Functional connectivity MRI is fast becoming a widely used non-invasive means of observing the connectivity between regions of the brain. In order to more accurately observe fluctuations in the blood oxygenation level of hemoglobin, parallel MRI reconstruction models such as SENSE and GRAPPA can be used to reduce data acquisition time, effectively increasing spatial and temporal resolution. However, the statistical implications of these models are not generally considered in the final analysis of the reconstructed data. In this study, the non-biological correlations artificially induced by the SENSE and GRAPPA models are precisely quantified through the development of a real-valued isomorphism that represents each model in terms of a series of linear matrix operators. Using both theoretical and experimentally acquired functional connectivity data, these artificial correlations are shown to incur false positives and negatives in functional connectivity conclusions, making regions of the brain appear to be either correlated or uncorrelated when they are not. With a precise quantification of the artificial correlations induced by SENSE, a new cost function has also been developed and implemented to optimize the design of RF coil arrays that generate more favorable magnetic fields for functional connectivity studies in specific brain regions. Images reconstructed with such arrays have an improved SNR and a minimal SENSE induced correlation within the regions of interest, effectively improving the accuracy and reliability of functional connectivity studies.