# The neural correlates of incrementally raised expectations in rapid serial visual presentation streams studied with MEG

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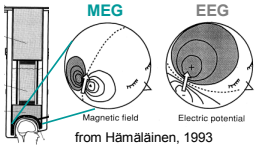
## Introduction

**Building up expectations about what we are likely to see enables us to be highly flexible in a rapidly changing world. However there may be costs when you do not see what you anticipated.**

### Magnetoencephalography (MEG)

Presenting targets within **rapid serial visual presentation** (RSVP) streams enables us to study information processing under high time pressures. **MEG** is an ideal neuroimaging method to capture rapid cognitive changes, with its **excellent temporal** (~1ms) & **spatial resolution** (~3mm at the source level).




from Hämäläinen, 1993

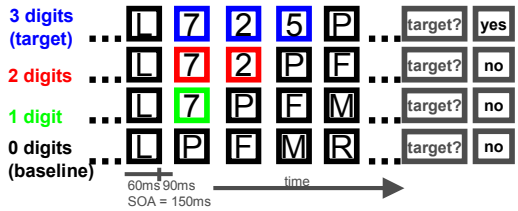
### Target Processing at High Speeds

The **P300** event-related potential/field (ERP/ERF) is typically observed when targets are detected, even at rates of 10 items per second. The P300 may reflect targets entering working memory (Kessler, 2005a,b; McArthur, 1999; Vogel, 1998). In the frequency domain, **beta-band** (~15 Hz) **synchronization** in a distributed network is crucial for target processing while **desynchronization** suppresses irrelevant distractors (Gross, 2004; Kessler, 2006; Kranczioch, 2007). **Raising expectation** for a target is linked to synchronization in the beta (Gross, 2006) & low gamma (~40Hz) bands (Nakatani, 2005).

## Aim of MEG study

**What are the neural correlates of raised but unsatisfied expectations?**

We investigate the **incremental build-up of target expectations** using a composite digit target. The full target (3 digits) is unveiled over time as digits are presented consecutively. Target expectations may develop with partial targets of 1 digit & especially 2 digits.




Behavioural experiments using the Attentional Blink task suggest that built but unsatisfied target expectations (with 2 digits) take time to overcome & interfere with subsequent information processing (Mohammed & Kessler, submitted).

## MEG Recording & Analysis

MEG data was collected from 15 participants using the 248-channel whole head system at the Centre for Cognitive Neuroimaging (CCNi) in Glasgow. Data was analysed using **FieldTrip**. Artifacts (eye-blinks, muscle, SQUID jump & heart artifacts) were rejected. **Event-related fields** (ERFs) were calculated on baseline-corrected (-0.4:0s relative to onset of 1st digit), detrended & low-pass (35Hz) filtered data. **Time-frequency representations** (TFRs) were calculated on detrended & dft-filtered data, padded to 10s. Power was estimated in 2-30Hz frequency ranges using **Hanning-windows**. An absolute baseline (-0.2:0s) was applied before plotting TFR. **Cluster-based permutation statistics** (Maris & Oostenveld, 2007) compared activity in 3, 2 & 1 digit levels to the 0 digit baseline condition.

## Lay Summary

We aimed to see whether raised but violated expectations for a visual target were reflected in the electromagnetic brain activity. Making predictions about what we will see keeps us flexible in a rapidly changing world. Magnetoencephalography (MEG) measures the synchronous magnetic fields generated by large neuronal populations, & likely reflects the summed post-synaptic potentials of pyramidal cells. Event-related fields (ERFs) reveal activity that is time-locked to the stimulus. We observe a P300 to each incoming digit, seen over distributed cognitive areas, including frontal, parietal & temporal regions. This could reflect the updating of information into working memory as each part of the target (1st, 2nd, 3rd digit) enters the brain. Meanwhile, time-frequency representations (TFRs) tell us about the changes in ongoing oscillatory activity in the brain. There are changes in alpha (α: 9-13 Hz) & faster beta (β: 19-23 Hz) wave activity with the digit levels. Strongly raising expectations (with 2 digits) reveals an early suppression of α & β activity, a pattern also seen with the full target (3 digits). Such suppression shows that active cognitive processing begins as the full target is being revealed & strongly suggests that target expectations are represented in oscillatory brain activity.

