

White Paper

Slice Order (Slice Timing) for fMRI Evaluation

Joachim Graessner, Dipl. Ing.

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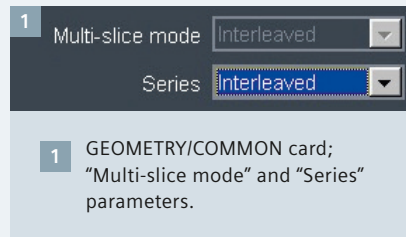
Siemens Healthcare, Hamburg, Germany

This article focuses on the temporal order of slices in EPI-BOLD experiments such as slice timing, which is essential at least for event-related paradigms.

The first thing to keep in mind is the difference between the "Multi-slice mode" and "Series" parameters (Fig. 1). The latter requires our attention for our topic slice order.

The **Multi-slice mode** describes the way slices are excited within one TR interval:

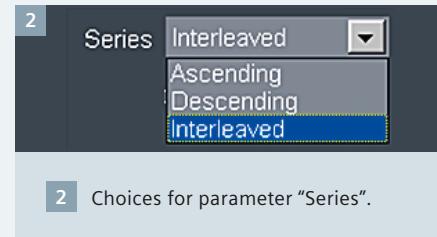
- Interleaved measurement means line-by-line data acquisition of all slices in the repetition time TR starting with the first and ending with the last phase encoding step for normal sequences, such as spin echo or gradient echo.



- For an EPI sequence the Multi-slice mode = Interleaved is actually a Single-Shot mode.

The **Series** parameter influences the excitation order of a stack of slices. You can select Ascending, Descending or Interleaved (Fig. 2)

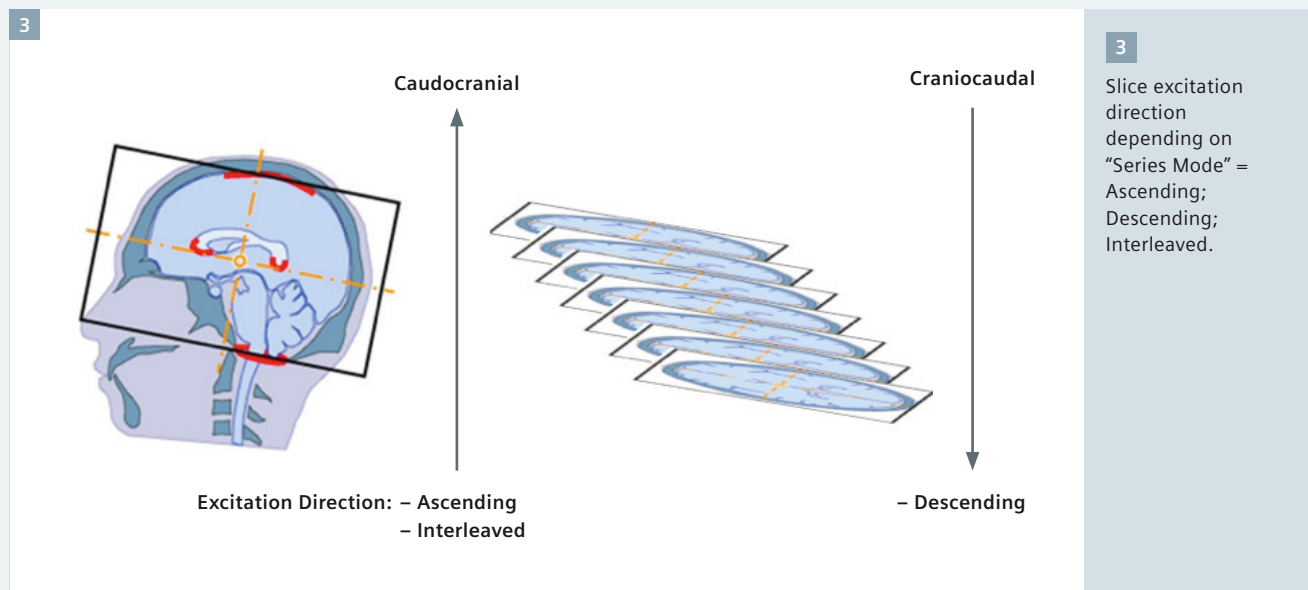
The interleaved mode is usually chosen to minimize crosstalk between the slices.

