control (e.g. dorsolateral prefrontal cortex) processes would differentiate deceptive and genuine pleas, given unique difficulty in the former (Hypothesis 2A). Moreover, we expected these neural correlates to exhibit weaker activation among older versus young adults (Hypothesis 2B). Finally, in a parametric fashion, we explored how individual variation in sensitivity to deception and truth bias related to brain activity in this paradigm.

Methods

Participants

Data for this analysis were taken from a larger study on social-cognitive ageing, and only measures relevant to this analysis are reported here. The University of Florida Institutional Review Board approved this study. All participants provided written informed consent. Participants were recruited from the local community and received monetary compensation for their participation. Participants over 55 years old were screened for signs of cognitive impairment using the Telephone Interview for Cognitive Status (Brandt *et al.* 1988). Those who scored below the cutoff (<30) were excluded from further participation. Participants were eligible if they had normal or corrected-to-normal vision and no recent history of neurological or psychiatric problems or other standard MRI contraindications (e.g. claustrophobia). For the current analysis, two young adults were excluded because they did not complete both runs of the task. After quality control, two additional young adults were excluded due to especially low temporal signal-to-noise ratio (tSNR) in the orbitofrontal cortex and four older adults due to significant residual noise after denoising. The analysed sample thus comprised 53 young (ages 18–33 years) and 50 older (ages 55–78 years) adults whose demographics are summarized in Table 1.

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Table 1. Sample description and task performance.

	Young adults ($n=53$)	Older adults ($n=50$)
	M (SD)/n	M (SD)/n
Demographics		
Age in years	22 (3.71)	67.7 (6.57)
Sex		
Female	41	35
Male	12	15
MoCA		27.46 (2.21)
Years of education	15.32 (2.23)	16.39 (2.64)
Race		
White	37	47
Black	2	1
Asian	9	0
American Indian or Alaska Native	0	1
Multiracial	5	1
Ethnicity		
Hispanic	11	3
Not Hispanic	42	47
Handedness		
Right	48	41
Left	4	7
Ambidextrous	1	2
Deception Detection Task		
Deceptive plea % accuracy	28.30 (18.37)	31.50 (22.90)
Genuine plea % accuracy	52.36 (23.52)	55.75 (26.51)
Truth Bias ('criterion')	–0.03 (0.79)	0.03 (0.92)
Sensitivity to deception (d')	–0.22 (1.00)	0.23 (1.03)
Speakers recognized		
Genuine pleas	0.13 (0.73)	0.38 (0.61)
Deceptive pleas	0.09 (0.56)	0.02 (0.14)

One older adult did not report their years of education. The range of observed Montreal Cognitive Assessment (MoCA) scores among older adults was 22–30. Positive 'criterion' values indicate a propensity to respond that a pleader is telling the truth. Positive d' scores indicate greater sensitivity to deception.

Task design

We adapted the high-stakes deception detection task from prior work (ten Brinke and Porter 2012, Gunderson and ten Brinke 2022) for the MRI environment. In brief, participants viewed videos of real news clips in which speakers made genuine or deceptive emotional pleas for help in finding a missing relative. Deceptive pleas were made by individuals (five men, three women) who were later convicted of murdering their missing relative based on physical evidence, whereas genuine pleas were made by individuals (five men, three women) not involved in the crime (e.g. the missing relative was found absent of foul play or another person was convicted of the murder). Specific videos were chosen from a larger pool using stratified random sampling, ensuring the same male and female distribution within genuine and deceptive pleas. Videos were edited from their variable original length to uniformly last 20 s (e.g. by removing interruptions where the pleader was not shown onscreen). Additionally, we developed a novel control condition in which participants viewed real news clips in which a speaker (five men, three women) described a disaster (e.g. fire, flood) that happened to them. Participants subsequently decided if the event had a high or low impact on the speaker. This condition was excluded from analysis here because responses were subjective and did not inform participants' ability to detect deception.

Participants were instructed that their goal was to decide if the pleader in the videos was telling the truth or lying after watching the pleas for information on the missing relatives. Each trial proceeded as follows: 8 s of fixation, 2 s of a prompt indicating participants would be making a deception detection (truth or lie) decision, a 20 s news clip, and a 3-s decision period wherein participants were asked 'Is this person telling the truth or lying? (response options: truth, lie)'. Each of the two runs consisted of four trials per condition, for which presentation order was pseudorandomized with the constraint that not more than two videos of the same type followed in a row. Participants were assigned to one of two counterbalanced versions of the task in which the presentation order within each run was reversed. Each run began with 4 s of fixation and ended with 10 s of fixation.

Procedure

Given the broader study goals, participants completed multiple testing sessions over the phone, virtually using videoconferencing software, and in the laboratory. In brief, we screened for eligibility and collected demographic information over the phone. Participants later completed the deception detection task while undergoing an MRI. Participants' recognition of the speaker (yes/no) was inquired to account for potential effects of familiarity on deception detection (Supplementary Table 1, Supplementary Figure 2).

