# Controlled Aliasing In Parallel Imaging

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**INTRODUCTION:**

Recently a new parallel imaging strategy, Controlled Aliasing In Parallel Imaging Results IN Higher Acceleration (CAIPIRINHA), was introduced, which modifies the appearance of the aliasing artifacts during the acquisition in order to improve the following parallel imaging reconstruction procedure. This concept was successfully applied to simultaneous multi-slice imaging (MS-CAIPIRINHA) [1] and 3D imaging (2D-CAIPIRINHA) [2].

**METHODS:**

- MS-CAIPIRINHA

Aliasing artifacts in simultaneous multi-slice imaging are modified by providing different slices (S1 and S2) with different phase cycles. This is realized by an excitation with alternating multi-band RF-pulses. In contrast to conventional simultaneous multi-slice parallel imaging [3] (Fig. 1a), overlapping slices can be shifted with respect to each other (Fig. 1b).

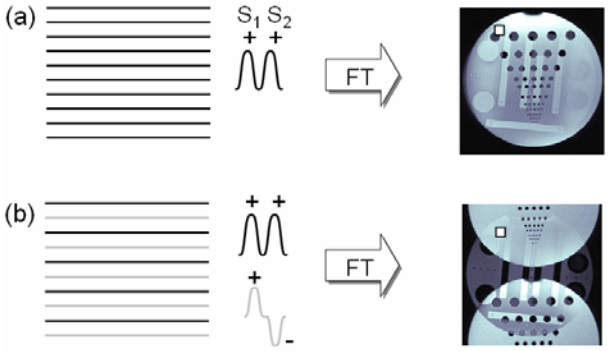


**Figure 1:** Acquisition scheme of **(a)** a conventional accelerated (R=2) simultaneous two-slice experiment (MS-SENSE) [3] and **(b)** an accelerated (R=2) MS-CAIPIRINHA-type experiment.

- 2D-CAIPIRINHA

In 3D imaging scan time reduction can be performed along two phase encoding directions (PE1 and PE2) [4]. By modifying the conventional 2D-SENSE phase encoding sampling pattern, aliasing artifacts can be influenced similar to MS-CAIPIRINHA. Overlapping partitions are then shifted with respect to each other according to the 2D sampling pattern (see Fig.2).

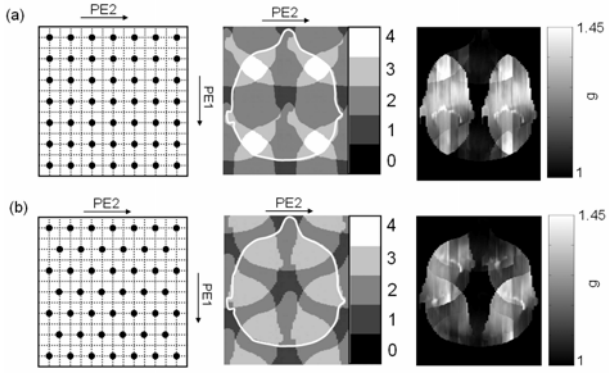


**Figure 2:** Reduced 2D phase encoding scheme (each dot represents one read-out line in k-space) of **(a)** a conventional 2D-SENSE experiment (R=2x2) and **(b)** a 2D-CAIPIRINHA-type experiment (R=4) with resulting aliasing pattern (middle) and calculated g-factor maps (right).

**RESULTS:**

Computer simulations were performed in order to investigate the reconstruction performance of MS-CAIPIRINHA and 2D-CAIPIRINHA compared to conventional volume excitation techniques. The position of one slice (partition) was held constant in the middle of one ring, while the position of the second slice was moved in 1cm increments towards the other ring. Additionally standard in-plane SENSE was simulated at the same slice positions.

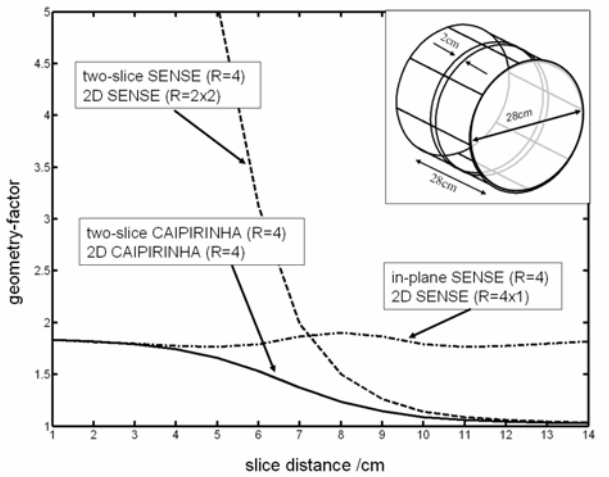


**Figure 3:** Mean g-factor as a function of increasing distance of two overlapping slices (partitions) for accelerated (R=4) SENSE-type and CAIPIRINHA-type acquisitions. The simulations are based on a standard 16 channel head array made up of two cylindrical 8 rings with 2cm overlap (see top right).

Normal in-plane SENSE provides a constant performance for all slice positions, since this method does not exploit any available sensitivity variations in the slice direction. The g-factor approaches infinity in two-slice SENSE (or 2D SENSE) when the distance between overlapping slices is small (no substantial sensitivity variation available) and improves significantly with increasing slice distance. In contrast, two-slice CAIPIRINHA (or 2D-CAIPIRINHA) starts with reasonable performance even when the two superimposed slices are directly adjacent and improves significantly with increasing slice distance approaching the two-slice SENSE (2D-SENSE) performance for large slice distances.

**DISCUSSION:**

In-vivo experiments and g-factor simulations indicate that CAIPIRINHA has the potential to exploit coil sensitivity variations along multiple dimensions more efficiently than standard volume excitation techniques.

**REFERENCES:**

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