Model Mining Through Phenomenology

The goal of this laboratory is to have you engage in phenomenology in order to inform your construction of a model that underlies a specific perceptual process. Phenomenology is the study of conscious experience. A phenomenological investigation is one in which a person closely examines their own subjective experiences as they change over time. The specific perceptual process to be investigated is the way in which a person's visual experience shifts between the left and right eyes over time, depending on the focus of attention and the actual visual information in different locations appearing to each eye. The assumptions underlying this laboratory are that A) different people may differ to some extent in their experiences, but there will nonetheless be robust commonalities in experiences across most people, B) these shared experiences are rich and systematically structured over space and time, and C) the resulting subjective impressions, when carefully attended and reflected upon, can place substantive constraints on the nature of the algorithm that the visual system employs to shift dominance between the eyes. We do not need to assume that our visual experiences are directly revealing our early visual processes, that they are authoritative, unambiguous, or unbiased. We can treat our visual experiences simply as reports that we tell ourselves – what Daniel Dennett (1991, 2003) calls heterophenomenology - an explicitly third-person, scientific approach to the study of consciousness that takes an observer's reports as part of the evidence for how they see the world without assuming the accuracy of these reports. In the phenomenon we will be studying, the reports are sufficiently structured and systematic that even if they are not authoritative, the details of the reports still require explanation, and people's reports turn out to be strongly correlated with neural and behavioral patterns.

Binocular Rivalry

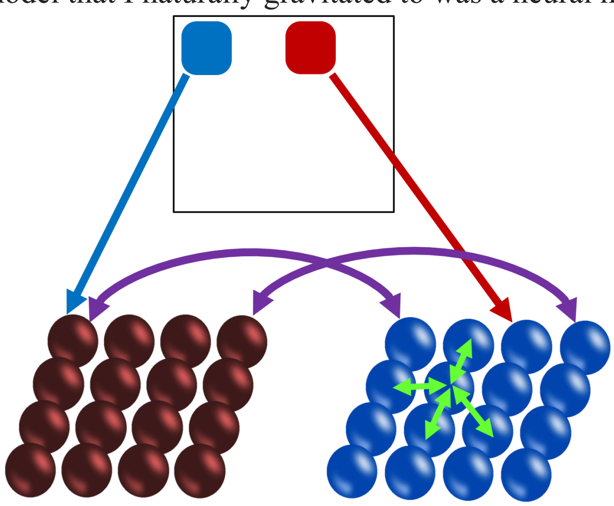
In the phenomenon of binocular rivalry, when different information is presented to a person's two eyes such that the two sources of information cannot be integrated to create a single coherent interpretation, then perceptual experience alternates between the two eyes. Sometimes only the image appearing to one of the two eyes will be visible to the observer, with the other eye's image being completely suppressed. Other times, parts of the images shown to the left and right eyes will appear in fragments, with the observer being aware of an amalgamation of pieces from each eye.

There are different ways of projecting different information to an observer's two eyes. In many psychology and neuroscience laboratories, liquid crystal glasses are employed that transmit different patterns of light selectively to the two eyes. A much cheaper and readily available technology simply involves having observers wear glasses with different colored lenses. Imagine that a red filter is in front of an observer's left eye and a cyan (a combination of blue and green) filter is in front of their right eye. The red filter will selectively allow red light to pass into the eye. A red image of equal luminance to a gray background appears nearly invisible to the left eye because both the red image and the background have an equivalent amount of red light that passes through the filter and this red light is the only light that passes through the filter.

A cyan image will appear darker than the background in the left eye because it contains very little red light and the background contains red, blue, and green light. Accordingly, the left eye with the red filter will see cyan images as dark shapes while the right eye with the cyan filter will see red images as dark shapes.

One felicitous side effect of using red-cyan 3D glasses to present different information to the two eyes is that the observer will have a phenomenologically salient cue as to whether they are seeing their visual world with their left or right eye. Every patch of their world, whether or not it contains an object, will appear tinted either red or cyan. If a patch appears to be red, then this means that the observer is seeing that patch with their left eye, while cyan-tinted patches are being seen with their right eye. These tints are subtle, lightly colored, and somewhat reminiscent of a halo. Normally, patterns of red- and cyan-appearing patches will be highly structured in both time and space.

