**Supplemental Data**

**Title:** Click here to claim your winnings! Financial exploitation is associated with structural and functional brain differences in healthy older adults

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**Supplemental Data:** Supplemental Methods, Table e-1, Appendix e-1

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**Supplemental Methods**

*Participants*

Local community agencies (Tompkins County Office of Aging, New York State Adult Protective Services) provided assistance in identifying financially exploited older adults and referred them to participate. Some exploited older adults were identified after study enrollment through standard recruitment, including five participants from Toronto. All participants were healthy, with normal or corrected-to-normal visual acuity, and no history of psychiatric, neurological, or other medical illness that could compromise cognitive functions.

*Neuropsychological and behavioral assessment*

The cognitive measures included Verbal Paired Associates (VPA), Symbol Digit Modality Test (SDMT), and the National Institutes of Health Toolbox Cognition Battery (NIH Cognition, completed on Desktop PCs). These measures were primarily implemented to assess working memory, cognitive flexibility, executive functioning, and attention. Measures examining personality and social factors included Reading the Mind in the Eye (MIE), the Toronto Empathy Questionnaire (TEQ), the Social Network Index (SNI), and National Institutes of Health Toolbox Emotion Battery (NIH Emotion). These measures were included to examine emotional traits, empathy, and available social support. Measures of financial valuation include Objective Numeracy, Temporal Discounting, Loss Aversion, The Delay of Gratification Inventory (DGI), The Future Anhedonia Index, the Self-Assessment of Financial Literacy, and the 5 Question Financial Literacy Questionnaire. These items were included to estimate participants’ financial and mathematical literacy as well as to examine their propensity to discount the value of a future reward in comparison to a reward presently available. We performed bootstrapping to identify 95% CIs to assess group differences on all measures of behavior, as well as computed Cohen’s d’s effect size estimates to inform future investigation.

*Neuroimaging*

*Structural imaging acquisition, preprocessing and analysis*

Anatomical scans from the Cornell MRI Facility were acquired on a GE750 Discovery series 3T scanner with a T1-weighted volumetric MRI magnetization prepared rapid gradient echo (repetition time (TR)=2500ms; echo time (TE)=3.44ms; flip angle (FA)=7°; 1.0mm isotropic voxels, 176 slices). Anatomical scans were acquired during one 5m25s run with 2x acceleration with sensitivity encoding.

Anatomical scans from the York University MRI Facility were acquired with a T1-weighted volumetric MRI magnetization prepared rapid gradient echo (TR= 900ms; TE=2.52ms; TI=900ms; FA=9°; 1.0mm isotropic voxels, 192 slices). Anatomical scans were acquired during one 4m26s run with 2x acceleration with generalized auto calibrating partially parallel acquisition (GRAPPA) encoding with an iPAT acceleration factor of 2.

Structural data was submitted to surface based morphometry as implemented in the Computational Anatomy toolbox in MATLAB (CAT12). Structural images were segmented into tissue classes using a local adaptive segmentation algorithm. Cortical thickness was calculated from segmented tissue information by projection-based thickness, which derives the local maximum of white matter distance from the cortical surface and projects this value to neighboring grey matter voxels[1]. From white matter distance, the central surface was then estimated as the midpoint between the grey/white matter boundary and the grey matter/cerebral spinal fluid boundary. The resulting surface was then corrected for topological artifacts to allow for inter-subject comparisons.

For each subject, cortical thickness was mapped onto the corrected central surface. Subject-specific central surfaces were then resampled to the Freesurfer average mesh (fs\_LR 164k), and subsequently smoothed with a 15mm FWHM Gaussian kernel. Smoothed cortical thickness maps were carried forward to a second-level contrast between financially exploited and non-exploited older adults, controlling for age, gender, and scanning site. Due to the small sample size and exploratory nature of the investigation, all results were assessed for significance at *p*<.005, uncorrected with 20 or more contiguous voxels.

*Functional imaging acquisition, preprocessing and analysis*

Multi-echo fMRI has been developed as a data acquisition sequence to facilitate removal of noise components from resting fMRI datasets[2, 3]. This method relies on the acquisition of multiple echoes, allowing direct measurement of T2\* relaxation rates. Blood-oxygen level dependent (BOLD) signal can be then distinguished from non-BOLD noise on the basis of echo time (TE) dependence. The preprocessing, multi-echo independent components analysis, has proven effective in denoising BOLD signal of motion and physiological artifacts in resting state fMRI[2, 3].

