Microscopic investigation of the resonant mechanism for the implementation of nc-MRI at ultra-low field MRI

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Introduction

The feasibility of the direct detection of the neuronal currents (NC) by MRI (nc-MRI) has been tested by different authors with the help of simulations (Bodurka and Bandettini, 2002; Konn et al., 2003; Xue et al., 2006; Park and Lee, 2007), phantoms (Konn et al., 2003), and in-vivo (Bianciardi et al., 2004)–in-vitro (Petridou et al., 2007) experiments. However, there is neither any confirmation that positive experimental results agree with the predictions, nor that the few, positive results can be undoubtedly attributed directly to the neuronal currents induced magnetic fields (NMF, or neuronal magnetic field) at high-field MRI (see Bandettini et al., 2005; Hagberg et al., 2008 for recent summaries).

We believe that this problem could be partially attributed to a non-systematic study of NC and of their effects on MRI with an integrated investigation of the links between their physiology, the neuronal networks and the spin dynamics. A similar study was recently afforded by a few groups (Blagoev et al., 2007; Cassarà et al., 2008) with the help of “realistic” simulations. However in order to solve the problem of the feasibility of nc-MRI we believe it would be necessary to define common basis or universal scientific starting points and goals for all the scientists working in field of the direct detection of the neuronal currents by MRI.

The term “realistic”, widely used along this article, express the fact that all the tools/ scripts realized or used in order to create the simulations considered a large variety of known characteristics of neuronal networks, like real morphologies, specifics connections, biophysical details of ionic channels, etc. With this meaning, the term “realistic” is hence used to indicate a good approximation of the reality. The limitations of models because of missing information or of limited computational power will be however described.

In the studies of Blagoev and Cassarà mentioned above, the predictions about the expected nc-MRI signals have been focused on the possible implementation of the technique at high-field MRI, where the static (or leading) magnetic field of the scanner, $B_0$, is on the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla. The main conclusions from these studies is that due to the weakness of the MR signal intensities with respect to the order of few tesla.