## Event-related Field (ERF) Results

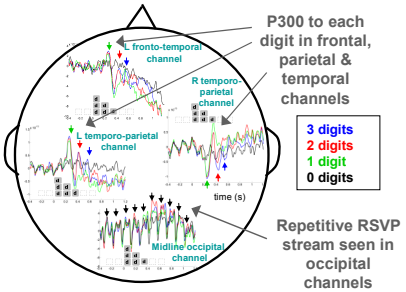



**Fig 1: Group ERFs in frontal, temporal, parietal & occipital single channels for 0, 1, 2 & 3 digits.**

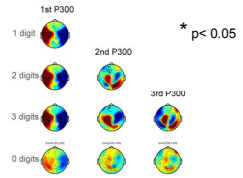



**Fig 2: Topographies for each P300 peak with statistics for differences between 1, 2 & 3 digits versus 0 digits.**
The first P300 is similar in 1, 2 & 3 digit conditions with a broad fronto-temporo-parietal topography. Subsequent P300s display a more central topography.

## Time-frequency Representations (TFRs)

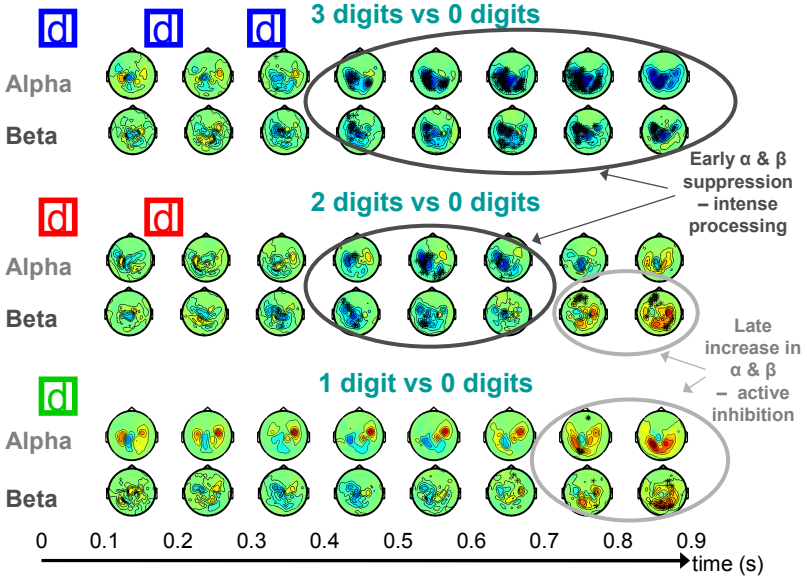



**Fig 3: Difference topographies (eg. 3 digit – 0 digit) with statistics comparing digit levels to the baseline (0 digit) condition in alpha (9-13Hz) & beta (19-23Hz) bands**

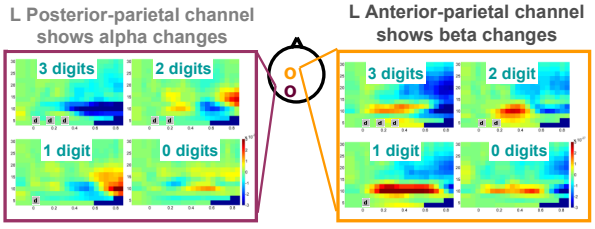



**Fig 4: Group TFR for posterior- & anterior-parietal channels.**
The z axis shows changes in power relative to the baseline (-0.2:0s). Red reflects power increases while blue shows power decreases.

## Conclusions

- The **dynamics of visual expectations are reflected in the frequency-domain**, & MEG can capture these changes over time.

- **Early suppression of alpha & beta activity** is present with 3 digits & 2 digits, suggesting **intense processing begins with the 2nd incoming digit** (*cf.* Klimesch, 2007; Osipova, 2008), which could reflect the build-up of **target expectations**. A **late increase in alpha & beta** with partial targets (1 digit & 2 digits) could reflect **active inhibition** once it is apparent there was no full target. The **P300 to each incoming digit** suggests all digits are processed at the level of awareness prior to the target/no target decision.

- Further analysis will be necessary to determine the **underlying cortical mechanisms** & to investigate whether target expectations are reflected by high **synchronization** within the network.

### Acknowledgements

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