Participants completed two 10m06s resting-state multi-echo BOLD functional scans with eyes open, blinking and breathing normally in the dimly lit scanner bay. At Cornell University, resting-state functional scans were acquired using a multi-echo echo planar imaging (ME-EPI) sequence with online reconstruction (TR=3000ms; TE’s=13.7, 30, 47ms; FA=83°; matrix size=72x72; field of view (FOV)=210mm; 46 axial slices; 3.0mm isotropic voxels]. Resting-state functional scans were acquired with 2.5x acceleration with sensitivity encoding. At York University, resting-state functional scans were acquired using a multi-echo echo planar imaging (ME-EPI) sequence with online reconstruction (TR=3000ms; TE’s=14, 30, 46 ms; FA=83°; matrix size=64x64; FOV=216mm; 43 axial slices; 3.4x3.4x3mm voxels]. Resting-state functional scans were acquired with 3x acceleration with GRAPPA encoding.

Data were preprocessed with ME-ICA [2, 3] version 2.5 (<https://afni.nimh.nih.gov/pub/dist/src/pkundu/meica.py>). Anatomical images were first skull stripped using the default parameters in FSL BET. ME-ICA processing was then run with the following options: -e 13.6, 29.79, 46.59; -b 12; --no\_skullstrip; –space = Qwarp\_meanE+tlrc.HEAD. Here, the Qwarp\_meanE+tlrc.HEAD file represented a site-specific, MNI-space template of 30 younger and 30 older non-linearly registered adults. This template was created in AFNI using @toMNI\_Qwarpar.  Finally, ME-ICA denoised time series were smoothed to 6mm FWHM in SPM8.

For functional network identification, an equal number of healthy younger adults as the older cohort were also included (n=26; age mean=22.0y, SD=1.8; 14 women). Following preprocessing, we performed Group Independent Component Analysis (ICA) using Group ICA Toolbox on the resting state data for 26 older and 26 younger adult participants in order to identify the targeted functional networks. ICA is a fully data-driven approach that separates a dataset into components by maximizing their independence using high-order statistics. More specifically, GIFT is a MATLAB toolbox that extends this approach to the group level through 3 steps: compressing the data using Primary Components Analysis, computing ICA on each subject, and back reconstructing individual subject ICA maps based on the aggregate map across subjects. We elected to estimate a 10-component solution and visually identified the salience and default networks out of the components. To render the whole brain network images for the salience and default networks, we conducted one sample t-tests on the back reconstructed images of each participant, and included gender and scanning site as covariates. Whole brain network maps were assessed for significance at *p*<.05 (FWE corrected). Critical for the current study, we then compared the functional integrity of the salience and default network between our exploited and unexploited older adult groups. To do so, we conducted two sample t-tests between the back reconstructed images, and included age, gender, and scanning site as covariates. This analysis allowed us to identify differences between these groups within these specific networks. Due to the small sample size and exploratory nature of the investigation, whole brain network difference maps were assessed for significance at *p*<.005 uncorrected with 20 or more contiguous voxels.

**Supplemental References**

[1] Dahnke R, Yotter RA, Gaser C. Cortical thickness and central surface estimation. NeuroImage. 2013;65:336-48.

[2] Kundu P, Brenowitz ND, Voon V, Worbe Y, Vertes PE, Inati SJ, et al. Integrated strategy for improving functional connectivity mapping using multiecho fMRI. Proc Natl Acad Sci U S A. 2013;110:16187-92.

[3] Kundu P, Inati SJ, Evans JW, Luh WM, Bandettini PA. Differentiating BOLD and non-BOLD signals in fMRI time series using multi-echo EPI. NeuroImage. 2012;60:1759-70.

