# Morphometric MRI Study of Hippocampal Shape in MCI using Spherical Harmonics

Li Shen[1], Andrew Saykin[2], Tara McHugh[2], John West[2], Laura Rabin[2],
Heather Wishart[2], Moo K. Chung[3], Fillia Makedon[4]
[1]Dept. of Computer and Info. Science, U. of Mass. Dartmouth, 285 Old Westport Rd., N. Dartmouth, MA 02747
[2]Departments of Psychiatry and Radiology, Dartmouth Medical School, Lebanon, NH 03756
[3]Department of Statistics, University of Wisconsin, Madison, WI 53706
[4]Department of Computer Science, Dartmouth College, Hanover, NH 03755
lshen@umassd.edu, {saykin, tara.mchugh, jwest, laura.rabin, heather.wishart}@dartmouth.edu,
mchung@stat.wisc.edu, makedon@cs.dartmouth.edu
phone 508 910 6691, fax 508 999 9144

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**Learning objectives**: Find hippocampal shape changes in MCI

**Background**: Mild cognitive impairment (MCI) is a condition characterized by significant cognitive impairment in the absence of dementia and by isolated memory impairment and memory complaints. Identifying the morphological abnormalities of brain anatomy, especially the hippocampus, responsible for learning and memory, is critical to early diagnosis and treatment of MCI and AD.

**Objective**: Volumetric analysis can identify hippocampal atrophy in MCI, but may not localize the structural changes. Shape analysis has the potential to provide important information beyond simple volume measurements and may characterize abnormalities in the absence of volume differences and localize the region of statistical significant structural changes. This study performs hippocampal shape analysis for MCI, aiming at a global and local quantitative representation of shape changes in MCI.

**Methods**: Participants were 40 adults with MCI (age $72.5 \pm 3.3$), 40 adults with cognitive complaints (CC) ($72.6 \pm 2.6$), and 42 healthy controls (CN) ($70.8 \pm 2.6$). MRI scan data were acquired on a 1.5 Tesla GE scanner as a T1-weighted SPGR coronal series. The hippocampi were segmented using the BRAINS 1.0 software. The left and right hippocampi were treated as a single shape configuration. The spherical harmonics (SPHARM) description was used for surface modeling, with the parameter space being aligned according to the first order ellipsoid for surface correspondence. After normalizing for the total volume, landmarks were created by uniform surface sampling (Figure 1(a,b)). A quaternion-based algorithm was used to align these landmarks. For each landmark, the local shape change was defined as the distance between an individual and the mean along the normal direction of the mean surface. Surface signals were modeled as Gaussian random fields, which was checked using quantile-quantile plots. Heat kernel smoothing was employed to increase SNR on the hippocampal surface (Figure 1(c)) and statistical inference was performed via random fields theory.

**Conclusions**: The results of group analyses ($t$-maps in Figure 2) show that statistically significant regions of shape changes only appear between CN and MCI. These structural changes are located mostly at the anterior part of the right hippocampus and also at the posterior part of the left hippocampus (Figure 3).

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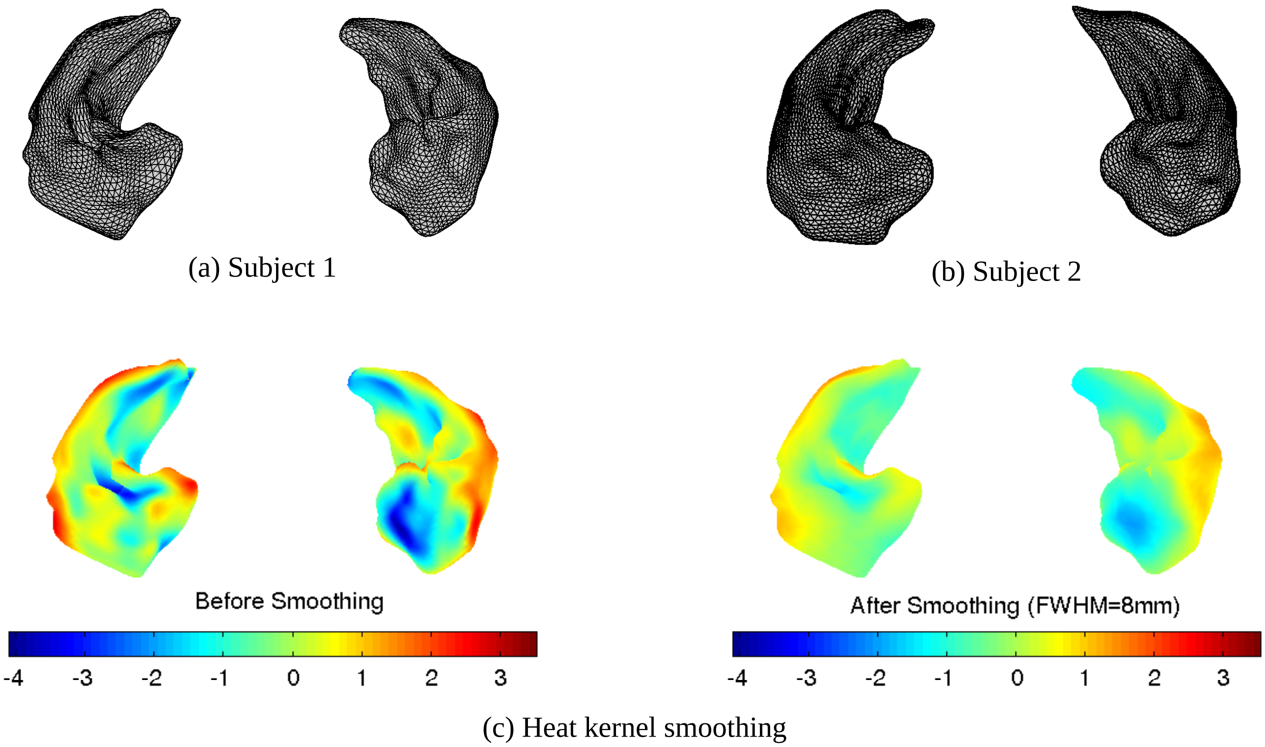