Magnetic resonance imaging acquisition and preprocessing

Image acquisition

Imaging data were collected on a 3T Siemens Magnetom Prisma MRI scanner with a 64-channel head coil. Anatomical scans were acquired using a T_1-weighted (T1w) volumetric magnetization-prepared rapid gradient echo sequence [time repetition (TR) = 2300 ms; 9° flip angle; 1 mm isotropic voxels; generalized auto-calibrating partially parallel acquisition (GRAPPA) encoding at an millimeter parallel acquisition technique (mmPAT) acceleration factor of 2]. Two 7-min blood oxygen-level dependent (BOLD) functional task scans were acquired with a multi-echo-planar imaging (EPI) sequence (420 volumes; TR = 1000 ms, echo time $(TE)_1$ = 12 ms, TE_2 = 30.11 ms, TE_3 = 48.22 ms; 50° flip angle; matrix size = 80 × 80; field of view (FOV) = 240 mm; 48 axial slices parallel to the plane of the anterior commissure–posterior commissure; 3 mm slice thickness; 4× multiband acceleration factor in interleaved descending order; 3 mm isotropic voxels; GRAPPA encoding at an mmPAT acceleration factor of 2]. Prior to task fMRI scans, we collected spin-echo fieldmaps in both AP and PA directions with 3 mm isotropic voxels (single-echo, single-band, six volumes, TA = 0:28, TR = 4041 ms, TE = 48 ms, FOV = 240 mm, FA = 90°, 48 slices at 3 mm thickness).

Anatomical and functional image preprocessing

Initial anatomical and functional image preprocessing was performed using fMRIPrep version 22.1.1 (Esteban *et al.* 2019) (RRID: SCR_016216). A *B0*-nonuniformity map (or 'fieldmap') was estimated based on two EPI references with 'topup' (Smith *et al.* 2004) (FSL 6.0.5.1:57b01774). The first echo of the fMRI data was used to estimate parameters for head motion and distortion correction. The fMRI data were resampled on their original, native space by applying the transforms that corrected for head-motion and distortions. The first four volumes of each echo were subsequently discarded using *fslroi* to account for potential non-steady state volumes. Next, the TE-dependence analysis (*tedana*, v0.0.11) workflow (DuPre *et al.* 2021) was performed on the scanner-space, minimally preprocessed echoes. *Tedana* relies on the TE-dependence model of BOLD signal to determine the $T2^*$ in every voxel, which is then used to optimally combine data across echoes and separate BOLD signal from non-bold sources of noise (DuPre *et al.* 2021). We applied the Kundu decision tree (v2.5; Kundu *et al.* 2013). We

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conducted analysis on the optimally combined and denoised voxel-wise timeseries output. Volume-based spatial co-registration to the T1w image and normalization to a custom young–old cohort template in MNI-space (Laurita *et al.* n.d.) was performed to reduce systematic template registration biases between age groups, using nonlinear registration with *antsRegistration* (ANTs 2.3.3). Subsequently, data were smoothed with an 8 mm full-width half-maximum Gaussian kernel to further address potential biases associated with spatial registration to a template across age groups (Castle *et al.* 2012, Cassidy *et al.* 2016, Zebrowitz *et al.* 2018).

Quality assessment

We inspected anatomical and functional co-registration, tSNR, and the percent of volumes retaining residual noise (>0.50 mm framewise displacement, DVARS >2; Power *et al.* 2012). If participants had 10% or greater of frames retaining residual noise in either run, they were excluded from analysis (four older adults).

Analytic approach

Behavioural analysis

We leveraged SDT (Stanislaw and Todorov 1999), as in prior work with this paradigm (Gunderson and ten Brinke 2022), to disentangle the multiple factors that could contribute to accuracy rates (see Table 1; Supplementary Material). Specifically, we calculated measures of sensitivity to deception (d′; higher values indicate better discrimination between deceptive versus genuine pleas) and truth bias (‘criterion’; higher values indicate a response tendency to say that the pleader was telling the truth). We compared sensitivity to deception and truth bias between age groups using a Welch’s *t*-test, assuming unequal variance among the age groups.

Functional magnetic resonance imaging analysis

We used partial least squares (PLS) to analyse patterns of brain activity associated with groups (age: young, older) and experimental conditions (plea type: deceptive, genuine). PLS is a multivariate analysis technique used to identify whole-brain patterns of activity [orthogonal latent variables (LVs)] that optimally relate the BOLD signal and experimental design (McIntosh *et al.* 1996, Krishnan *et al.* 2011). Unlike univariate analyses, PLS is sensitive to distributed voxel response rather than the activity of individual voxels. Each trial—comprising the prompt, video, and decision period—was 25 s in duration. Data were standardized against the first TR of the block (during the prompt). The analysis space was restricted to voxels with the default minimum intensity threshold of 0.15 multiplied by the maximum intensity of the image; voxels less than this threshold were considered non-brain regions and not analysed.