**Table e-1A**

*Group Mean Differences, Bootstrapped 95% CIs, and Effect Sizes in Measures of Cognition*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Exploited | |  | Unexploited | |  | 95% CI | |  |
|  | *M* | *SD* |  | *M* | *SD* |  | Upper | Lower | *|d|* |
| Cognition Function | 122.7 | 17.0 |  | 124.3 | 12.7 |  | 12.3 | -9.7 | .11 |
| Crystallized Cognition | 135.1 | 12.6 |  | 133.6 | 15.5 |  | 8.6 | -11.9 | .10 |
| Fluid Cognition | 100.5 | 13.0 |  | 102.5 | 8.7 |  | 10.9 | -6.1 | .18 |
| Early Childhood Cognition | 112.7 | 12.6 |  | 112.1 | 8.3 |  | 7.1 | -8.5 | .05 |
| Picture Vocabulary | 131.0 | 10.6 |  | 127.4 | 17.1 |  | 7.1 | -14.2 | .25 |
| Oral Reading Recognition | 124.2 | 13.1 |  | 124.0 | 8.9 |  | 8.1 | -8.7 | .01 |
| List Sorting Working Memory | 113.3 | 12.0 |  | 117.1 | 11.0 |  | 12.5 | -4.4 | .34 |
| Picture Sequence Memory | 107.6 | 20.8 |  | 110.2 | 14.8 |  | 16.6 | -9.9 | .15 |
| Verbal Paired Associates I | 28.5 | 10.5 |  | 27.1 | 10.0 |  | 5.4 | -8.4 | .14 |
| Verbal Paired Associates II | 8.9 | 3.3 |  | 8.5 | 3.0 |  | 1.8 | -2.8 | .12 |
| Verbal Paired Associates II Recognition | 33.9 | 5.4 |  | 34.5 | 5.0 |  | 4.5 | -3.3 | .10 |
| Verbal Paired Associates II Recall | 14.0 | 5.6 |  | 13.5 | 5.2 |  | 3.4 | -4.6 | .09 |
| Symbol Digit Modalities Oral | 56.5 | 7.6 |  | 56.6 | 3.7 |  | 4.9 | -4.4 | .02 |
| Symbol Digit Modalities Written | 48.9 | 6.1 |  | 48.5 | 5.3 |  | 3.8 | -4.7 | .05 |
| Flanker Inhibitory Control & Attention | 96.0 | 13.4 |  | 93.1 | 9.7 |  | 6.5 | -11.8 | .25 |
| Dimensional Change Card Sort | 105.5 | 11.5 |  | 105.4 | 10.2 |  | 7.8 | -7.8 | .01 |
| Pattern Comparison Processing Speed | 89.6 | 17.7 |  | 88.8 | 16.1 |  | 12.3 | -12.1 | .04 |

*Note. All measures from the NIH Cognition Toolbox reflect age-adjusted scores. Each of the composite scores includes a subset of the individual measures. Fluid Cognition: Flanker, Dimensional Change Card Sort, Picture Sequence Memory, List Sorting, and Pattern Comparison; Crystallized Cognition: Picture Vocabulary, Oral Reading Recognition; Cognitive Function: all Fluid and Crystallized Cognition measures; Early Childhood Cognition: Picture Vocabulary, Flanker, Dimensional Change Card Sort, and Picture Sequence Memory. Higher scores reflect better performance on all measures.*

**Table e-1B**

*Group Mean Differences, Bootstrapped 95% CIs, and Effect Sizes in Measures of Personality and Social Interaction*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Exploited | |  | Unexploited | |  | 95% CI | |  |
|  | M | SD |  | M | SD |  | Upper | Lower | *|d|* |
| Positive Affect | 48.7 | 8.8 |  | 50.5 | 5.7 |  | 7.3 | -3.8 | .24 |
| Life Satisfaction | 58.2 | 10.4 |  | 60.8 | 8.8 |  | 10.0 | -4.4 | .28 |
| Meaning & Purpose | 54.8 | 9.9 |  | 51.7 | 10.4 |  | 4.9 | -10.9 | .31 |
| Emotional Support | 46.3 | 7.9 |  | 45.6 | 8.7 |  | 5.6 | -6.8 | .08 |
| Instrumental Support | 49.7 | 6.8 |  | 45.9 | 11.2 |  | 2.6 | -10.7 | .42 |
| Friendship | 48.9 | 11.7 |  | 49.5 | 6.9 |  | 7.6 | -6.9 | .07 |
| Loneliness | 54.5 | 7.7 |  | 55.6 | 5.7 |  | 6.3 | -4.2 | .15 |
| Perceived Rejection | 54.8 | 8.7 |  | 52.7 | 6.7 |  | 3.5 | -7.9 | .26 |
| Perceived Hostility | 51.6 | 10.4 |  | 51.7 | 7.5 |  | 7.1 | -6.7 | .01 |
| Self Efficacy | 53.5 | 10.6 |  | 51.6 | 5.2 |  | 4.2 | -8.1 | .23 |
| Perceived Stress | 49.4 | 12.0 |  | 46.3 | 9.8 |  | 4.7 | -10.5 | .29 |
| Fear Affect | 54.1 | 8.3 |  | 50.5 | 10.5 |  | 3.0 | -11.2 | .38 |
| Fear & Somatic Arousal | 46.7 | 6.5 |  | 45.7 | 7.2 |  | 4.1 | -5.6 | .14 |
| Sadness | 45.3 | 13.6 |  | 48.2 | 7.3 |  | 10.9 | -5.9 | .27 |
| Anger Affect | 52.6 | 10.9 |  | 50.1 | 5.2 |  | 3.4 | -8.3 | .29 |
| Anger & Hostility | 50.4 | 6.7 |  | 44.9 | 6.8 |  | -0.2 | -10.4 | .81\* |
| Anger Physical Aggression | 56.2 | 6.9 |  | 51.4 | 6.9 |  | 0.7 | -9.5 | .70 |
| Reading the Mind in the Eyes | 23.6 | 3.5 |  | 25.4 | 2.9 |  | 4.5 | -0.7 | .57 |
| Toronto Empathy Questionnaire | 51.2 | 7.6 |  | 48.7 | 7.1 |  | 2.8 | -8.3 | .34 |
| Social Network Index | 6.3 | 2.6 |  | 6.3 | 2.6 |  | 1.8 | -2.2 | .00 |

