Pre-stimulus neural activity predicts success in ignoring

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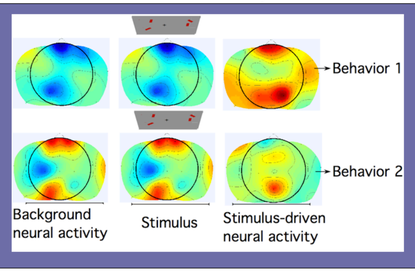
INTRODUCTION

Stimulus processing requires two aspects of attention: ignoring irrelevant stimuli, and enhancing processing of relevant stimuli. Here we exploit an intentional ignoring paradigm in order to examine how attention and ignoring are linked.

It is well known that attention alters neural processing (e.g., Hillyard and Anllo-Vento, 1998). We explore the idea that ongoing background neural activity also impacts stimulus processing, as schematized in the figure.

Does background neural activity prior to stimulus presentation affect subsequent stimulus-driven neural activity and behavior?

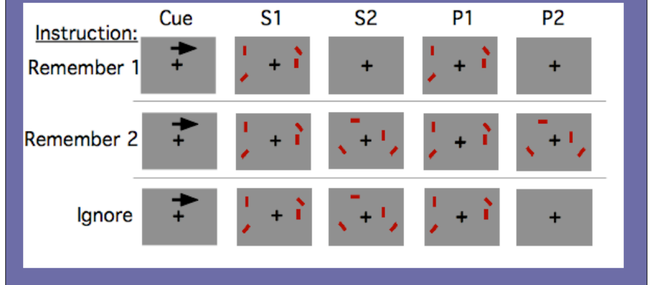


Remember/ Ignore Task

Subjects performed three tasks in blocks of 60 trials each. In the **Remember 1** condition subjects view a display of oriented bars (2 on each side of fixation), and judge whether a subsequently presented probe (P1) differs from that display. This task resembles Vogel and Machizawa's (2004) change detection task.

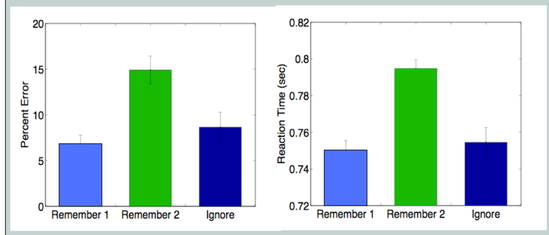
The **Remember 2** condition is similar to Remember 1, but subjects must remember <u>two</u> sequentially-presented stimulus arrays (S1 and S2). Subjects then respond to sequentially-presented probes (P1 and P2).

The **Ignore** condition is similar to Remember 2, but here subjects are not tested on S2, and are instructed to ignore it (Yotsumoto and Sekuler, 2006).



Random delays of 700 to 1200 ms between stimuli onsets. S1 and S2 are on the screen for 100 ms each. P1 and P2 are on the screen until response or 2000 ms.

Ignoring stimulus 2 overcomes interference



23 subjects performed well on the **Remember 1** condition, with few errors and fast reaction times. When required to **Remember 2** stimuli, the second stimulus interfered with the memory for the first, resulting in poorer performance: more errors ($p < 0.01$) and slower reaction times ($p < 0.01$). When subjects **Ignore** stimulus 2, they can overcome this interference. Reaction time and proportion correct in Ignore are statistically indistinguishable from Remember 1 condition (but variance is greater).

What brain measures correlate with overcoming interference?

EEG methods

13 subjects performed the Remember/Ignore task while EEG data were collected using a 128 electrode net from EGI systems. 240 trials of each condition were performed. After pre-processing, trials with blinks or other artifacts were removed from further analysis, leaving at least 100 trials per subject, per instruction condition. Data from 3 subjects were excluded because of poor performance or technical issues.

Data were collected at 250 Hz, hardware filter high pass at 0.1 Hz, low pass at 100 Hz.
Data preprocessing: High pass filtered at 1 Hz, low pass filtered at 20 Hz. Data averaged to 27 electrode array.

References:
Fox, M.D. and Raichle, M.E. (2007). Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. Nat Rev Neurosci, 8(9):700-711.
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Vogel, E. K. and Machizawa, M. G. (2004). Neural activity predicts individual differences in visual working memory capacity. Nature, 428(6984):748–51.
Yotsumoto, Y. and Sekuler, R. (2006). Out of mind, but not out of sight: intentional control of visual memory. Memory & Cognition, 34(4):776–86.

