Does spatial attention modulate afferent activity in primary visual cortex?

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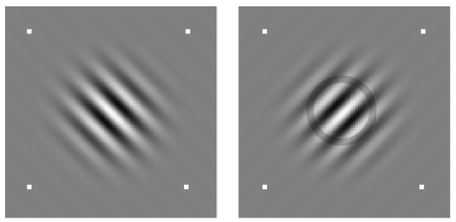
Background

Whether visual spatial attention can modulate feedforward input to V1 is debated. [1]

- Long-standing hypothesis: attention can influence processing in V1, but only at delayed latencies, suggesting a feedback-mediated mechanism. [2]
- Recent challenge: amplitude enhancements of the earliest visual ERP (C1, 50-80 ms) for attended vs. ignored locations suggest a modulation of feedforward input to V1. [3]
- Kelly et al. (2008) [3] combined several methodological improvements that may be essential for demonstrating a C1 attention-effect:
  - stimulus locations & electrode positions tailored for each individual subject
  - trial-by-trial cueing of endogenous spatial attention
  - difficulty of target detection task dynamically adapted for each individual
- Here, we used all of these methodological procedures, with one small change:
  - Kelly et al. (2008): attended vs. ignored locations were *diagonally opposed*, crossing both horizontal and vertical midlines of the visual field.
  - Current study: attended vs. ignored locations were in *either* the upper *or* lower visual field (on separate blocks of trials), crossing only the vertical midline.

Methods

- Subjects (N=17) participated in an initial "probe" experiment that helped identify the ideal stimulus positions and electrode locations for eliciting and measuring the C1.
- Based on this probe data, two locations (and electrodes) in the upper field, and two in the lower field were selected for the main attention experiment.
- In separate blocks of trials (for upper/lower fields), subjects were cued to attend to either the left or right location in order to detect infrequent target stimuli.



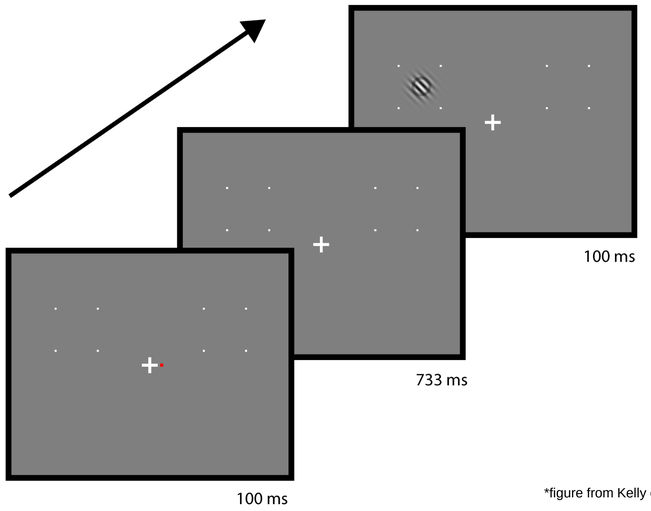
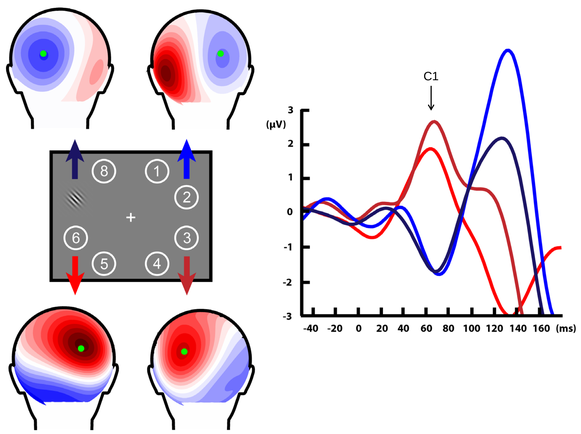


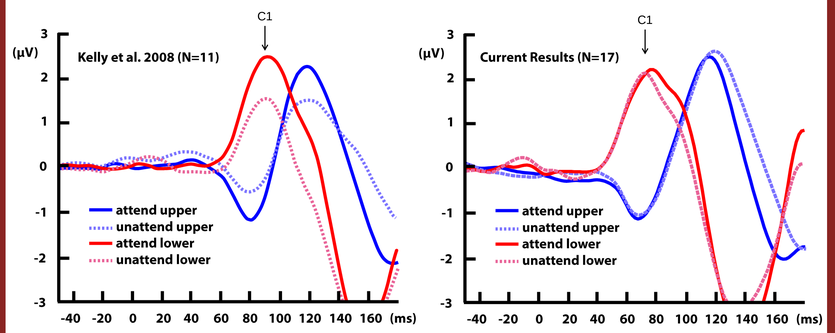
*figure from Kelly et al. (2008) [3]

Results: Probe Experiment



Example probe data for a single subject. All 8 locations were randomly probed. A pair of locations in the upper field and a pair in the lower field that elicited the largest amplitudes in the C1 time window were selected for the main attention experiment. Selected locations were always symmetrical (7/2, 8/1, 6/3, 5/4).

