Philosophy of Attention Session 2:
The Amplification View of attention
(Fazekas & Nanay 2021)

1. Setting the stage

The Disunity Problem: At the neural level, attention is highly disjunctive. Many different mechanisms and functions with nothing that unifies them.

The Overgeneralization Problem: Functions and mechanisms of attention also occur without attention.

The Amplification View: The neural mechanism of attention (its *core neural realizer*) is the amplification of stimulus specific inputs to certain canonical computations, when this amplification is not stimulus-triggered.

2. The Disunity Problem

- At the psychological level, attention has different functions, including:
  - **Selecting and filtering** (dichotic listening paradigm; see Cherry 1953).
  - **Increasing processing efficiency** (Posner's cueing paradigm; see Posner 1980)
  - **Modulating visual appearances** (Marisa Carrasco's paradigm; see Carrasco & Barbot 2019).

- These effects are achieved by many different modulations of neuronal processing, including:
  a) Effects on receptive fields (**Receptive field remapping;** see Handout 1)

  b) Effects on firing rates
  - **Multiplicative gain**: An homogeneous increase in firing rate, regardless of stimulus; this is observed with *spatial* attention.
  - **Tuning curve sharpening**: More firing increases for some stimuli and less for others; this is observed with *feature* attention.

  c) Effects on contrast processing
  - **Contrast gain:** More firing increases for stimuli with lower and intermediate contrasts.
  - **Response gain:** More firing increases for stimuli with higher contrasts.

  d) Effects on relations between neurons
  - Suppression effects
  - Response correlations

3. The Amplification View

<u>Part 1</u>: Attention recruits a built-in *mechanism*.

- Stimuli with higher contrast evoke stronger neuronal responses. This is a built-in mechanism of perceptual processing. Call it C.
- Attending to a stimulus has a similar effect to increasing its physical contrast. So attention also triggers built-in mechanism C.
- But attention triggers C in a distinctive way:
  (i) it increases the strength of the *input* (presynaptic) signal

(ii) it does it in a *stimulus-independent* way

- Conversely, attentional effects (like receptive field remapping) can be mimicked by altering stimulus contrast (p.8).

Part 2: Attention affects the inputs of a canonical brain *computation*.

- The normalization model of attention: Identifies a single role of attention in determining neuronal *outputs* (see Reynolds & Heeger 2009):

$$\text{Neuronal output} = \frac{\text{Excitation}}{\text{Suppression}} = \frac{\text{Stimulation drive} \times \text{Attentional field}}{\text{Suppressive drive} * (\text{Stimulation drive} \times \text{Attentional field})}$$

4. How the view solves problems

- **Answering the Disunity Problem**: Using the normalization model, the Amplification View can explain the different neural effects of attention as results of different operation conditions of the same mechanism.

- **Answering the Overgeneralization Problem**: The Amplification View does not overgeneralize, because it *specifically* characterizes the *core neural realizer* of attention.

  - **Classic conditioning as activity-dependent amplification** (Hawkins et al. 1983): What is amplified in classic conditioning is a facilitation effect of connecting neurons, not an input signal.
  - **Computing light intensity** (Carandini & Heeger 2012): This amplification is not stimulus-independent (it is triggered by the stimulus).
  - **Responding to the mereological fallacy**: Neurons do not pay attention, because attention only arises within a more complex mechanism (a *total* neural realizer).
  - **Amplification without awareness of attending**: Absence of awareness does not indicate absence of attention, as attention can be captured unconsciously.
  - **Amplification without behavioral signs**: Even when the core neural realizer of attention is at work, its total neural realizer might be missing (for instance because of malfunction of some of its parts).

5. Why the function of attention is not selection

- Amplification is more general, and, maybe, more fundamental: it can account for all the effects typically attributed to selection.
- In fact, selection is a consequence of amplification: it results from normalization computations.
- Furthermore, attention does not always seem to select some properties and de-select others (e.g., perceived contrast, distributed attention).
- What is really selective is the *orienting* mechanism that controls the allocation of attention.
- Because of the distinction between attention and orienting, bottom-up attention is not a problem for the Amplification View.