T2-weighted MRI increases machine learning accuracy in Alzheimer's disease

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Introduction:
Support vector machines (SVM) have proven to be an accurate technique for the diagnosis of several brain diseases (Aribisala et al., Lecture Notes in Computer Science 2010; Ecker et al., Neurobiology of Disease 2010; Klöppel et al., Brain 2008). In Alzheimer's disease (AD), SVM studies have primarily employed T1-weighted MR scans to train and test the classification algorithm (Klöppel et al., Brain 2008; Magnin et al., Neuroradiology 2009; Savio et al., Lecture Notes in Computer Science 2009; Mesrob et al., Proceedings of MIAR 2008). Recent work in AD suggests that T2-weighted scans may contain greater diagnostic information: they are as sensitive to atrophy as T1-weighted scans but also contain strong MR signal intensity changes that are not seen with T1-weighted scans (Diaz-de-Grenu et al., Neuroimage 2011). The latter were seen most notably in posterior cingulate and ventro-mesial frontal regions both of which are known to harbour intense amyloid deposits. The aim of this study was therefore to test if the additional information found in T2-weighted data improved the performance of SVM classification compared to that using T1-weighted scans. In addition, we also explored the benefits of specifically training data from the regions known to be most severely affected in AD.

Methods:
A cohort of 33 mild patients diagnosed with AD according to Dubois criteria (Dubois et al., 2007) and 19 healthy age-matched elderly controls (CN) were scanned. Mean MMSE scores: 24.2±3.0 (AD) and 28.8±1.1 (CN). A Siemens Trio 3T system equipped with a 12-channel phased-array TIM head-coil was used. The 3D T1-weighted acquisition consisted of an MPRAGE pulse sequence with the following scan parameters: TR/TE/inversion time (TI)/flip angle =2300 ms/2.86 ms/900 ms/9°, 144 slices, 192×192 matrix dimensions and 1.25×1.25×1.25 mm^3 voxel size. True-3D, high-resolution T2-weighted images were acquired with the SPACE pulse sequence using the following parameters: TR/TE/NEX=3200 ms/450 ms/2; matrix, 192×192; 144 slices and isotropic voxel resolution, 1.25×1.25×1.25 mm^3. To improve warping performance, all images were skull-stripped and RF bias corrected (Acosta-Cabronero et al., Neuroimage 2008). SPM5 (Ashburner and Friston, Neuroimage 2005) was used to coregister the pre-processed structural images to the MNI305 template; normalised images were modulated to preserve their volumetric information. Note that each brain mask and SPM5 warp transform (using MPRAGE volumes) was applied to their corresponding SPACE image. Finally, to enable direct comparison, T1- and T2-weighted MR signal intensities were normalised to a common occipital control region that is known to be relatively spared in AD. The SVM-light (http://svmlight.joachims.org/) algorithm—modified to handle NIFTI format—using a linear kernel was used to perform "leave-one-out" experiments. To assess the performance of SVM, we compared results for each contrast–T1 and T2–in a) whole-brain images and in b) regions of interest (ROI) relevant to AD. The chosen ROIs were (i) the mesial temporal lobe (MTL), (ii) the MTL plus a posterior cingulate (PC) region both collapsed together, and (iii) and the MTL + the PC + a ventromedial frontal (VMF) lobe region (Fig. 1). ROIs were manually delineated on the standard template using the Analyze software (http://mayoresearch.mayo.edu/robb_lab/analyze.cfm)**.**

Results and Discussion:
The analyses confirmed the prior hypothesis that AD classification can be improved using T2-weighted MR images in SVM. The highest "leave-one-out" classification rate with T2 volumes was 92.3%, whereas the best performance for T1 contrasts was 88.5% (Table). Overall, all assessments were consistent in that they showed improved classification using T2-weighted scans. In the (predominantly atrophic) MTL region, however, T2 images did not appear to provide useful additional information. Note that the best perfomance for T1-weighted images was found in this region, whereas for T2-weighted images, the combination of the MTL, the PC and the VMF lobe ROIs yielded the highest classification accuracy.

Conclusion:
Our results demonstrated that the accuracy of supervised machine learning techniques in the detection of mild Alzheimer's disease can be increased using T2-weighted MR images. It is notable that inclusion of areas known to be associated with β-amyloid deposition in AD (Frisoni and Delacourte, J Nutr Health Aging 2009) improved accuracy with T2-weighted data. This is concordant with previous results that highlighted that although T1-weighted structural scans are accurate in the detection of MTL atrophy in the AD, T2-weighted images also contain highly-relevant MR signal intensity changes beyond this area in posterior cingulate and ventro-mesial frontal regions (Diaz-de-Grenu et al., Neuroimage 2011).

	Whole brain	ROI		
		MTL only	MTL + PC	MTL + PC + VMF
T1-weighted				
Nº wrong AD	4	2	4	3
Nº wrong CN	6	4	5	5
Accuracy (%)	81.50	88.46	82.70	84
T2-weighted				
Nº wrong AD	1	4	2	1
Nº wrong CN	8	2	3	3
Accuracy (%)	83.33	88.46	90.40	**92.30**

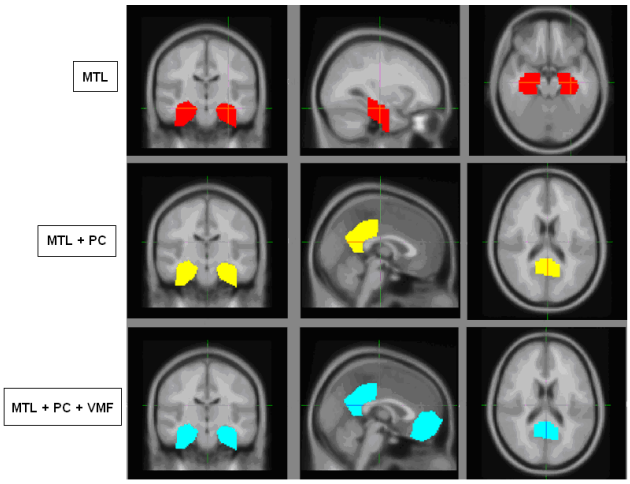

Fig. 1: Illustration of the ROIs used in this study: mesial temporal lobe (MTL), MTL + posterior cingulate (PC), MTL + PC + ventromedial frontal lobe (VMF).