The data matrix was expressed as the voxel-by-voxel deviation from the condition mean within each age group (i.e. removing the ‘main’ effect of age group; mean-centring option 0 in the PLS graphical user interface). This matrix was then analysed with singular value decomposition to derive the patterns that maximally covaried with the experimental design. Each brain voxel was given a singular value weight, known as a salience (akin to a component loading in principal components analysis), which is proportional to the covariance of activity with the task contrast on each LV. Multiplying the salience by the BOLD signal value in that voxel and summing the product across all voxels gives a composite brain activity score for each participant and experimental condition on a given LV (like a component score in principal components analysis). These scores can be used to examine similarities and differences in brain activity across conditions. Confidence intervals (95%) for the mean composite brain activity score in each condition and group were calculated from the bootstrap, and differences in activity between conditions were determined via their lack of overlap.

The significance of each LV was determined via permutation testing by randomly reordering the assignment of participants to groups and conditions within subjects over 500 iterations. LV *P*-values were calculated as the frequency for which the observed singular value exceeded the permuted singular values for each LV. In a second independent step, the reliability of the saliences for the brain voxels across subjects, characterizing each pattern identified by an LV, was determined by bootstrap resampling, using 500 iterations, to estimate standard errors for each voxel. We report clusters larger than 10 voxels, with a minimum spatial distance of 20 mm between peaks and a bootstrap ratio (akin to a *z*-score) >2.58 (approximate $P < .01$). Because PLS identifies whole-brain patterns of activity in a single analytic step, no correction for multiple comparisons is required.

Brain-behaviour analysis

To characterize the relation between sensitivity to deception (d′), truth bias (‘criterion’), and brain activity, we conducted a behaviour PLS analysis, which is an extension of the above-described task PLS. This behaviour PLS correlated the two behaviour scores with activity in all brain voxels and then examined, using singular value decomposition, how these correlation patterns differed across age groups and experimental conditions (Krishnan *et al.* 2011). In behaviour PLS, correlation values represent the relations between behaviour scores and the whole-brain pattern identified in the analysis. Significance and reliability were tested as above by permuting the correspondence of behaviour scores and brain activity. Sensitivity to deception (d′) and truth bias (‘criterion’) were tested in the same model because brain activity related to each could overlap. The relatively low number of trials could introduce greater sampling error (Stanislaw and Todorov 1999). We characterized sampling error as the higher proportion of subjects with low performance variability who (in)correctly identified either all deceptive or all genuine pleas (5 young, 10 older; see Supplementary Fig. 1). We then re-computed the behaviour PLS and replicated its results without these participants (see Supplementary Fig. 4).

Results

Behavioural responses: both age groups had poor sensitivity to deception and no evidence for a truth bias

Descriptive statistics of sensitivity to deception (d′) and truth bias (‘criterion’) by age group and plea type are presented in Table 1. Older adults had greater sensitivity to deception (d′; Fig. 1A) than young adults, $t(100.31) = 2.27$, $P = .03$, $d = .45$, 95% CI [0.09, 0.85]. Neither age group, however, indicated good ability to discriminate deceptive from genuine pleas, as reflected by no difference in d′ scores from zero [older adults: $t(49) = 1.61$, $P = .11$; young adults: $t(52) = 1.60$, $P = .12$]. Moreover, age differences in sensitivity to deception appeared to be driven by young adults’ greater propensity for false alarms (i.e. say a genuine pleader is lying; Supplementary Fig. 1). Young and older adults had similar propensity to respond that a pleader was telling the truth (criterion; Fig. 1B), $t(96.85) = 0.39$, $P = .70$, $d = .08$, 95% CI [−0.32, 0.52]. In addition, neither age group exhibited a truth bias, as reflected by no difference in criterion scores from zero [older adults: $t(49) = 0.26$, $P = .79$; young adults: $t(52) = 0.30$, $P = .77$].

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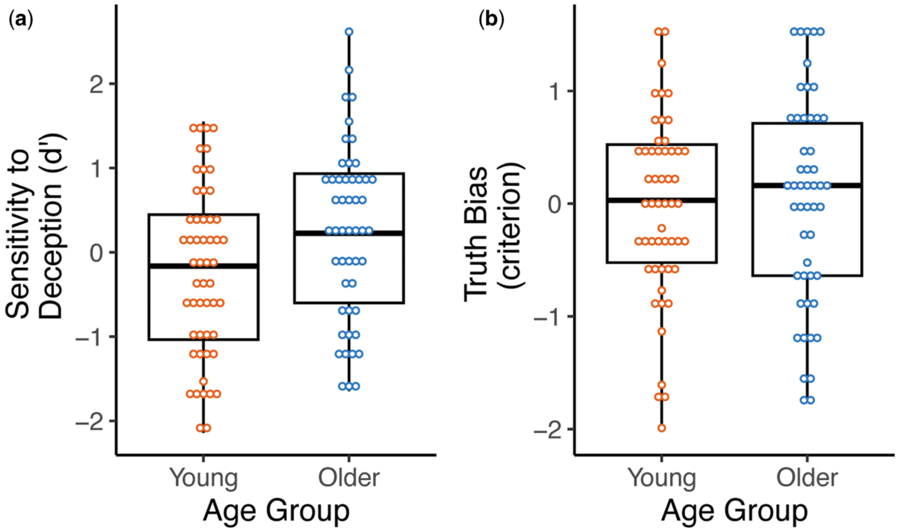

Figure 1. Behavioural scores for the high-stakes Deception Detection Task. Sensitivity to deception (d′; A) and truth bias (‘criterion’; B) by age group (young, older) and plea type (deceptive, genuine) with individual participants plotted as overlaid dots. The black line represents the median, the box indicates the interquartile range, and the whiskers extend to the minimum and maximum values within 1.5× the interquartile range.

