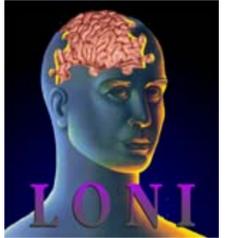


# Plasma protein associations with hippocampal atrophy across the cognitive spectrum from normal aging to Alzheimer's disease

Nicole Chow, BS<sup>1,2</sup>, Kristy Hwang, BS<sup>1,2</sup>, John Ringman, MD<sup>1</sup>, Edmond Teng, MD, PhD<sup>1</sup>, Paul M. Thompson, PhD<sup>1,2</sup>, Greg Cole, PhD<sup>1</sup>, Karen Gylys, PhD<sup>1</sup>, Clifford Jack, MD<sup>3</sup>, Leslie Shaw, PhD<sup>4</sup>, John Trojanowski, MD, PhD<sup>4</sup>, Holly Soares, PhD<sup>5</sup>, Michael W. Weiner, MD<sup>6</sup>, Liana G. Apostolova, MD, MS<sup>1,2</sup>



<sup>1</sup> Department of Neurology, University of California Los Angeles, Los Angeles, CA, United States

<sup>2</sup> Laboratory of Neuro Imaging, University of California Los Angeles, Los Angeles, CA, United States

<sup>3</sup> Department of Neurology, Mayo Clinic, Rochester, MN, United States

<sup>4</sup> Department of Pathology and Lab Medicine, University of Pennsylvania, Philadelphia, PA, United States

<sup>5</sup> Department of Translational Medicine, Bristol-Myers Squibb, Wallingford, CT, United States

<sup>6</sup> Department of Radiology, University of California San Francisco, San Francisco, CA, United States

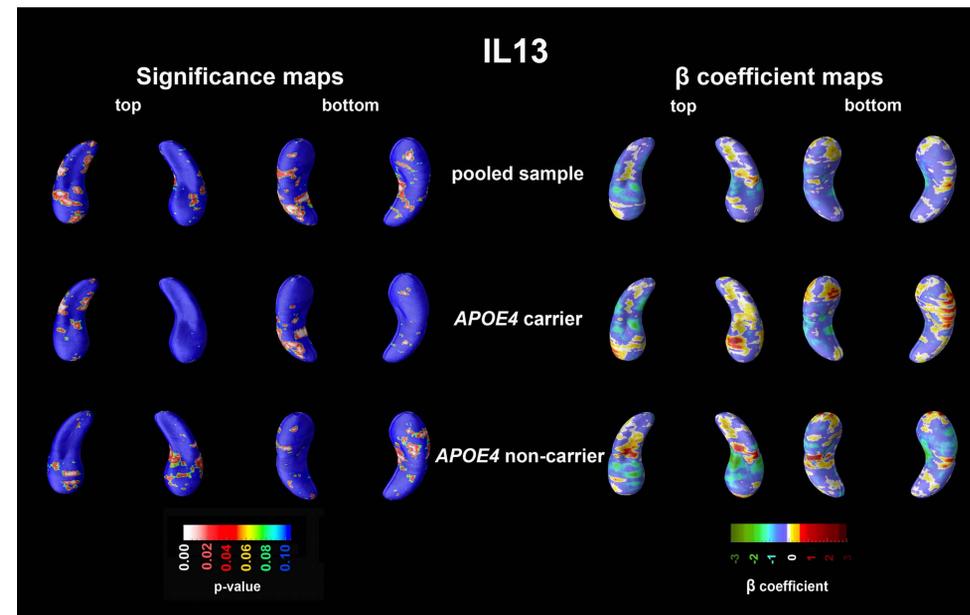
**Background:** We recently reported lower plasma levels of interleukin 13 (IL13), tissue inhibitor of metalloproteinases 1 (TIMP1), and angiopoietin 2 (ANG2) in apolipoprotein E4 (APOE4) positive subjects relative to APOE4 negative subjects at risk for familial Alzheimer's disease (FAD). Here, we investigated the correlation of these plasma protein levels with hippocampal atrophy in the ADNI sample.

**Methods:** We analyzed the imaging and plasma protein biomarker data from the Alzheimer's Disease Neuroimaging Initiative (ADNI) study. Our sample included 475 subjects – 58 normal controls, 310 MCI and 107 AD subjects of whom 244 were APOE4 carriers and 231 APOE4 non-carriers. Baseline EDTA plasma samples were collected and analyzed with a 190 analyte multiplex immunoassay panel based on the Luminex xMAP platform. Hippocampal segmentations were generated from 1.5T 3D T1-weighted brain MRI scans with a novel automated segmentation technique based on the AdaBoost machine learning method. Hippocampal thickness was analyzed with the radial distance technique. We applied linear regression models to study the associations between IL13, TIMP1, and ANG2 plasma protein levels and hippocampal radial distance. Our linear regression models were adjusted for age and gender. We ran analyses in the pooled sample and then separately in APOE4 carriers and non-carriers. For multiple comparisons correction, we used permutations with threshold  $p < 0.01$ .

