A Whole Body Transmit Coil and Head Receive Coil Configuration for fMRI at 3T

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Introduction

Functional MRI requires excellent system stability as a prerequisite to successful experimentation. The transmit performance of the RF coil and the power amplifier subsystem are especially important aspects of achieving sufficient stability for fMRI. At 3T the demands placed on system components are even more stringent. Commercial MRI scanners at 1.5T are equipped with a whole body RF coil and a head RF coil. However, there are two approaches to the operation of the head RF coils. **Mode A** -the head coil is a receive only RF coil and the whole body coil is used to transmit the RF excitation or, alternatively, **mode B** - the head coil is a transmit and receive RF coil. Both of these configurations have been used for fMRI at 1.5T although a comparison of the relative merits of each may not have been performed.

In general the main advantage of mode **A** is that:-

(1) A more homogeneous RF excitation is possible particular in the superior-inferior direction. This can be used to increase the field of view of the coil or reduce the length of the receive RF coil and increase the signal to noise ratio (SNR).

(2) RF spin lableling outside of the head RF coil, for example in the neck, can be performed.

(3) The RF amplifier is always connected to the same transmit coil so the RF electronics can be optimised to this coil.

The main advantages of mode **B** are that:-

(1) Lower transmit RF power is required for head imaging.

(2) Only the head is in the RF field so less total RF power is deposited in the body.

(3) The design has been proven at high field (3T).

Whole body RF coils at 3T have only recently been available (1,2) so the choice of head coil mode for 3T MRI scanners has always been mode **B**. The purpose of this abstract is to compare the two head coil modes for BOLD fMRI at 3T. In particular the effect of coil mode choice on signal stability is examined. Additional problems may be expected in mode **A** because physiological noise is an important source of noise in fMRI (3) and in mode **A** the entire body is coupled to the RF coil system. This may lead to loading fluctuations due to breathing or movement which in turn lead to RF flip angle variations. Another potential problem is that much greater power is required in mode **A** and the RF amplifier output may be less stable.

Methods

All images were acquired with a Marconi Medical Systems 3.0T Infinion System. Two similar head coils were constructed. The transmit and receive coil was an 18 rung bird cage with diameter and length 31cm. The head receive only coil was a 16 rung birdcage with a diameter and length of 29cm. The whole body coil was a 24 rung birdcage with diameter 58cm and length 60cm. (2) The body and head coils were actively decoupled during transmit/receive with pin diodes and chokes.

The signal stability of a phantom (sphere diameter 12cm)containing doped water and volunteers were measured using a typical sequence used for BOLD fMRI – gradient echo EPI, FOV 22cm, 5mm slice thickness, TE 30ms, flip angle 90 degrees. A TR of 1s was chosen for the volunteer so that breathing was not aliased. A TR of 3s was used for the phantom. A series of 100 images was recorded in both coils in close succession.

The transmit RF power and SNR from a 30 pixel region of interest in the phantom and the white matter was measured. The signal stability was defined as the ratio of the signal mean to the standard deviation of the mean of the region of interest through the time course. The measurement error was obtained by repeating the experiment in the phantom and by comparing the left and right hand side of the brain in the volunteers. The same volunteer was imaged in both coils. The homogeneity was measured with an oil filled phantom and a saggital GRE sequence with TR/TE/FA = 800ms/10/5degrees and the length defined as where the intensity dropped to 90% of the maximum value.

Results

Coil/Object	Tx power (W)	SNR	Stability (%)	S/I homogeneity (mm)
Phantom Mode **A**	N/A	600 ± 20	0.15 ± 0.02	112± 2
Phantom Mode **B**	N/A	510 ± 20	0.14 ± 0.02	98± 2
Volunteer Mode **A**	40 ± 10	130 ± 10	0.57±0.02	N/A
Volunteer Mode **B**	410 ± 10	110 ± 10	0.62 ± 0.05	N/A

Table 1

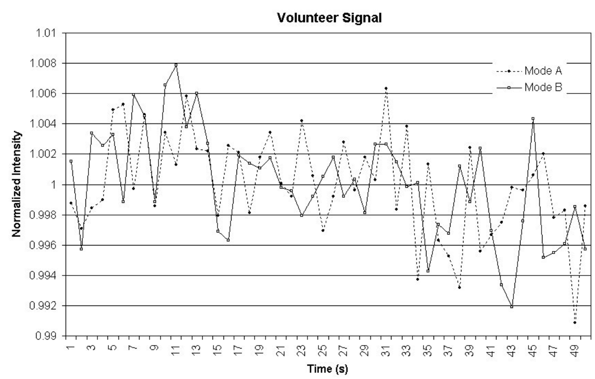

Figure 1

Discussion

The SNR increased slightly with mode **A** which is consistent with a slightly smaller and hence more efficient RF coil. There is no significant difference between the signal stability of the two coils modes with the phantom or volunteer data despite the RF power increasing by a factor of ten for mode **A**.

The data shows that there is no signal stablility change between the RF coil modes and that a whole body RF coil can be used as the transmit coil for fMRI at 3T. This encouraging result suggests that noise in the comparisons performed in this study is dominated by factors that are not affected by the RF coil size or loading. Physiological noise, independent of the coil type, including respiratory effects which change the magnetic field or cardiac blood flow maybe the dominant source. The data can be seen to have a periodic nature (see figure 1), hence a further anaysis of the frequency components in the data may help to identify more subtle differences between the coil modes caused by physiological noise.

This result also leads the way to the use of specialist receive only surface coils for increased SNR and sensitivity encoding, SENSE (4) imaging with phased arrays, for fMRI at 3T using a whole body transmit RF coil.

References

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