Functional magnetic resonance imaging analysis: brain activity dissociated genuine and deceptive pleas

A first PLS analysis examined potential differences between plea types (genuine, deceptive) among young and older adults. Resulting LVs are data-driven contrasts, ranked by how much covariance each LV explained between brain activity and the experimental design. There was one significant LV ($P < .014$, 83% covariance explained) that distinguished brain activity during genuine pleas from brain activity during deceptive pleas across both age groups (Table 2; Fig. 2). When viewing genuine versus deceptive pleas, participants had stronger activity in the left fusiform gyrus and left lingual gyrus extending into the bilateral associative visual cortex and bilateral angular gyri, dorsal posterior cingulate cortex, bilateral temporal poles extending into the middle temporal gyrus in the left hemisphere, left precentral gyrus and right supplementary motor area, and left inferior frontal gyrus. No regions showed stronger activity during deceptive pleas. To characterize regional effects, we extracted BOLD signal from peak coordinates [neighbourhood size = 1 (27 voxels); Supplementary Fig. 3]. No other significant LVs (e.g. indicating an interaction between plea type and age group) emerged.

Brain-behaviour analysis: older adults’ sensitivity to deception related to their brain activity when making deception detection decisions

Using behavioural PLS, we next examined whether individual variation in sensitivity to detection (d′) and truth bias (‘criterion’) related to brain activity. We observed one significant LV ($P = .002$, 64% covariance explained): In older adults, sensitivity to deception was positively related to brain activity for genuine and deceptive pleas (i.e. when making any deception detection decision), whereas in young adults, sensitivity to deception was negatively related to brain activity for deceptive pleas only (Table 3; Fig. 3). Elaborated further, higher sensitivity to deception in older adults was related to stronger activity in the ventral and dorsal medial prefrontal cortex, bilateral frontal eye fields, bilateral dorsolateral prefrontal cortex, bilateral inferior frontal gyrus, ventral posterior cingulate cortex, left hippocampus, and left angular gyrus. Among young adults, higher sensitivity to deception was related to weaker activity of these regions during deceptive but not genuine pleas. Truth bias was unrelated to brain activity.

Discussion

The current study examined young and older adults’ brain activity during a high-stakes deception detection task. Young and older adults had similar poor deception detection (sensitivity), and there was no evidence that older adults had a stronger propensity to assume pleaders were telling the truth (truth bias), contrasting Hypotheses 1A and 1B, respectively. Even so, there was stronger activation, particularly in occipital and parietal areas, for genuine versus deceptive pleas. This finding supports our hypothesis that the plea type influenced participants’ neural response (Hypothesis 2), despite the fact that the same type of decision (i.e. deception detection) was being made in both conditions. Lastly, older adults with greater sensitivity to deception, but not truth bias, had stronger recruitment of multiple distributed brain regions when viewing both genuine and deceptive pleas, including the dorsal and ventral medial prefrontal cortex, bilateral dorsolateral prefrontal cortex, bilateral inferior frontal gyrus, left hippocampus, and right anterior cingulate cortex. Conversely, young adults with better sensitivity to deception recruited these regions to a lesser extent when viewing deceptive pleas. Together, these results contribute to growing literatures suggesting that age differences in brain and behaviour are impacted by rich context afforded by naturalistic paradigms (mirroring daily life) and that individual variability among older adults is important for understanding vulnerability or resilience to deception.

Overall, participants were not sensitive to deception, although both groups were more accurate for genuine (correct rejection) than deceptive (hit) pleas (Supplementary Fig. 1). Greater accuracy for genuine pleas has been observed even among experts (e.g. military intelligence personnel; Burgoon *et al.* 1994) and may reflect assumptions about the underlying base rates of honest/dishonest communications in daily life (Levine 2014). Furthermore, although older adults had higher sensitivity to deception than young adults, this effect was driven by young adults’ greater propensity to say that a genuine pleader was lying (false alarms; Supplementary Fig.

