How early does attention modulate visual information processing? The importance of experimental protocol and data analysis approach

Slagter, H.A.; Alilovic, J.; Van Gaal, S.

DOI
10.1080/17588928.2017.1372405

Publication date
2018

Document Version
Final published version

Published in
Cognitive Neuroscience

Citation for published version (APA):
Slagter, H. A., Alilovic, J., & Van Gaal, S. (2018). How early does attention modulate visual information processing? The importance of experimental protocol and data analysis approach. *Cognitive Neuroscience*, *9*(1-2), 26-28.
https://doi.org/10.1080/17588928.2017.1372405

How early does attention modulate visual information processing? The importance of experimental protocol and data analysis approach

Heleen A Slagter[a,b], Josipa Alilovic[a,b] and Simon Van Gaal[a,b]

[a]Department of Psychology, University of Amsterdam, Amsterdam, The Netherlands; [b]Amsterdam Brain and Cognition, University of Amsterdam, Amsterdam, The Netherlands

ABSTRACT

Whether attention can influence afferent information processing in primary visual cortex (V1) has long been topic of scientific debate. Findings from a recent study by Baumgarter et al. (this issue) add to this debate by providing a null replication of an influential study that reported that spatial attention can enhance feedforward information processing in human V1, as reflected in the amplitude of the C1 ERP component (Kelly, Gomez-Raminez, & Foxe, 2008). Here we discuss several factors, including analytic approach, experimental design, and motivational factors, that, once scientifically tested, may help resolve discrepancies in the current literature.

ARTICLE HISTORY

Received 3 July 2017; Revised 20 August 2017; Published online 18 September 2017

KEYWORDS

V1; spatial attention; EEG; ERP; C1; selective attention

Whether attention can influence afferent information processing in primary visual cortex (V1) has long been topic of scientific debate. Findings from a recent study by Baumgarter et al. (this issue) add to this debate by providing a null replication of an influential study that reported that spatial attention

CONTACT Heleen A Slagter h.a.slagter@uva.nl Department of Psychology, University of Amsterdam, Postbus 15915, 1001 Amsterdam, NK, The Netherlands

https://doi.org/10.1080/17588928.2017.1372405

can enhance feedforward information processing in human V1, as reflected in the amplitude of the C1 ERP component (Kelly, Gomez-Ramirez, & Foxe, 2008). Here we discuss several factors, including analytic approach, experimental design, and motivational factors, that, once scientifically tested, may help resolve discrepancies in the current literature.

Like Baumgartner, Graulty, Hillyard, & Pitts (this issue), most previous human ERP studies have failed to observe modulations of afferent input to V1 by spatial attention (Ding, Martinez, Qu, & Hillyard, 2014). This contrasts with results from single-unit recordings in non-human primates (Slotnick, 2013) and human fMRI studies, which have generally reported that spatial attention can induce changes in baseline activity and stimulus-evoked responses in V1 (Sylvester, Shulman, Jack, & Corbetta, 2009). Yet, these modulations are generally weaker than those in extra-striate cortex. For anatomical (e.g., large inter-individual variability in V1 anatomy and small receptive fields) and methodological (e.g., dependence of EEG signal on the co-activation of thousands or millions of parallel-oriented neurons) reasons, it may be difficult to reliably pick up on weak attentional modulations of V1 activity, if they exist, with scalp EEG. We list three factors that could enhance sensitivity.

First, multivariate analyses that take into account activity from many scalp electrodes, may be more sensitive in picking up weak attentional modulations than the analytic approach of only looking at the C1 peak electrode, as in Baumgarter et al. and Kelly et al. Importantly, this could also reveal attentional effects that are not reflected in activation strength, but in how information is represented in activity patterns, similar to attention-related sharpening of neural representations in V1 observed using BOLD fMRI (Jehee, Brady, & Tong, 2011).