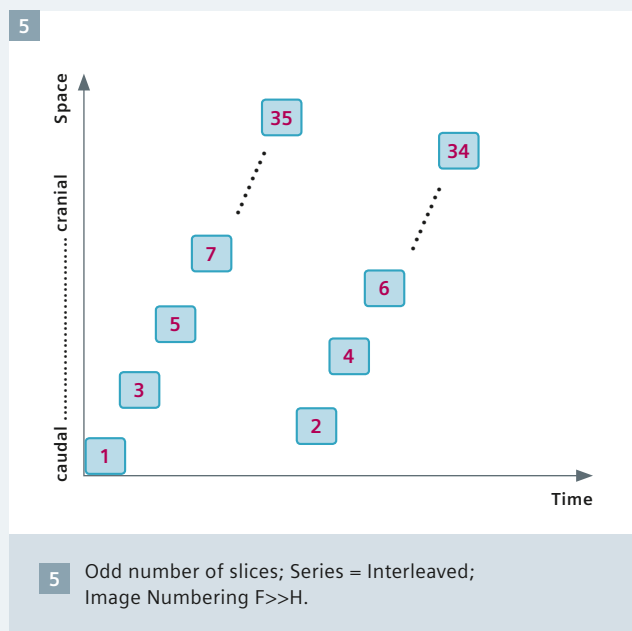
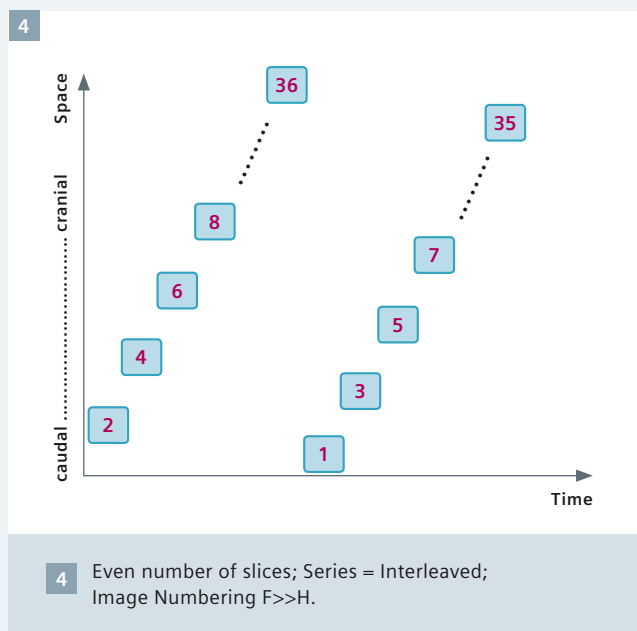


In ascending and interleaved mode, the direction of transverse slice excitation is always from foot to head. In descending mode the direction changes to head to foot for axial slices. (Fig. 3)

All examples are valid for transverse slices only, meaning the orientation parameter with a leading "TRA >".

In interleaved mode the number of slices determines which slice is excited





first when image numbering feet to head is used:

- Even number of slices:
slice number 2 first
- Odd number of slices:
slice number 1 first

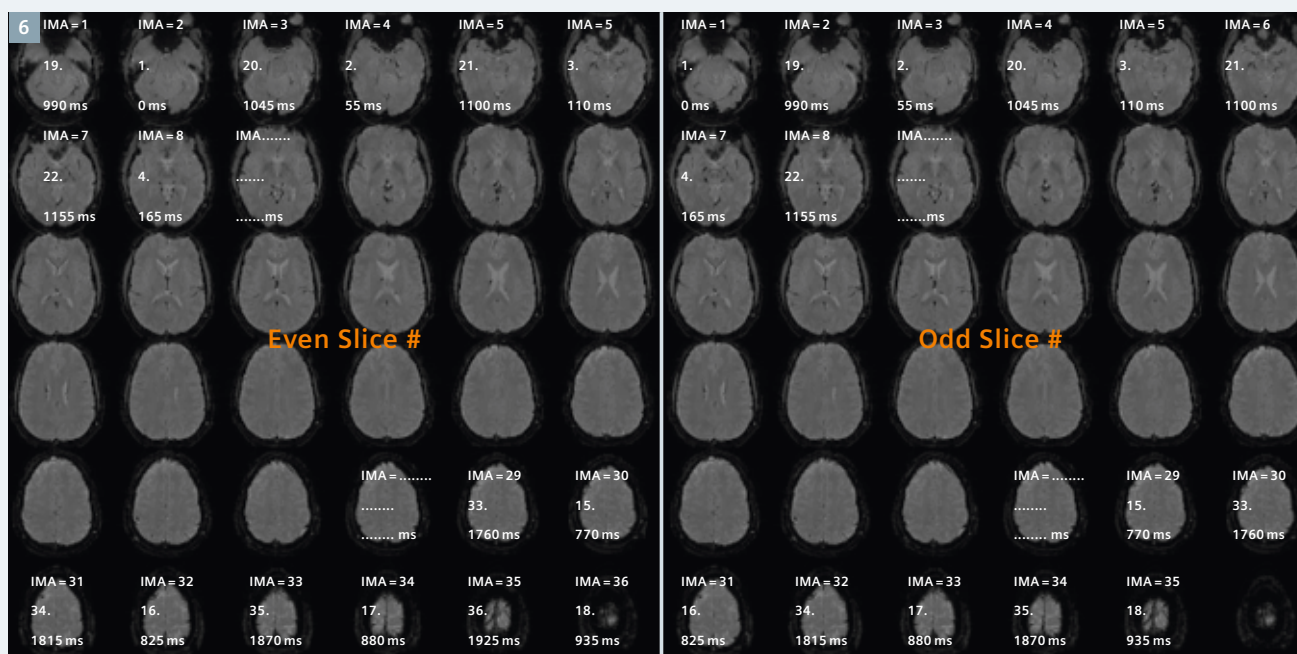
Example: Image numbering F>>H

- 36 slices: even number of slices (Fig. 4)

