Peer Review for Josue Orellana

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1 General Comments

From what I read, it seems like you have a lot of information down on the page, but the information is a little hard to process. There's a lot of technical terms associated with neuroscience that you don't explicitly define, which made the writing hard for me to follow since I have no neuroscience background. I also found some inconsistencies in the terminology you used for certain parameters, which is an easy fix that makes the discussion a lot easier for non-experts to follow.

I think you could also be a little more focused and explicit on what it is *you* did, and what is general neuroscience knowledge/previous work. There are also some style changes that I think could make the paper seem more polished - make the header names their own lines, use different notation for citations and equation numbers, and un-bolding the abstract - for example.

You do a good job of introducing a topic quickly and to the point, and I found the figure very helpful in untangling some of the notation and equations. I think if you added a little more background and basics to your introduction, and made some changes to the notations and definitions, you have a good, complete section on Population Code.

2 Specific Comments, suggestions, and edits

- Page 1, sentence 1: The sentence is basically 'There is considerable interest in ...', even though you use many verbs to describe the brain. Maybe you could change it to 'The brain uses populations of spiking neurons to encode, communicate, combine... We are interested in understanding this process through bayesian inference'

- Page 1, sentence 2: I thought this was too much detail of previous work for an abstract. I spent a lot of time trying to decode the technical words (sensorimotor, optimal combination, sensory input, neural modeling, bayesian inferences) that don't focus on your work.

  Maybe condense sentence 2 and 3 into one: For instance, previous work from Kording and Wolpert (2004) and Ma et al (2008) focused on the form in which inputs were combined to produce the posterior mean and variance.

- Page 1, sentence 5: Could make more active - Performance of population vector-based inference is investigated using various tuning functions (?)

- Page 1, sentence 6: It was unclear to me what 'it' is here. Is it the population vector based inference? The spiking neurons? Also maybe use 'We found that...' to make it clear that it is *your* work

- Page 1, sentence 7: Is there a way you can link this to something else that's already been mentioned? It seemed to me to be totally new information. For instance: 'Finally, based on our findings regarding tuning functions (?), we suggest that encoding stability...'

- Page 2, sentence 1: I liked the use of the same words as your abstract, but thought the 'see the review by (3)' was an awkward citation. Maybe start with, 'a literature review by Ma et all (3) has shown there is considerable interest....'

- Page 2, sentence 2: What is a population code? I think you need another sentence before this to introduce the terms in a way that is easier for the reader. Maybe put 'we investigate the population code to try to understand ....' before this?

- Page 2, sentence 4: I'd make the link between encoding of features and neural responses more clear here.

- Page 2, Equation 1: This might be a personal preference, but I find equations easier to follow when the parameters it uses are introduced before the equation itself. For instance:

  Population Code: Let us suppose that spikes from each neuron i, within a population of N neurons follow independent point processes $r = \{r_i\}_{i=1,..,N}$. We model each point process, r_i, conditional on the intended direction of reach, θ, using the preferred direction for neuron i, θ_{PDi}, and the mean response, $f_i(\theta)$. That is,

  $$P(r_i|\theta) = \frac{\exp(-f_i(\theta))f_i(\theta)^{r_i}}{r_i!}$$

  it's also unclear whether 'population code' refers to just equation (1), or if it describes the section through equation (2) and beyond. I'd also take out the 'Here' in 'Here, we define f_i as a von Mises function,...

- Page 2, equation 2: Again, I'd define A_i and B_i before using them in an equation. Maybe:

  We define f_i as a von Mises function, which defines an exponential family on the unit circle and is analagous to the normal distribution on the real line. To do so, we need to use the i^{th} neuron's amplitude, A_i, and its precision, B_i. We then have that

  $$f_i(\theta) = A_i \exp(B_i \cos(\theta - \theta_{PDi})).$$

- Page 2 Sentence 10: Here you refer to θ_{PDi} as the preferred stimulus, while earlier it was defined as the preferred direction. If these are equivalent, that needs to be more explicit. I would pick one definition and then be consistent throughout.

- Page 3, Figure 1: It would be helpful to have the parameter names included on all of the axis labels.

- Page 3, sentence 1: why do we use a poisson distribution? It's also unclear what the poisson distribution refers to. Maybe a sentence explaining why we assume a poisson distribution for the spikes beforehand.

  Do we need to use the term Fano factor? It's the only time you use it in the paper, and it is a little distracting when you could just use a '... the stimulus with a variance to mean ratio of 1'.

- Page 3, sentence 3: To make more active, I'd use 'If we assume that every neuron...' instead of 'Under the assumption that every neuron...'.

- Page 3, sentence 4: I'd switch the clauses so that the old information comes first:

  We maintain the assumption of independence for mathematical simplicity, although experimental evidence shows that neural populations do exhibit correlations in firing rate