Triggering through the Parallel Port

1) What to program in your stimulus software.

The Elekta MEG system uses a binary system of triggering via the parallel port. Each of the 8 available data pins on the parallel port can be set to 0 or 1, and the patterns of 0s and 1s describe the trigger which is received by the MEG system.

To understand how this works, it's useful to be familiar with binary counting, though you can just extract some appropriate decimal trigger values from the table below.

A Brief Introduction to Counting in Binary

A detailed description of binary counting can be found on Wikipedia http://en.wikipedia.org/wiki/Binary_numeral_system but here is a brief summary.

In decimal counting, each digit represents a power of 10, because there are 10 possible numbers, 0-9, in each position. So for example in the decimal number 346 we have 3 hundreds (3x102), 4 tens (4x101), and 6 ones (6x100).

In binary, we only use the numbers 0 and 1, so each digit represents a power of 2. As an example, the binary number 10010 means that we have (working from left to right) 1x24, 0x23, 0x22, 1x21, 0x20. Work these out and add them up to get the equivalent decimal number: 18.

In your stimulus program, the easiest way to work is to associate a trigger on one individual pin of your parallel port with each of your stimuli. You can do this by using trigger codes that are decimal powers of 2 – only one pin will be set to 1 and the others will remain at 0 when a trigger is sent. The table below shows the decimal values which activate only one pin at a time.

Table of Binary Codes

Power of 2	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7
Binary Number	1	10	100	1000	10000	100000	1000000	10000000
Decimal Values	1	2	4	8	16	32	64	128

If you used a number between the powers of 2, you will be activating more than one pin at a time. For example if you set a trigger value of 3 (binary 11) the acquisition computer will receive trigger values 1 and 2 simultaneously because both pins are set to 1. Our MEG system will sum these triggers to record a 3 without problems, but you'll need to do a little extra work to make the on-line averager work.

If you are purposefully sending more than one trigger at once, perhaps in a multimodal experiment for example, do bear in mind that the MEG system will not be able to discriminate between, for example, a 3 and a simultaneous 1 and 2.

Although the MEG system can receive large numbers of different triggers, please be aware that successful MEG studies tend to have few stimulus categories with good signal to noise. A maximum of about 4 different triggers is recommended

2) What to set up in the MEG acquisition Software

The MEG system has one main stimulus channel, STI101, which sums all triggers sent from the parallel port of your stimulus PC. When setting up your acquisition protocol, if you engage channel STI101, all your triggers up to a value of 256 will be recorded.

The on-line averaging function in the Elekta Acquisition software is very useful and we recommend that you use it, not least because it provides a quick way to see if your paradigm is working. If you have chosen trigger values which are powers of two, you don't need to change any of the default event settings. The binary codes for Event 1 are set up for a trigger value of 1 on STI101, the binary codes for Event 2 are set up for a trigger value of 2 on STI101, Event 3 for a value of 4, etc, etc. The table is reproduced below showing the event numbers for each of the trigger values up to 128. You just need to select the event and add your averaging parameters.

Table of Binary Codes, reproduced with Event numbers

Power of 2	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7
Binary Number	1	10	100	1000	10000	100000	1000000	10000000
Decimal Values	1	2	4	8	16	32	64	128
Event Number	1	2	3	4	5	6	7	8

The on-line averager can also be customised to accept triggers between the powers of 2 on the STI101 channel, if required. You need to select an event and define the code in the '*Event Characteristics*' box. There are two lines of trigger codes shown here, one for 'New' values and one for 'Old'. The 'Old' values are set to 0 and describe the situation where there is no trigger; you can ignore these unless you are doing some fancy negative triggering setup.

You need to make sure that the values in the 'New' line are the same as the binary codes you have set for this event in your stimulus presentation package. You can simply edit the Value/Mask boxes, and the adjacent bit pattern will change automatically. In the Value box, you can enter the size of your trigger. For example if you enter 3, this should automatically enter 1 in the first two bits (working from left to right) adjacent. The number of 1s coded in binary by the number in the Mask box sets how many bits are available (available bits are set as 0 or 1 rather than *). The default mask of 63 (binary 111111, i.e. 6 digits) ensures that each of the first 6 bits are available so you can have triggers up to value 63. If you wanted a trigger value above 63, you'd need to change the mask to 127 (binary 1111111, 7 digits) to activate one additional bit, or 255 (for 8 digits).

If you want to average your data offline, for example using Graph, it's easy if you have used triggers which are powers of 2 and also included some of the individual stimulus channels, STI001, STI002, etc. These allow

you to see each trigger on a separate line. Note, though, that trigger codes activating more than one pin (i.e., numbers between the powers of 2) will not be correctly represented on these individual channels – for example, a trigger 3 will activate channels 1 and 2 and will be trickier to use *post-hoc*

In summary, the simplest MEG paradigm with 4 conditions would use trigger values 1, 2 , 4, and 8 sent from the stimulus PC. Channel STI101 would be included, as well as channels STI001, STI002, STI003, and STI004 for easy offline averaging. Online averaging would be set to use events 1, 2, 3, and 4 without any need for modification of bit patterns.