INTRODUCTION

Recently, we introduced a framework for automatically estimating the brain age of subjects from their structural MRI scans (Franke et al., 2010) using relevance vector regression (RVR; Tipping, 2001). In order to control for probable data-specific effects in further studies, this study analyzes the influences of different scanner sites as well as varying scanning parameters on brain age estimation.

METHODS

For the current study we utilized three different data sets. The first data set included structural MRI data of 20 healthy subjects (aged 19-34 years) from the OASIS database (www.oasis-brains.org), for whom a double-scan was available. The second test sample included 1.5T as well as 3.0T structural MRI data of 60 healthy elderly subjects (aged 60-87 years) from the ADNI database (www.loni.ucla.edu/ADNI). The third data set consisted of 30 structural MRI data of the same healthy male subject (CG), obtained on four different MRI scanners (#1-3: 1.5T; #4: 3T) with varying scanning parameters over a time period of nearly 12 years. As described in Franke et al. (2010), our age estimation model was trained with GM images of 410 healthy subjects from the publicly accessible IXI cohort (www.brain-development.org), applying relevance vector regression (Tipping, 2001). Subsequently, the brain ages of the test data were estimated. The difference between the estimated and the chronological age resulted in the brain age gap estimation (BrainAGE) score.

RESULTS

The OASIS data set resulted in mean (SD) BrainAGE scores of 12.9 (6.1) years for the 1st and 13.1 (6.1) years for the 2nd scan (Fig. 1). The correlation between the BrainAGE scores of the 1st and 2nd scan was $r=0.92$. This shows strong stability of the estimated BrainAGE scores, but also a sample-specific offset. The ADNI data set showed mean (SD) BrainAGE scores of -2.7 (7.5) years for the 1.5T data and -7.5 (7.6) years for the 3.0T data (Fig. 2), with $r=0.93$ between the estimated brain ages for 1.5T and 3.0T data. These results additionally suggest a strong dependency of brain age estimation on field strength, with 1.5T data resulting in larger BrainAGE scores than 3T data. With mean (SD) BrainAGE scores of 12.6 (1.2), 10.7 (1.6), 9.3 (1.6), and 2.9 (1.7) years for scanners #1-4 in the 3rd data set (CG), respectively (Fig. 3), the brain age estimation again shows a strong dependency on scanner site and field strength. Moreover, the BrainAGE scores were strongly dependent upon the scanning parameters (Fig. 4). These results suggest a negative relationship between BrainAGE and signal-to-noise ratio (SNR) as well as contrast-to-noise ratio (CNR; BrainAGE).

CONCLUSIONS

BrainAGE estimation strongly depends on the MRI scanner, scanning sequence, and specific parameters. Therefore, the influences of varying image quality and segmentation quality in training and test data on estimation quality should be carefully controlled in future studies as well as further analyzed within even larger samples. When examining the BrainAGE scores in clinical groups, scanner-specific samples of healthy subjects have to be considered to control for scanner-dependent offsets. Furthermore, the potential of SNR and/or CNR to quantify the sample or rather scanner-specific adjustment for BrainAGE estimation should be studied in more detail.

REFERENCES