Figure 1: (a-b) Landmark representation for hippocampal shapes: mesh vertices are landmarks. (c) Heat kernel smoothing result: on the left, the initial signal is mapped on to the surface; on the right, the signal is smoothed using a heat kernel of FWHM $= 8$ mm. Our scaling scheme makes the mean shape have a total volume of $6780\,\mathrm{mm}^3$.

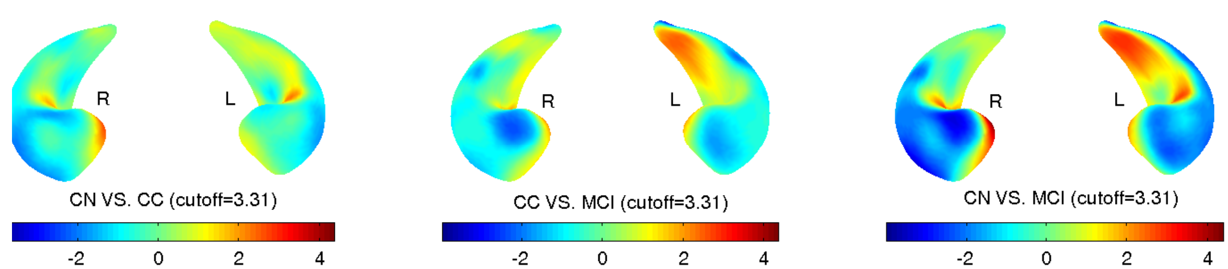


Figure 2: $t$-maps of group analyses for CN versus CC (left), CC versus MCI (middle), and CN versus MCI (right), where FWHM $= 8$ mm is used for heat kernel smoothing. Positive/negative $t$-values indicate that outward/inward directions change the mean to shapes of the first class. Regions of statistically significant shape changes only appear between CN and MCI.

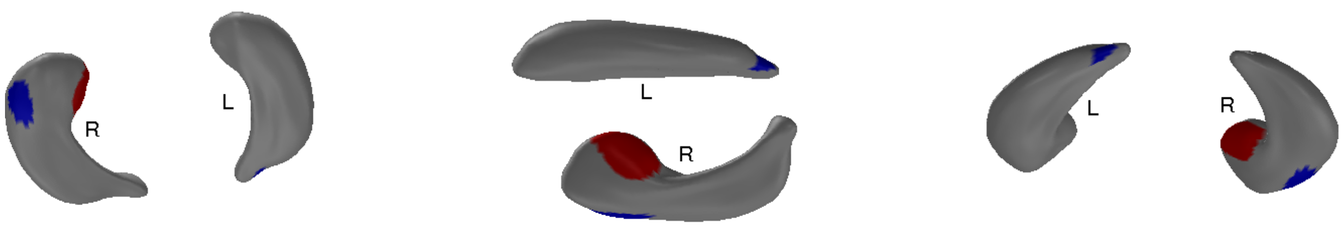


Figure 3: Regions of statistically significant structural changes between CN and MCI, which were created by thresholding the $t$-map using the cutoff value $3.31$ (corrected for $95\%$ confidence level). Three different views are displayed. Red/blue colors indicate that outward/inward directions change the mean to CN. Structural changes are located mostly at the anterior part of the right hippocampus and also at the posterior part of the left hippocampus.