PET Effects on MR Data Quality in an Integrated MR-PET Human Brain Scanner

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Introduction

Simultaneous MR-PET imaging has been demonstrated in small animal systems [1-4]. Recently, a research prototype human brain scanner (BrainPET, Siemens Medical Solutions, Erlangen, Germany) has been unveiled. This scanner can be operated either as a stand-alone PET scanner or – when inserted into the bore of the standard Siemens Magnetom TIM Trio MR scanner – as an integrated MR-PET system [5]. The simultaneous acquisition of MR and PET data in humans is possible with new PET detectors based on magnetic field insensitive avalanche photodiodes (APDs). The PET gantry inner and outer diameter are 36 cm and 60 cm, respectively. The axial FoV is 19.25 cm and the transaxial FoV is ~30 cm. Each of the 32 detector modules consists of six 12×12 lutetium oxyorthosilicate (LSO) crystal arrays with an individual crystal size of 2.5×2.5×20 mm^3 read out by a 3×3 array of APDs (Hamamatsu 8664-55, Japan). The APD signals are processed and shaped by an on-board charge-sensitive preamplifiers and pole-zero circuits. The signals from the PET modules are taken from the gantry via 10 meter long cables to the acquisition electronics module, located outside the Faraday cage of the magnet. The purpose of this study is to evaluate the effect of the PET insert in operating mode on the quality of the MR data with regard to RF noise, shim, signal-to-noise ratio (SNR) and temporal SNR (t-SNR).

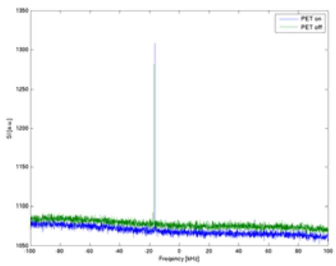

Figure 1*: RF noise power spectrum collected with PET on (blue) and PET off (green).*

Methods

Imaging was done on an integrated MR-PET human brain scanner (3 T Siemens TIM Trio with prototype BrainPET). An 8 channel receive head coil was used inside a CP transmit head coil. Measurements were performed to check for differences in RF noise, shim, SNR and temporal SNR (t-SNR). The same scans were run with the PET insert in operational mode inside the bore and with the PET insert switched off and removed from bore in parking position at the side end of the MR scanner. A special RF screen was placed in bore to tune head coils properly when the PET insert was not used. A spherical phantom of 160 mm diameter was used for all scan.

The following scan parameter were used: *RF noise*: 18,300 measurements of 16 ms duration were collected without RF or gradient switching, TR = 16.5 ms, 500 kHz bandwidth, 5:02 min:s acquisition time; *field mapping*: 2-D gradient echo sequence, TR = 1850 ms, $TE_{1/2}$ = 7.38/9.84 ms, FA = 55°, 128×128 matrix size, 192×192 mm^2 FoV, 128 slices, 1.5 mm slice thickness, no gap, bandwidth 175 Hz/px, 7:57 min:s; *SNR*: 3-D gradient echo sequence, TR = 6.5 ms, TE = 3.0 ms, FA = 10°, 192×192×192 matrix size, 192×192×192 mm^3 FoV, bandwidth 260 Hz/px (plus one additional scan with same parameters but transmitter switched off), 4:00 min:s each; *t-SNR*: 2-D single-shot EPI sequence, TR = 1000 ms, TE = 30 ms, FA = 90°, 64×64 matrix size, 200×200 mm^2 FoV, 16 slices, 5 mm slice thickness, 1 mm gap, bandwidth 2298 Hz/px, 200 measurements, 3:20 min:s.

Power spectra were calculated from the ADC data for RF noise measurements. Field maps were calculated from the two echoes for each scan and subtracted to result in a difference field map. SNR was calculated according to the NEMA standard MS 1-2001 [6] using the magnitude image and the pure noise image; t-SNR was calculated as mean of all measurements divided by the standard deviation of all measurements for each of the two scans (with and without PET) before subtraction of the t-SNR maps [7].

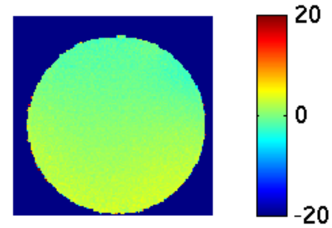

Figure 2*: Transverse slice of field map difference between PET on and PET off in Hz.*

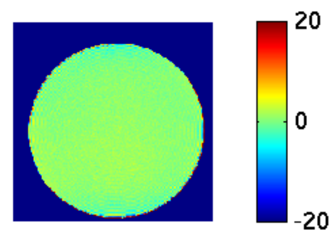

Figure 3*: Transverse slice of SNR difference between PET on and PET off in percent.*

Results and Conclusion

The scanner passed the manufacturer's tune-up and QA procedures in MR-only and MR-PET mode. Some differences of the measurements and results for MR-only and MR-PET scans are due to small differences in phantom positioning relative to the head coil and bore. *RF noise* (Figure 1): the power spectra show one RF noise peak of unknown origin that is not affected by the PET insert; the slight shift in frequency of the RF noise peak is due to the different frequency adjustment (877 Hz) in MR-only and MR-PET mode; *field mapping* (Figure 2): small differences in the field map of a few Hz scan be seen which are in the range of scan-to-scan variations; *SNR* (Figure 3): small differences in SNR are within the range of scan-to-scan variations; *t-SNR* (Figure 4): noisy t-SNR image is caused by low spatial resolution and limited number of measurements; t-SNR is comparable in MR-only and MR-PET mode. In summary, the PET insert does not appear to have a significant effect on the MR scanner data regarding RF noise, shim, SNR and temporal SNR.

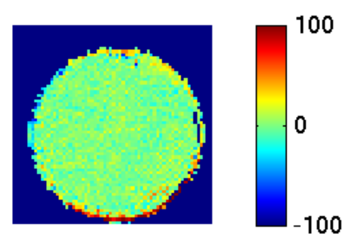

Figure 4*: Transverse slice of t-SNR difference between PET on and PET off in percent.*

Acknowledgments

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References

[1] Catana C, et al. J Nucl Med. 2006;47(12):1968–1976. [2] Judenhofer MS, et al. Radiology 2007;244(3):807–814. [3] Catana C, et al. Proc Natl Acad Sci USA. 2008;105(10):3705–3710. [4] Judenhofer MS, et al. Nat Med. 2008;14(4):459–465. [5] Schlemmer HP, et al. Radiology. 2008;248(3):1028–1035. [6] National Electrical Manufacturers Association (NEMA). NEMA Standards Publication MS 1-2001. [7] Sodickson DK, et al. Magn Reson Med 1999;41:1009–1022.