Nonlinear response functions can still be used to build conjunction detectors: Reply to May and Zhaoping

Jonathan W. Peirce

Nottingham Visual Neuroscience, School of Psychology, University of Nottingham, UK

Introduction

I am delighted that May and Zhaoping (2013) now agree that, at least for the vast majority of V1 neurons, nonlinear contrast response functions could be used in building effective AND gates, and appear no longer to contest that only neural mechanisms for strict multiplication can achieve such a goal.

In this issue, however, they contest that the scheme would still ultimately fail to be useful due to the strongly supersaturating neurons, which will respond weakly when high-contrast compounds are presented. The argument is facile in two ways: It is based on an extremely small proportion of neurons and it assumes that all neurons in primary visual cortex (V1) have the same role.

It is clear from May and Zhaoping's own analysis that inputs from moderately supersaturating response functions are barely affected by the issue they raise (compare their figure 1C with figure 1D), and I suspect the exact choice of response threshold levels could mitigate this further. So the issue really revolves around the strongly supersaturating neurons (as in figure 1E). Such neurons are really quite rare, sufficiently so that most electrophysiology papers don't mention their existence at all. In the sample I presented previously (Peirce, 2007) only eight of 263 V1 neurons reduced their response by 50% or more at maximum contrast. It seems somewhat harsh to reject a theory on the basis that it would not work for 3% of V1 neurons (or 3.4% in V2) for high-contrast compound stimuli.

Even if the proportion of such neurons were substantially larger we need only conjecture, quite reasonably, that not all neurons in V1 have the same purpose. For instance, these neurons would provide a useful signal for a detector that was selective for moderate- rather than high-contrast conjunctions. Or, potentially, such cells are useful for an entirely different purpose. Many neurons in V1 are not orientation selective, but we would not reject the hypothesis that V1 is useful in orientation coding. May and Zhaoping suggest that strongly-saturating functions are useful in encoding the contrast of gratings by suggesting that different neurons might code different regions of the contrast domain. Curiously, with plaids they consider that same scheme to be unreasonable because it requires more neurons than would a simple-rate code.

None of the arguments they have raised indicate that nonlinear response functions would not be a generally useful component in constructing AND gates for the purpose of conjunction detection.

Acknowledgments

Commercial relationships: none.
Corresponding author: Jonathan W. Peirce.
Email: jon@peirce.org.uk.
Address: Nottingham Visual Neuroscience, School of Psychology, University of Nottingham, Nottingham, UK.

References

May, K. A., & Zhaoping, L. (2013). The potential roles of saturating and supersaturating contrast-response functions in conjunction detection: Reply to Peirce. *Journal of Vision, 13*(4):24, 1, http://www.journalofvision.org/content/13/4/24, doi:10.1167/13.4.24. [Article]

Peirce, J. W. (2007). The potential importance of saturating and supersaturating contrast response functions in visual cortex. *Journal of Vision, 7*(6):13, 1–10, http://www.journalofvision.org/content/7/6/13, doi:10.1167/7.6.13. [PubMed] [Article]

Citation: Peirce, J. W. (2013). Nonlinear response functions can still be used to build conjunction detectors: Reply to May and Zhaoping. *Journal of Vision*, *13*(4):23, 1, http://www.journalofvision.org/content/13/4/23, doi:10.1167/13.4.23.

doi: 10.1167/13.4.23 Received December 10, 2012; published March 28, 2013 ISSN 1534-7362