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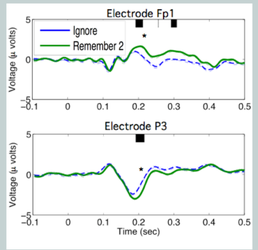
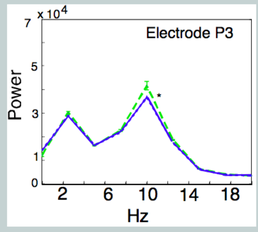
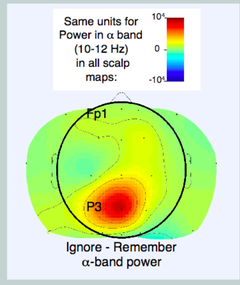
Stimulus-driven activity

ERP and α- band power reflect decreased attention to an Ignored stimulus

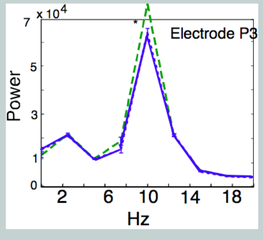


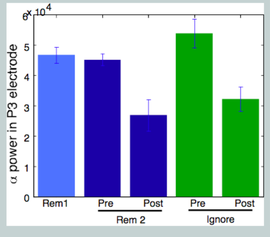
Stimulus-driven ERPs for S2 are larger for **Remember 2** than **Ignore** trials. Power in the α band (10-12 Hz) is larger in **Ignore** trials, consistent with literature (see references). Bars and * indicate significant differences at $p<0.05$. ERPs were baseline corrected and multiple comparison corrected using bootstrap methods.





Pre-stimulus activity



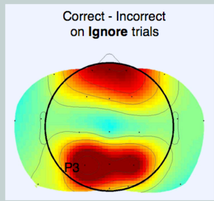


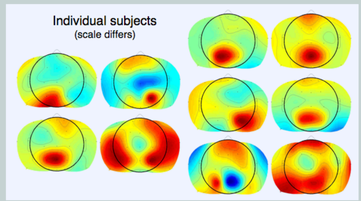
Before presentation of S2, power in the α band is larger in **Ignore** trials, consistent with preparation to ignore the stimulus.
Significant differences at $p<0.05$ with *. ERP multiple comparison corrected using bootstrap methods. Within-subject error bars.
Pre vs post-stimulus activity shows alpha suppression

Does this pre-stimulus activity impact behavior?

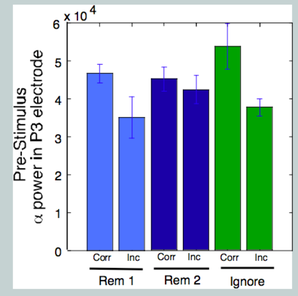
Pre-stimulus activity may predict "successful" ignoring

High α-band power before to-be-ignored stimulus (S2) predicts correct memory for the unrelated stimulus (S1).





Pre-stimulus activity in electrode P3 predicts whether the subject will effectively ignore the stimulus ($p = 0.01$). In **Ignore** trials, higher α-band power before the to-be-ignored stimulus for correct trials than error trials. Note individual variability. Range of number of errors committed by a subject: 9 to 67



Alpha power before S2 predicts performance for the **Ignore** condition.
In the **Remember 1** condition, no stimulus is presented; alpha power in the interval between S1 and P1 is greater for correct than incorrect trials.
In **Remember 2** condition, correct and incorrect trials show similar pre-stimulus α power.

CONCLUSIONS

Remember/Ignore task provides a behavioral index of ignoring's effectiveness.
- **Ignoring a second stimulus overcomes the potential interference from that stimulus (Proportion correct and Reaction time).**
- **This task alleviates need for explicit test of ignored stimulus.**

Intentional ignoring manipulates the attention system.
- **Variations in stimulus-driven EEG power and ERPs are consistent with previous findings in the attention literature.**

Dynamic changes in α power are associated with ignoring.
- **Preparatory activity predicts subsequent accuracy in memory for a *different* stimulus.**
- **"Good ignoring" (as defined by high α -band power) predicts ability to overcome interference (defined by behavior).**
- **In this paradigm, transient α-band power is associated with *good* performance, due to suppression of interfering information.**

Consistent with role of α in active inhibition, not "idling."