- Order: 2,4,6,8,10,..., 34,36,1,3,5,7,10,...,33,35
- 35 slices: odd number of slices (Fig. 5)
 - Order: 1,3,5,7,10,..., 33,35,2,4,6,8,10,...,32,34

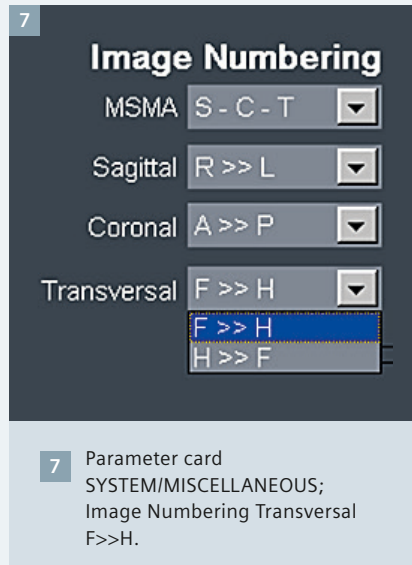
The EPI mosaic in figure 6 shows a series containing 36/35 interleaved

measured slices with text overlays for image numbers, excitation order number and relative offset time. The latter value can be extracted from the DICOM header in tag (0019,1029) „MosaicRefAcqTimes“ together with tag (0008,0032) „Acquisition time“ to calculate the absolute time of an image.



6 Mosaic images with even/odd number of slices; Series = Interleaved; Image Numbering F>>H.

The displayed slice numbers in this example are identical to the image numbers of the series as long as the default setting for image numbering is used: Transversal F>>H on parameter card System/Miscellaneous (Fig. 7)



Do not use the mode H>>F because this complicates the numbering and you will have to sort images manually in most fMRI post-processing tools. The excitation of the slices in this case also starts caudally with the highest image numbers counting backwards! The rule with even or odd image numbers is not applicable. Furthermore, the images are displayed in a reverse order on the mosaic images. When used accidentally, the excitation order is shown below.

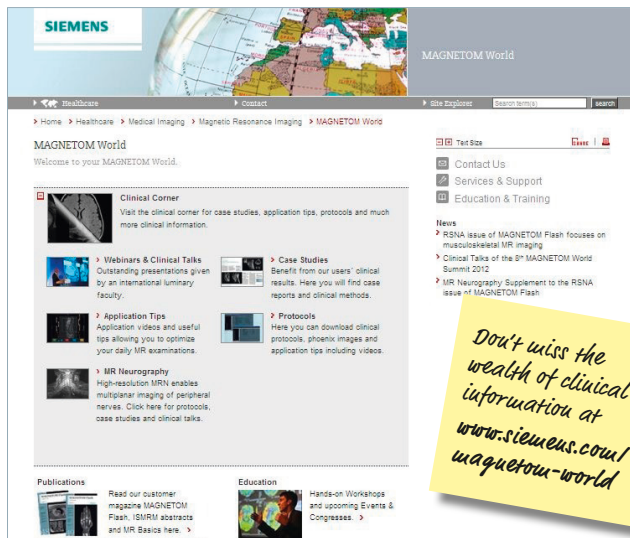
Example: Image numbering H>>F

- 36 slices: Even number
 - Order: **35,33,31,29,...,3,1,36,34,32,30,...4,2**
- 35 slices: Odd number
 - Order: **35,33,31,29,...,3,1,34,32,30,28,...4,2**

Please make sure that your evaluation software takes care of the slice order specified above.

Contact

Joachim Graessner, Dipl. Ing.
Siemens AG Healthcare
RC-DE COC NB CM
Lindenplatz 2
20099 Hamburg
Germany
joachim.graessner@siemens.com



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Global Siemens Headquarters
Siemens AG
Wittelsbacherplatz 2
80333 Muenchen
Germany

Global Siemens Healthcare Headquarters
Siemens AG
Healthcare Sector
Henkestr. 127
91052 Erlangen, Germany
Phone: +49 9131 84-0

Legal Manufacturer
Siemens AG
Wittelsbacherplatz 2
DE-80333 Muenchen
Germany