Results: Attention Experiment

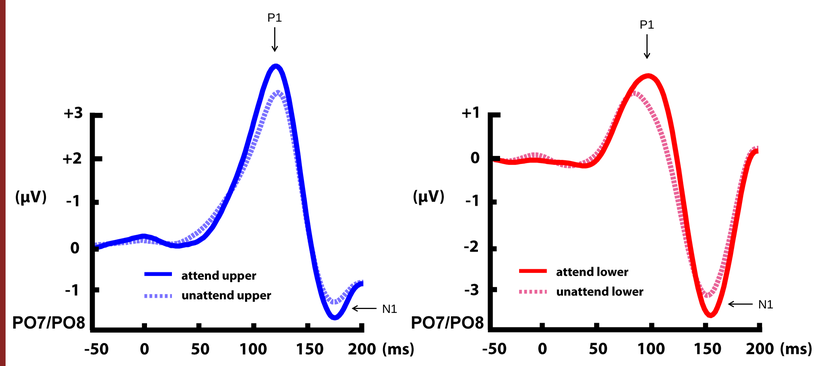


Grand-averaged ERPs from Kelly et al. (2008) and from the current study. Mean C1 amplitudes (50-80 ms) were compared between attend vs. unattend conditions.

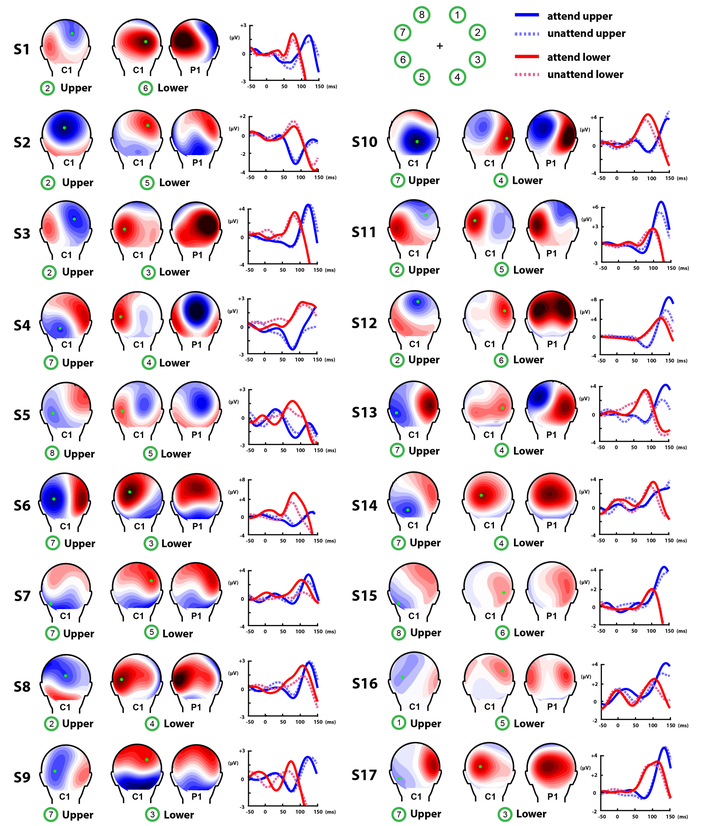
C1 attention effects were absent in the current study: F(1,16) = 0.28, p = 0.61

- Upper field: t(16) = -1.09, p = 0.29
- Lower field: t(16) = -0.11, p = 0.92

P1 & N1 attention effects were evident at more lateral electrode sites than the C1:



Results: Individual Subjects



Summary / Discussion

- No evidence for attention-based modulation of the C1 (50-80 ms)
- Attention-based amplitude enhancements were evident for the P1 (90-140 ms) and the N1 (150-180 ms)

Why did Kelly et al. (2008) find a C1 attention effect while we did not?

- Interpretation #1: There is something unique about using diagonally opposed attended vs. ignored locations (this was the only difference between studies).
- Interpretation #2: There is a C1 attention effect, but our findings (and many others, e.g. [4,5]) failed to find such an effect, thus making a type 2 error.
- Interpretation #3: There is no C1 attention effect, thus Kelly et al.'s (2008) results were due to a type 1 error.

Why does it matter if there is a C1 attention effect?

- Informs our understanding of how much information is automatically encoded in the visual system. This has implications for the "cognitive penetrability" debate, and the debate over the "richness / sparseness" of visual awareness.

References

[1]Slotnick, S. (2013). The nature of attentional modulation in V1 (pp. 44-69). In *Controversies in Cognitive Neuroscience*, Palgrave Macmillan, New York, NY.

[2]Martinez et al. (1999). Involvement of striate and extrastriate visual cortical areas in spatial attention. *Nature Neuroscience, 2(4),* 364-369.

[3]Kelly, S., Gomez-Ramirez, M., & Foxe, J. (2008). Spatial attention modulates initial afferent activity in human primary visual cortex. *Cerebral Cortex, 18,* 2629-2636.

[4]DiRusso, F., Martinez, A., & Hillyard, S. (2003). Source analysis of event-related cortical activity during visuo-spatial attention. *Cerebral Cortex*, *13*, 486-499.

[5]Ding, Y., Martinez, A., Qu, Z., & Hillyard, S. (2014). The earliest stages of visual cortical processing are not modified by attentional load. *Human Brain Mapping*, *35*, 3008-3024.