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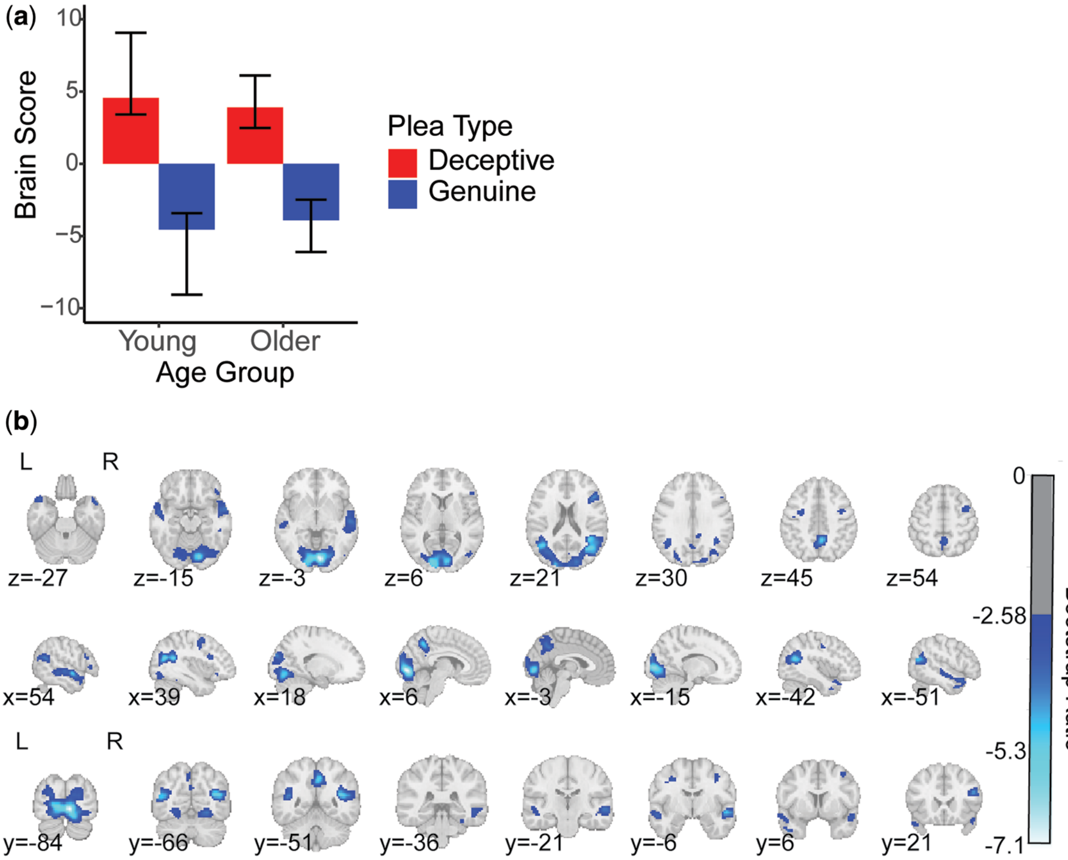

Figure 2. Brain activity associated with young and older adults viewing genuine versus deceptive pleas. Results from the PLS analysis dissociated deceptive and genuine pleas across age groups. (A) Bar chart shows the composite brain activity scores that convey the expression of the LV for task conditions and age groups. Negative brain scores indicate brain activity associated with viewing genuine (>deceptive) pleas, represented in the cool-coloured brain areas in Panel B. (B) The LV expressed on volumetric brain slices in neurological orientation in MNI152-space. Voxel-wise bootstrap ratios (analogous to z-scores) were thresholded to an effective $P < .01$ (± 2.58). See Supplementary Fig. 3 for BOLD signal estimates from peak coordinates reported in Table 2.

1). Possibly, there is an age- (or cohort-) related asymmetry in the perceived consequences of calling someone a liar when they are not. Put another way, how young and older adults make errors may inform which decision attributes are salient to each group (Frazier *et al.* 2019, Horta *et al.* 2024). Also, no age differences or greater-than-chance propensity emerged for truth bias. These results contrast a prior report using the same paradigm that instead found young and older adults had similar, above-chance sensitivity to deception, and both groups had a truth bias, but more so among older adults (Gunderson and ten Brinke 2022). Multiple factors may explain these discrepancies. For instance, we adapted the news clip stimuli to be shorter and of consistent video length for use inside the MRI scanner (a distracting environment). Another report from a partially overlapping sample found accurate interoceptive awareness related to better accuracy for deceptive pleas, particularly among the eldest older adults (Heemskerk *et al.* 2024). This finding intriguingly suggests that intrinsic signals influence deception detection and could be disrupted by external factors like the distracting MRI environment.

Interestingly, there was a stronger neural response to genuine than deceptive pleas across bilateral primary and associative visual areas, the left fusiform gyrus, bilateral precentral gyrus regions, and the bilateral temporal poles extending to the middle temporal gyrus on the left. Many of these regions relate to sensory processing (Yeo *et al.* 2011) and are implicated in the identification of facial expressions of emotion (Kitada *et al.* 2010). Such regions may have

Table 2. Brain activity that differentiated plea type (deceptive, genuine) across age groups (young, older).

Region	BA	X	Y	Z	BSR	k
Positive bootstrap ratios (deceptive > genuine)						
None						
Negative bootstrap ratios (genuine > deceptive)						
L lingual gyrus	18	−6	−84	−3	−7.12	3183
L dorsal posterior cingulate cortex	31	−6	−51	45	−5.03	365
L superior/middle temporal gyrus	21/22	−54	−6	−9	−4.91	519
L inferior frontal gyrus, triangular part	44	−48	21	24	−4.24	115
R temporal pole	38	48	12	−21	−3.98	287
R supplementary motor area	6	30	−3	42	−3.62	43
L precentral gyrus	6	−39	0	51	−3.59	89
L fusiform gyrus	37	−33	−39	−21	−2.82	13

BA, Brodmann area; region labels were derived from the AAL3 atlas (Rolls *et al.* 2020). BSR: bootstrap ratio from the PLS analysis indicating reliability of reported cluster; R: right hemisphere; L: left hemisphere. BSRs were thresholded to an effective $P < .01$ (±2.58), the minimum cluster size allowed was 10 voxels, and peaks had a minimum distance of 20 mm. Coordinates in MNI152-space. See also Fig. 2.