*Note. All measures from the NIH Emotion Toolbox reflect age-adjusted scores. Higher scores reflect higher self-report for experiencing the corresponding trait or social interaction. \* denotes a CI that does not cross zero.*

**Table e-1C**

*Group Mean Differences, Bootstrapped 95% CIs, and Effect Sizes in Measures of Financial Valuation*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Exploited | |  | Unexploited | |  | 95% CI | |  |
|  | M | SD |  | M | SD |  | Upper | Lower | *|d|* |
| Objective Numeracy | 8.8 | 2.2 |  | 9.4 | 1.5 |  | 1.9 | -0.5 | .33 |
| Temporal Discounting, AUC | 0.6 | 0.4 |  | 0.7 | 0.3 |  | 0.3 | -0.2 | .10 |
| Loss Aversion, AUC | 0.1 | 0.0 |  | 0.1 | 0.1 |  | 0.1 | -0.0 | .34 |
| Delay of Gratification Inventory | 54.9 | 5.7 |  | 56.5 | 8.5 |  | 6.7 | -4.2 | .22 |
| Future Anhedonia | 0.1 | 0.4 |  | 0.2 | 0.4 |  | 0.4 | -0.2 | .31 |
| Self-Assessment of Financial Literacy | 5.1 | 1.3 |  | 5.8 | 0.8 |  | 1.5 | -0.1 | .65 |
| 5 Question Financial Literacy | 3.6 | 1.2 |  | 4.1 | 0.9 |  | 1.2 | -0.2 | .44 |
| 3 Question Debt Literacy | 1.2 | 1.0 |  | 1.0 | 0.9 |  | 0.5 | -0.9 | .24 |
| 8 Question Financial/Debt Literacy | 4.9 | 1.8 |  | 5.1 | 1.3 |  | 1.4 | -0.9 | .15 |

*Note. Higher scores in measures of numeracy and financial literacy reflect a better understanding of number conversions and financial knowledge. A higher score in Temporal Discounting reflects a greater number of choices to wait for larger later rewards over smaller sooner rewards. A higher score in Loss Aversion reflects a greater number of choices to put off losing more money in the future rather than losing a smaller sum immediately. Higher scores on the Delay of Gratification Inventory reflect more reporting of the ability to delay gratification. Higher scores in Future Anhedonia reflect higher valuation of present rewards over future rewards.*

**e-Appendix 1**

Financial exploitation incidents

01 Interpersonal: Daughter charged approximately $2000 of goods to her account without her knowledge.

02 Interpersonal: Grandson and his girlfriend stole money multiple times.

03 Interpersonal: Grandson continually stole money. The participant confronted him and told him not to but it continued. She started hiding her money until he moved out.

04 Interpersonal: At a gas station, son bought a $500 gift card with the participant's credit card while the participant was in the car.

05 Interpersonal: Shared a basement and utility costs with a neighbor. Items were stolen from basement and the neighbor would not pay their share of utilities.

06 Interpersonal: Sister was renting participant’s apartment. She stopped paying rent and began borrowing money for living expenses.

07 Interpersonal: Son stole participant's money.

08 Interpersonal: Son continually steals small amounts of money without permission, then indicates that he will pay it back, but does not.

09 Interpersonal: Son would take out additional money for himself when sent to the ATM.

10 Interpersonal: Son's girlfriend borrowed $4000 and never paid it back.

11 Interpersonal: Step-daughter stole participant's money.

12 Phone scam: Phone call from "Microsoft". Provided credit card information to remove viruses reported to be on their computer and charged hundreds of dollars.

13 Internet scam: Provided credit card information to a website, that initiated multiple unauthorized charges.