A 30 minute imaging protocol at 1.5T exploring higher spatial and functional information around white matter lesion and brain morphology in a large scale epidemiological study of the aging brain

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Introduction: To develop and implement preventive interventions we must know the relevant pathogenetic mechanisms to intervene on, the risk factors that we should seek to modify, and how to identify the individuals at risk who may benefit from specific interventions. Recent advances in non-invasive brain imaging provide us with markers of structural and functional cerebral changes that reflect developing specific pathology in pre-symptomatic persons. An epidemiological program in our institution, known as the Rotterdam Study (1), has initiated in the past a large, prospective population-based study to investigate the causes of dementia by focusing on the underlying brain abnormalities that can be assessed through neuro-imaging.

Purpose: We would like to describe the choices made for the MR sequences for a second stage of the large epidemiological study of the aging brain using the newer MR imaging hardware available.

Material and Methods: The 30 minute data collection protocol described strives to acquire a large load of information. The characteristics of the protocol devised as compared to previous efforts is the use of the enhanced capabilities of the new hardware/software present on 1.5T MRI scanners using multi-channel array technology to: (1) speed up the imaging protocols, (2) provide better signal-to-noise (SNR) and (3) more contrast capabilities (Figure 1) with the ultimate goal of delivering images with finer detail and better spatial coverage. The datasets have been carefully chosen to maximize the amount of information available within the imaging collection period and define a set of features that can provide better automatic segmentation and volume quantification of WM lesions and the different tissues that form part of the brain such as the cerebro-spinal fluid (CSF), white matter and gray matter. Diffusion tensor imaging (b=1000 mm^2/s, 25 tensor directions), global blood flow to the brain and a sequence sensitive to microhemorrhages and venous structures (susceptibility weighted scanning, SWI) have been incorporated. An execution timetable of the protocol is demonstrated in Table 1. The protocol was implemented on a 1.5T General Electric MRI using an 8-channel head coil for signal reception. Parallel imaging was available to optimize for imaging time (acceleration factor of 2).

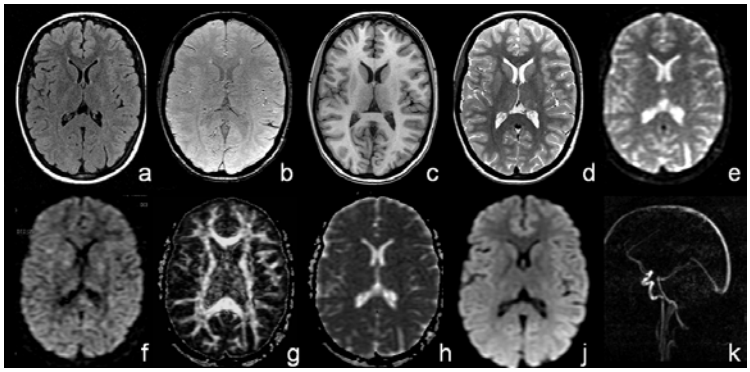

Figure 1: 3D data sets collected on an 80 year old volunteer providing coverage of the entire brain with thin slices and high in-plane spatial resolution (a) 2D FLAIR TR/TE/TI=8000/122/2000 ms, (b) 3D SWI TR/TE=45/31 ms, (c) 3D T1W TR/TE/TI=13.8/2.8/400 ms, (d) PDW TR/TE=12300/17 ms, (e) T2W EPI –b=0 mm^2/s, (f) DWI tensor b=1000 mm^2/s, (g) fractional anisotropy, (h) diffusion map, (j) isotropic diffusion (k) flow scout for brain global blood flow. The finer sensitivity of FLAIR is used to identify white matter lesions while the other data sets complement showing white matter lesions as white spots in white matter regions. Analysis of all these datasets shall provide a better understanding on how lesions develop in the aging brain and provide a setup in which automatic processing be performed to separate all the different tissues in the brain. The in-plane resolution of the morphological scans was 0.60 x 1.0 mm^2, number of slices and thickenesses as denoted in Table 1.

Protocol Brain Scanning: Resolution Protocol	Time (min)	Time (sec)	Observations	Slices	Thickness (mm)	ASSET
Scout	0	7	Positioning	3	5	no
Asset calibration	0	12	Parallel Imaging - coil sensitivity correction data	60	5	no
Phase Contrast Scout	0	12	Localizer for global brain blood flow - VENC=60 cm/s	1	60	no
Proton Density - FSE	6	9	Proton density (PDW) - FSE2D	90	1.6	no
FLAIR	6	25	Fluid attenuated - T2-weighted - FSE2D	64	2.5	no
Global brain flow	0	50	Basilar flow setup, 2D, VENC=120 cm/s	1	3	no
DTI	3	44	Diffusion Tensor Imaging - 25 directions	39	3.5	yes
T1-3D	6	24	Magnetization Prepared T1-weighted 3D	100 (200)	1.6 (0.8)	no
SWI-3D	5	55	Susceptibility weighted 3D	100 (200)	1.6 (0.8)	yes
Total Scanning Minutes (Not counting preparation times)			**30 min**			
Automatic Reconstruction Sets (Available after acquisition)	0		Diffusion map			
	0		Fractional anysotropy map			
	0		Average Diffusion Weighted Scans @ b=1000			

Table 1: The Execution timetable
This table represents a summary of the complete scanning protocol. Scan time is approximately 30 minutes for the entire study. Accelerated imaging (using ASSET) has been selected only for two sequences only, DTI and SWI-3D scanning, respectively. For DTI, geometrical distortions and signal loss at the base of the skull are minimized. For the T2*W SWI-3D sequence, the long scan time nature for this setup (long TR, long TE) could be effectively reduced given that the SNR was sufficient. The overall scan time indicated in the table does not take into account the preparation period required by each scan (receiver adjustments), which can amount to approximately 4-5 minutes.

Results and Discussion:
The protocol was first optimized with regards to resolution and number of contrasts available using ASSET. Nonetheless, the prevalence of reconstruction artifacts from the accelerated scanning and the lower SNR prompted for slightly longer scan times and less contrast types, leading to the protocol as described in table 1. Massive use of parallel imaging produced a lag on the image reconstruction engine and obstructed the smooth execution of the protocol even with the fastest reconstruction hardware present. The protocol as described has been active since August 2005 and has acquired successfully data on more than 300 patients.

References:
1.- Ott A, Breteler MMB, van Harskamp F, Stijnen T, Hofman A. Incidence and risk of dementia. The Rotterdam Study. Am J Epidemiol 1998;147:574-80.