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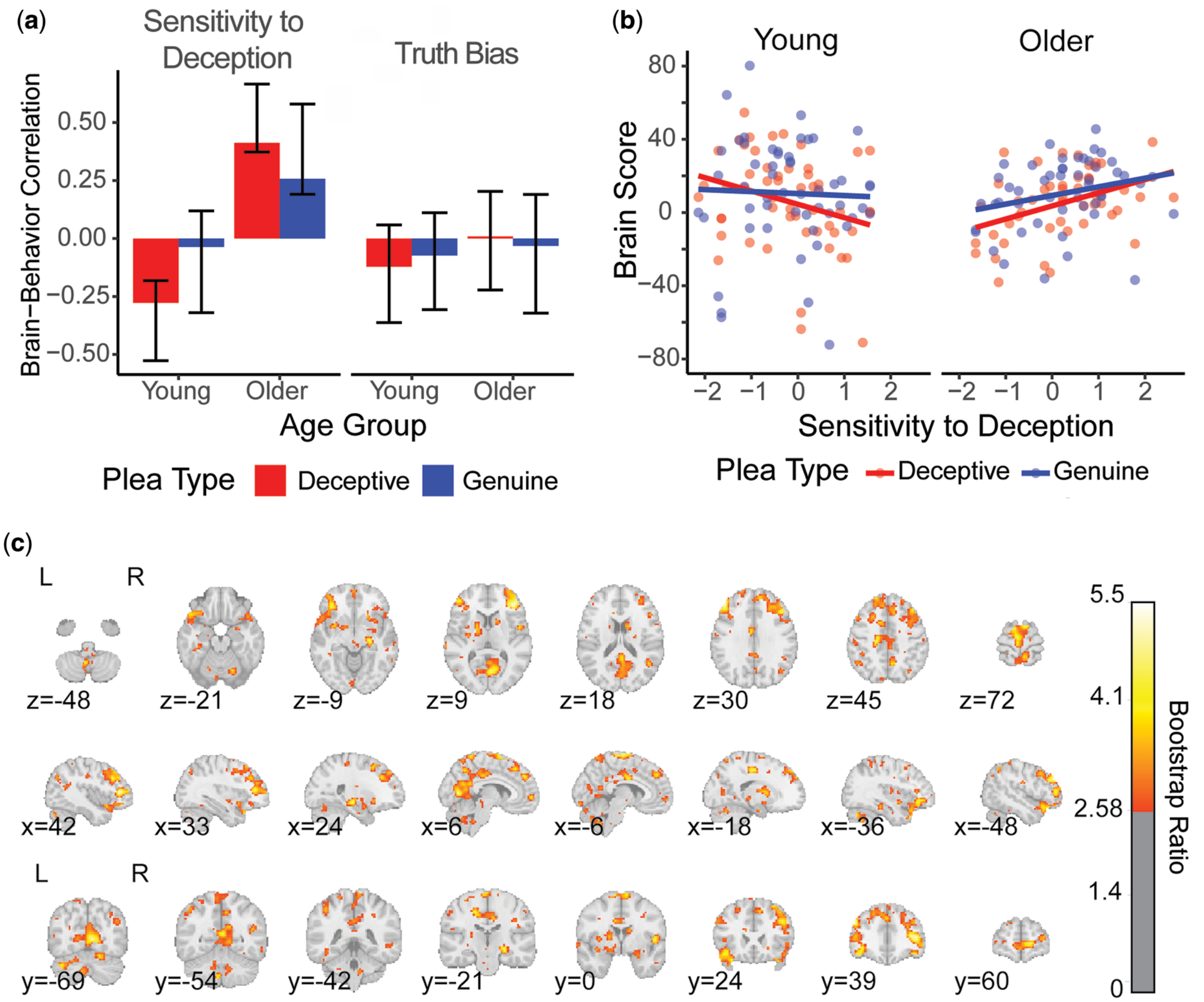

Figure 3. Brain activity covarying with sensitivity to deception (d′), but not truth bias (criterion), in young and older adults viewing deceptive and genuine pleas. Results from the behaviour PLS analysis found that the association between sensitivity to deception and brain activity varied by age group and plea type. Truth bias did not relate to brain activity. (A) Bar chart showing the bootstrapped correlation values between behaviour and a composite brain activity score. Positive brain scores indicate a positive association between sensitivity to deception and brain activity, represented in the warm coloured brain areas in Panel C. (B) Scatterplots of the same association. (C) Brain activity that covaried with sensitivity to deception, expressed on volumetric brain slices in neurological orientation in MNI152-space. Voxel-wise bootstrap ratios (analogous to z-scores) were thresholded to an effective *P* < .01 (±2.58).