Second, boosting the strength of stimulus-driven activation may increase the sensitivity in detecting weak attentional modulations. Certain stimuli elicit larger, i.e. less noisy, C1 components, than others. For example, in one study, texture displays elicited C1's of −10/+7μV (Pourtois, Rauss, Vuilleumier, & Schwartz, 2008), compared to C1 amplitudes of −1.5/+2μV in the Baumgarter et al. and Kelly et al. studies.

Third, motivational factors and reward may be important to take into account in future studies. For instance, non-human primates are typically motivated by rewarding accurate task performance, whereas humans are usually not. Notably, a recent study in humans reported that spatial cues predicting reward during successful task performance enhanced the amplitude of the C1, while spatial attention did not (Bayer et al., 2017). This may suggest that motivation, but not spatial attention, facilitates early afferent processing. Yet, reward and attention have also been reported to engage strongly overlapping selection mechanisms in monkey V1 (Stănişor, Van Der Togt, Pennartz, & Roelfsema, 2013). It is hence possible that only under conditions of high motivation, attention is directed such that its effects are implemented already in V1 and/or strong enough to be measured with scalp EEG.

Future EEG studies should also disentangle effects of attention (stimulus relevance) and expectation (stimulus likelihood) on afferent information processing. fMRI research shows that both top-down influences can modulate V1 activity (Kok, Rahnev, Jehee, Lau, & De Lange, 2012). Yet, in probabilistic cuing tasks, like the one employed by Baumgarter et al., attended stimuli are also always predicted and unattended stimuli always unpredicted. To what extent attention and/or expectation can influence feedforward processing in V1 thus is an important question for future studies.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by a ERC starting grant to HAS by the H2020 European Research Council [ERC-2015-STG-679399].

References

Bayer, M., Rossi, V., Vanlessen, N., Grass, A., Schacht, A., & Pourtois, G. (2017). Independent effects of motivation and spatial attention in the human visual cortex. *Social Cognitive and Affective Neuroscience*, *12*(1), 146–156. doi:10.1093/scan/nsw162

Ding, Y., Martinez, A., Qu, Z., & Hillyard, S. A. (2014). Earliest stages of visual cortical processing are not modified by attentional load. *Human Brain Mapping*, *35*(7), 3008–3024. doi:10.1002/hbm.22381

Jehee, J. F. M., Brady, D. K., & Tong, F. (2011). Attention improves encoding of task-relevant features in the human visual cortex. *Journal of Neuroscience*, *31*(22), 8210–8219. doi:10.1523/JNEUROSCI.6153-09.2011

Kelly, S. P., Gomez-Ramirez, M., & Foxe, J. J. (2008). Spatial attention modulates initial afferent activity in human primary visual cortex. *Cerebral Cortex*, *18*(11), 2629–2636. doi:10.1093/cercor/bhn022

Kok, P., Rahnev, D., Jehee, J. F. M., Lau, H. C., & De Lange, F. P. (2012). Attention reverses the effect of prediction in silencing sensory signals. *Cerebral Cortex*, *22*(9), 2197–2206. doi:10.1093/cercor/bhr310

Pourtois, G., Rauss, K. S., Vuilleumier, P., & Schwartz, S. (2008). Effects of perceptual learning on primary visual cortex activity in humans. *Vision Research*, *48*(1), 55–62. doi:10.1016/j.visres.2007.10.027

Slotnick, S. (2013). The nature of attentional modulation in V1. In S. Slotnick (ed.), *Controversies in cognitive neuroscience* (pp. 44–69). New York, NY: Palgrave Macmillan.

Stănişor, L., Van Der Togt, C., Pennartz, C. M. A., & Roelfsema, P. R. (2013). A unified selection signal for attention and reward in primary visual cortex. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(22), 9136–9141. doi:10.1073/pnas.1300117110

Sylvester, C. M., Shulman, G. L., Jack, A. I., & Corbetta, M. (2009). Anticipatory and stimulus-evoked blood oxygenation level-dependent modulations related to spatial attention reflect a common additive signal. *Journal of Neuroscience*, *29*(34), 10671–10682. doi:10.1523/JNEUROSCI.1141-09.2009