Your task is to experiment with the lab software, with the aim of eventually proposing a model that can account for your conscious phenomenological patterns. You are free to describe any kind of model that you think makes a compelling account for your introspections. The kind of model that I naturally gravitated to was a neural network roughly organized like:



where the image elements (a blue and red blob) are shown at the top, and below are two banks of neurons for the left and right eyes. I imagined that the neurons/units within a bank are organized spatially in two dimensions, such that a blue object in the upper left portion of the display would activate the upper-left unit in the left eye (remembering that the blue dot will be invisible to the eye with the blue filter in front of it). Strong activation of this left-eye unit would lead to the subjective impression of a reddish tint in this upper-left region of the space. Fleshing out this model for me, then, amounted to specifying the kinds of excitatory and inhibitory relations between the units, as exemplified by the purple and green arrows, adding some randomness to each unit's activation at each moment, and including another mechanism that I purposefully am not describing here but was needed to even roughly accommodate my epiphenomenal experiences.

Assignment

Like much of contemporary cognitive science, your assignment has an empirical component, a modeling component, and a bridge between them.

Part I. Empirical

you should create displays for yourself (including, perhaps, completely white displays) and closely observe and report what you see. Some specific suggestion for creating the report on what you see while wearing red-cyan glasses:

- Pay attention to whether different patches of your visual world are subtly tinted red or cyan. How are different colors spatially organized? How do these organization change over time?
- When you are shown a display of horizontal red and vertical cyan stripes (by pressing the “stripes” button), how does your perception of horizontal and vertical stripes change over time? Pay particular attention to the <u>transitions</u> between perceptions of horizontal versus vertical stripes.
- Try blinking. How did that change your immediate perceptual experience upon re-opening your eyes?
- Try creating different displays consisting of red and blue regions. How do changes in these visual patterns change what you see over time?
- When you shift your gaze to a red or blue patch, how does that change the appearance of the patch?

Part II. Model

Once you have gathered and described in some detail a set of visual experiences from different displays that you present to yourself, you should then describe a model that you believe can accommodate your observations. The input to your model would be visual displays presented to an observer’s left and right eyes. The output of your model would be a prediction for each location in space as to whether the observer is seeing what is visible to the left eye, the right eye, or both eyes. Likely aspects of your model will include:

- What are the elements of your model, and how are they structured?
- How are the elements influencing themselves and each other from moment to moment?

I am being intentionally vague in this description because I want you to have flexibility in terms of your choice of modeling framework and assumptions. In prior classes we have described three neural network approaches to perceptual tasks: apparent motion, binocular depth perception, and word recognition. Given your familiarity with this kind of model, you may want to adopt this neural network approach, in which case you would be describing how neurons/units excite and inhibit each other and change their activity over time. However, if you have (or want to gain) experience with purely mathematical descriptions, dynamical systems approaches, Bayesian models, statistical models, system dynamic models (e.g. stocks and flows), then these approaches could be aptly applied to the binocular rivalry phenomenon instead, but you’ll be more on your own in terms of developing the model.

You do not have to actually program a computational model or present mathematical equations, although if doing so helps you to rigorously describe your model, then I enthusiastically encourage you to do so. All that is required is for you to describe your model in sufficient detail and clarity that it is apparent what your model assumptions are and how the model makes predictions for what a person will see over time.

Part III. Application of model to the phenomeno~~n~~logy

The third stage of your report will be to describe why your proposed model can account for several of the key observations that you made in Part I. Your model does not have to account for all of the phenomenon you described. When it does not, point this out, and describe possible elaborations of the model that could accommodate the observation. If there are stimuli that you could not show to yourself due to limitations in the lab software, what does your model predict for what you will see over time? A good model is one that explains several different phenomena using only a small number of assumptions.

References

Dennett, D. (1991). Heterophenomenology in Dennett, D. *Consciousness Explained*, Penguin Press.

Dennett, D. (2003) Who's On First? Heterophenomenology Explained. *Journal of Consciousness Studies, Special Issue: Trusting the Subject? (Part 1)*, 10, No. 9-10, October 2003, pp. 19–30.