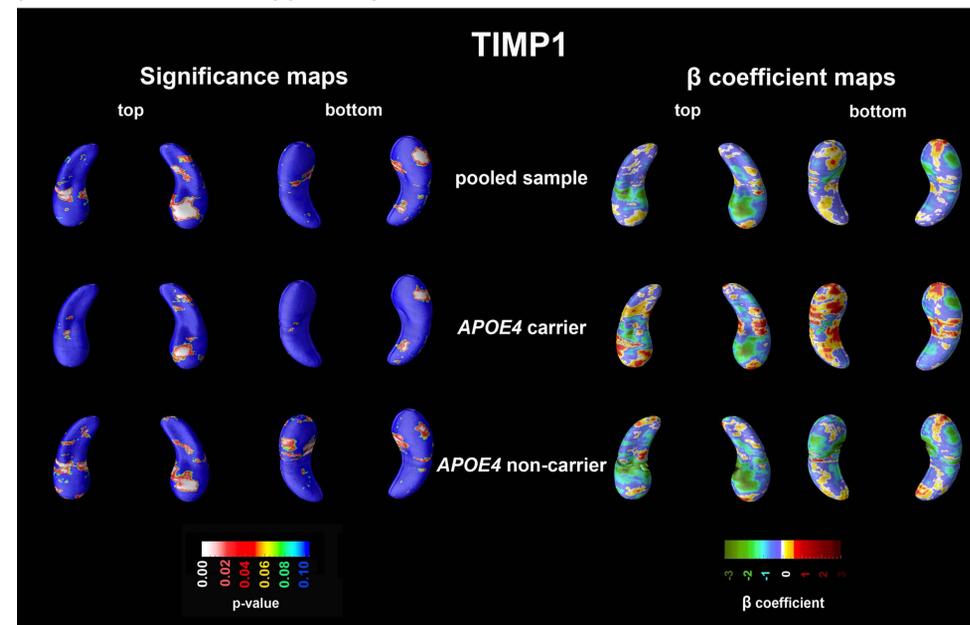
**Table 1.** Demographic and biomarker data [mean (SD)]

Variable	APOE4 carriers (N=244)	APOE4 non-carriers (N=231)	p-value
Age, yr	74.21 (6.907)	75.85 (7.771)	0.015
Gender, M/F	153/91	144/87	0.934
Education, yr	15.40 (3.101)	15.94 (2.935)	0.053
MMSE	25.86 (2.387)	27.09 (2.310)	<0.001
IL13	1.61 (0.175)	1.58 (0.161)	0.100
TIMP1	2.03 (0.102)	2.04 (0.109)	0.288
ANG2	0.642 (0.138)	0.658 (0.151)	0.220

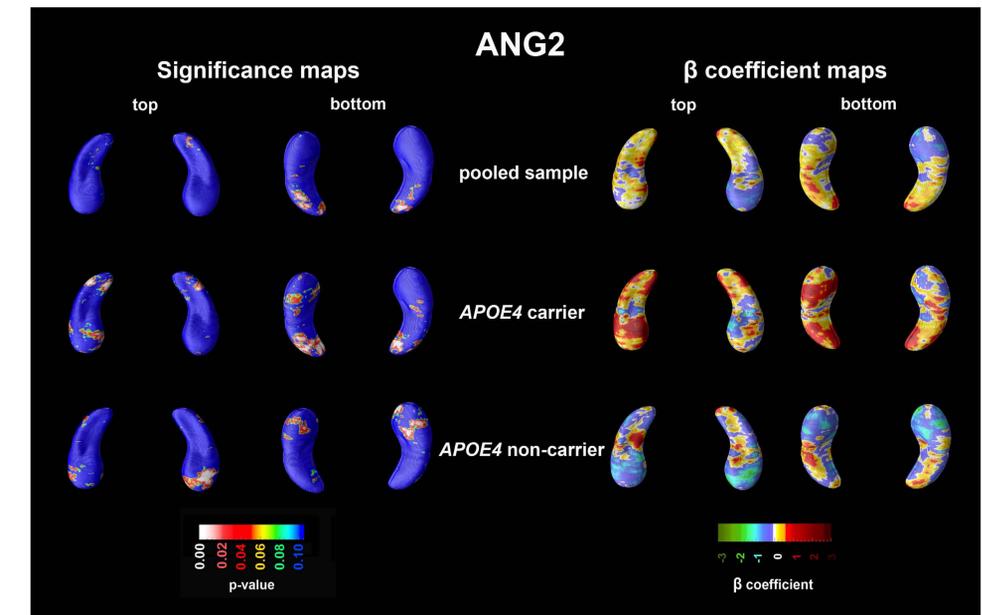
**Figure 1.** Significance and  $\beta$  coefficient maps of the association of IL13 plasma levels with hippocampal radial distance



**Figure 2.** Significance and  $\beta$  coefficient maps of the association of TIMP1 plasma levels with hippocampal radial distance



**Figure 3.** Significance and  $\beta$  coefficient maps showing the association of ANG2 plasma levels with hippocampal radial distance



**Results:** High levels of IL13, a well-established inflammatory protein, showed a significant negative association with right hippocampal radial distance in the pooled sample ( $\beta = -0.31$ ,  $p_{\text{corrected}} = 0.039$ ; **Figure 1**). High levels of TIMP1, a protein that promotes cell proliferation and has an anti-apoptotic function, showed a significant negative association with hippocampal radial distance in the pooled sample on the left ( $\beta = -0.42$ ,  $p_{\text{corrected}} = 0.027$ , **Figure 2**). ANG2, a regulator of neuronal progenitor differentiation and migration, showed a significant positive association with hippocampal radial distance on the right in APOE4 carriers ( $\beta = 0.53$ ,  $p_{\text{corrected}} = 0.018$ ), but a significant negative association on the left in APOE4 non-carriers ( $\beta = -0.2$ ,  $p_{\text{corrected}} = 0.026$ , **Figure 3**).

**Conclusions:** Hippocampal atrophy in the ADNI cohort was associated with plasma levels of several proteins whose plasma levels were previously reported to differ between APOE4 carriers and non-carriers in a presymptomatic FAD cohort.