responded more strongly because genuine high-intensity facial expressions of emotions are less ambiguous and therefore more easily identified than deceptive ones, as determined by expert coders (Porter *et al.* 2012). Naïve observers, however, do not accurately detect the veracity of high-intensity facial emotions (Porter *et al.* 2012), as we also observed. Thus, specific brain regions, like expert coders, may be sensitive to differences between plea types but not solely determine behavioural decisions given the presence of other cues or how those cues are used (Lighthall 2020). We also observed posterior cingulate cortex, bilateral temporoparietal junction, and bilateral temporal pole activity to be stronger for genuine than deceptive pleas. This finding is interesting because these regions are commonly implicated in inferring others' mental states, such as intentions and feelings (Hughes *et al.* 2019, 2024b), which participants were explicitly instructed to do in both conditions. Thus, these results may reflect more nuanced functional roles of these regions based on the salience (Schuwerk *et al.* 2017) or differential use (Gobbini *et al.* 2007) of cues between plea types. Supporting this possibility, we did not observe a difference in the medial prefrontal cortex, another core theory of mind region that shows weaker activity among older versus young adults (Moran *et al.* 2012). In fact, we did not observe the hypothesized interaction between plea type and age group on brain activity, which foremost parallels the accuracy result. But also, much prior literature relies on less naturalistic paradigms (Moran *et al.* 2012, Henry *et al.* 2013), which could exacerbate age differences in brain and behaviour. These findings highlight the need for more research on the contextual factors, such as the availability of multiple cue modalities, influencing deception detection.

Rather, age differences emerged such that older, but not young, adults with higher sensitivity to deception in our study had a stronger neural response to both genuine and deceptive pleas among a distributed complement of brain regions. This shared pattern of neural activity across plea types in older adults, as opposed to sensitivity to deception relating only to deceptive pleas, may reflect that the same decision (deception detection) was being made across those conditions. Specifically, older adults with better sensitivity to deception had stronger activation of several prefrontal

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Table 3. Brain activity that covaried with sensitivity to deception (d′) differed among age groups (young, older) and plea types (deceptive, genuine).

Region	BA	X	Y	Z	BSR	k
Positive bootstrap ratios						
R middle frontal gyrus	45	48	42	30	5.5298	221
L inferior frontal gyrus, triangular part	45	−42	39	9	5.2187	804
L lingual gyrus	17	−6	−69	6	5.0634	820
R supplementary motor area	6	3	−15	75	4.9094	493
L hippocampus		−24	−21	−9	4.7335	139
L superior frontal gyrus, medial	10	−15	60	0	4.6929	140
L inferior frontal gyrus, triangular part	48	−45	27	30	4.6796	998
R middle cingulum	23	18	−21	45	4.6385	433
R inferior frontal gyrus, pars orbitalis	47	42	36	−15	4.4836	611
L Rolandic operculum	48	−51	0	6	4.4759	58
R cerebellum crus 1		36	−72	−33	4.3759	199
R postcentral gyrus	43	63	−12	36	4.0615	76
R cerebellum 9		6	−57	−51	4.0019	156
L caudate		−12	12	12	3.9886	65
R fusiform gyrus	20	39	−30	−18	3.9754	80
L cerebellum 6		−18	−69	−21	3.9149	75
R pallidum	48	18	3	6	3.7769	170
R putamen	48	33	3	−9	3.7706	51
L middle temporal gyrus	39	−45	−57	18	3.7611	56
R inferior parietal gyrus	40	42	−45	51	3.7256	142
R middle cingulum	32	12	9	45	3.7169	37
L middle occipital gyrus	19	−42	−72	33	3.6043	43
Cerebelum_Crus1_L		−42	−78	−33	3.5848	29
L middle temporal gyrus	21	−51	−39	−6	3.4876	43
R parahippocampal gyrus	35	21	−12	−24	3.4521	13
R superior temporal gyrus	22	69	−30	6	3.4092	14
L calcarine	17	6	−90	−12	3.404	30
R hippocampus		21	−27	−3	3.1997	17
R cuneus	19	15	−81	39	3.1764	34
L postcentral gyrus	3	−24	−30	57	3.0829	16
L inferior parietal gyrus	40	−30	−39	39	3.0459	10
L postcentral gyrus	48	−39	−21	33	2.9898	20
R posterior cingulum	23	3	−30	24	2.952	11
R cuneus	23	12	−57	21	2.8192	10
Negative bootstrap ratios						
None						

BA: Brodmann area; region labels were derived from the AAL3 atlas (Rolls *et al.* 2020); BSR: bootstrap ratio from the PLS analysis indicating reliability of the reported cluster; R: right hemisphere; L: left hemisphere. BSRs were thresholded to an effective $P < .01$ (± 2.58), the minimum cluster size allowed was 10 voxels and peaks had a minimum distance of 20 mm. Coordinates in MNI152-space. Refer to Fig. 3 for interpretation of positive and negative bootstrap ratios.

cortex regions. Stronger activation and poorer modulation of prefrontal regions in older adulthood (Cabeza 2002, Turner and Spreng 2015), such as in the dorsolateral prefrontal cortex, are commonly noted as possibly compensating for declining cognitive control in older age (Park and Reuter-Lorenz 2009). Speculatively, that enacting (Dupont *et al.* 2023) and detecting deception share neural correlates (e.g. anterior cingulate cortex) suggests that both processes require awareness of incongruity between the truth and what is said, which is impaired among older adults (Hughes *et al.* 2024a). Individuals who are successful at deception detection must not only identify sources of conflict but must also integrate information towards a decision using cognitive control (Lighthall 2020). Additional recruitment of bilateral inferior frontal gyri among successful older adults in the current study may have reflected such compensatory recruitment of the prefrontal cortex (Buhle *et al.* 2014).

