Introduction: Images with good grey/white matter contrast are important for determining normal developmental changes in the pediatric brain, primarily myelination but also cortical maturation. Conventional T1- and T2-weighted images offer some degree of grey/white matter contrast but any pulse sequence improvements would be beneficial, particularly for subtle changes occurring early in life. In this work we have evaluated one such method using a phase sensitive inversion recovery (PSIR) sequence which appears quite promising for improving grey/white matter differentiation in the pediatric brain.

Materials and Methods: All studies were performed with a 1.5 T General Electric LX scanner operating at the 8.2 hardware/software configuration. Ten patients, aged 6 months through 20 years (average 7.5 years) and one 38 year old volunteer were imaged with a fast spin echo (FSE) version of a PSIR sequence using the following sequence parameters: TR/TE/ETL/TI = 4000/1514/400. The image matrix was 192 x 256, FOV was 20 cm, and one signal average was used to acquire eight, 5 mm thick axial slices of the brain in 3 minutes and 18 seconds. The use of phase sensitive approaches rather than standard magnitude reconstructions theoretically improves the available dynamic range for T1 contrast. For phase sensitive reconstruction, however, a customized regional seed growing phase algorithm was necessary to correct for smoothly varying phase differences across the image and to remove these phase differences from the bipolar phase of the inversion recovery component (1). Conventional T2-weighted FSE sequences (TR/TE/ETL = 4000/84/8) and T1-weighted spin echo sequences (TR/TE = 400/14) were obtained for comparison with the PSIR images. For all three pulse sequences, signal intensities from grey matter in the putamen and myelinated white matter in the centrum semiovale were used to calculate the following contrast parameter:

\[ CP = \frac{I_{wm} - I_{gm}}{I_{wm} + I_{gm}} \]  

where \( I_{wm} \) and \( I_{gm} \) are the signal intensities of the white and grey matter, respectively. Statistical analyses were performed using Student's paired t-test to evaluate differences between the contrast parameter CP among the three sequences tested. Although the patients had a number of different brain pathologies, the putamen and centrum semiovale were judged to be unaffected by the particular pathology encountered.

Results: The PSIR images were of excellent diagnostic quality with no obvious phase roll artifacts and a level of pulsatile flow artifacts from vessels qualitatively similar to that seen in magnitude T1- and T2-weighted images. The grey/white matter contrast obtained from the PSIR images was greater than in either the T2- or T1-weighted images at levels approaching statistical significance, as shown in Table 1. Other observations include improved visualization of the white matter tracts in the brainstem, thalami and peri-aqueductal grey matter in PSIR images compared to the conventional images, particularly in the very young patients. In one case of band heterotopia, the abnormal grey matter was much better visualized on the PSIR images than on the conventional counterparts.

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<th>PSIR</th>
<th>T2</th>
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<tr>
<td>Mean</td>
<td>0.13</td>
<td>0.06</td>
<td>0.07</td>
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<td>SD</td>
<td>0.11</td>
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Table 1: Means and standard deviation of the grey/white matter contrast parameter CP of Eq. 1 obtained for the three different sequences. The P value between PSIR and T1W contrast was 0.04. The P value between PSIR and T2W contrast was 0.07 as measured with Student's paired t test.

Discussion: For grey/white matter contrast in the pediatric brain, the PSIR sequence offers an improvement over conventional T2- and T1-weighted sequences, most probably due to the full range of T1 contrast afforded by the PSIR sequence once phase correction algorithms are used for reconstruction. As currently implemented, however, the PSIR sequence is somewhat inefficient from a volume coverage vs scan time perspective (8 slices in 3.3 minutes) due to the 400 ms TI "dead time". This could be improved with a distributed interleaved approach in which the inversion pulses are applied in consecutive groups to different slices followed by FSE type acquisitions from those slices at the requisite time (2,3). In such a format, the PSIR sequence should be quite useful for evaluating the pediatric brain in conjunction with conventional methods.

References:
1. Ma, J., GE Medical Systems Systems Note, 1/98.