Speaking to socioemotional processing and integration (Frazier *et al.* 2019), older adults with higher sensitivity to deception also exhibited stronger dorsal and ventral medial prefrontal cortex activity. These regions are implicated in impression formation (Denny *et al.* 2012), understanding others' thoughts and intentions in both older and young adults (Moran *et al.* 2012, Hughes *et al.* 2019, 2024b), and recognizing facial emotions (Cassidy *et al.* 2021). The ventromedial prefrontal cortex has specifically been seen in both lesion (Asp *et al.* 2012) and BOLD (Koestner *et al.* 2016) studies related to the ability to discern false advertising in printed materials. Moreover, a stronger ventromedial prefrontal cortex BOLD response, and its functional connectivity with the dorsolateral prefrontal cortex, were related to better memory-dependent decision making (Lighthall *et al.* 2014).

Beyond the prefrontal cortex, higher sensitivity to deception among older adults also related to the left hippocampus and the right parahippocampal cortex, both involved in episodic memory (Andrews-Hanna *et al.* 2014), as well as the left dorsal angular gyrus, implicated in semantic processing (Seghier *et al.* 2010), and for which lower cortical volume was associated with less financial capacity in individuals with amnestic mild cognitive impairment (Stoeckel *et al.* 2013). The involvement of memory-related regions speculatively reflects older adults' increased reliance upon stored representations to support goal-directed task performance (Spreng and Turner 2019). Together, our results and extant theories highlight the involvement of distributed brain regions with distinct functional roles during decision-making in ageing (Frazier *et al.* 2019). Here, we show some of the first evidence that successful

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deception detection in high-stakes, naturalistic contexts is related to more distributed neural processing in older but not young adults. This finding generates new directions for deception detection research; for instance, about what kinds of stored representations from cumulative life experience (e.g. schemas about deceptive cues) aid or impair deception detection among older adults.

In conclusion, this study sheds light on the salience of genuine (without concealment) versus deceptive high-stakes pleas among both young and older adults. We also demonstrated that some older adults may have better deception detection ability through different patterns of neural recruitment than young adults, which could potentially reflect different cognitive strategies for deception detection with older age. We observed some similar patterns of neural recruitment when compared with other work using printed advertisements (Asp *et al.* 2012), which may indicate that some cognitive (Chen *et al.* 2025) and neural mechanisms of deception detection may be modality-independent, including for targeted phishing emails (Lin *et al.* 2019, Ebner *et al.* 2020, Pehlivanoglu *et al.* 2023), which will be an important area for future research. Yet, exploitation (e.g. financial)—a severe consequence of being deceived—is most often perpetuated by close others (Acierno *et al.* 2010, Peterson *et al.* 2014), highlighting the need to understand the social factors contributing to deception. Moreover, a limited number of studies have indicated differences in brain structure and resting-state function between financially exploited older adults and those older adults who successfully rebuffed an exploitation attempt (Spreng *et al.* 2017, Weissberger *et al.* 2020). Relatively less work has interrogated age differences in brain function as older adults are making deception detection decisions. Doing so is an important contribution of the current work and advances understanding of the extent to which age-related vulnerabilities arise from general or context-specific differences in brain function. These insights can inform the routes by which deception can lead to exploitation and potential areas for intervention (Spreng *et al.* 2016).

Author contributions

Colleen Hughes (Formal analysis [lead], Visualization [lead], Writing—original draft [lead]), Natalie C. Ebner (Conceptualization [equal], Data curation [equal], Funding acquisition [equal], Investigation [equal], Methodology [equal], Project administration [equal], Supervision [equal], Writing—review & editing [equal]), Didem Pehlivanoglu (Data curation [equal], Investigation [equal], Writing—review & editing [equal]), Amber Heemskerk (Data curation [equal], Investigation [equal], Writing—review & editing [equal]), Tian Lin (Data curation [equal], Investigation [equal], Writing—review & editing [equal]), Leanne ten Brinke (Conceptualization [equal], Methodology [equal], Writing—review & editing [equal]), Gary Turner (Conceptualization [equal], Methodology [equal], Writing—review & editing [equal]), and R. Nathan Spreng (Conceptualization [equal], Formal analysis [supporting], Funding acquisition [equal], Supervision [equal], Writing—review & editing [equal])

Supplementary data

Supplementary data are available at *SCAN* online.

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Data availability

The data supporting the findings of this manuscript are available upon request.

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