ATTN:MODEL

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Q400 Senior Seminar

Introduction to the research

- Create and test a sophisticated model of excitatory and inhibitory connections to attended stimuli.
- Model implemented as artificial neural network.
- Use cognitive psychology experiments to test the predictions that the model makes.

What is attention (again)?

- Interconnected systems of the brain have co-evolved into one massive network with such complicated internal relationships that it is often hard to tell where one mechanism stops and another starts
- Top-down and bottom-up control mechanisms

Anatomy (again)

- **Prefrontal cortex** controls task specific memory and top down reset
- **Posterior parietal cortex** guides spatial memory.
- **Anterior cingulated cortex** is the connection between the PFC, the PPC, and the amygdale.
- **Frontal eye fields** are involved in motor planning for saccades in visual attention.
- **Basal ganglia** function is in biasing the attentional system towards stimuli with high appetitive value.
- **Superior colliculus** is responsible for saccade targeting in the visual processing stream
- **Pulvinar nuclei** provide attention indexing support.
- **Locus coerleus** is responsible for norepinephrine (NE) release and alerting.

Past explorations

- When a frog is presented with two stimuli of similar salience such as two tasty flies, the frog will take longer to act on its environment than when there is just one choice. (Obvious, but the frog isn't thinking about what would suit his tastes better here. Frogs are dumb as hell.)
- Cognitive Psychology experiments suggest that there is a complicated interaction between the representations of target and distractor stimuli in the brain. (Stroop task, etc.)
- Has been claimed that schizophrenic and autistic humans have problems preventing irrelevant stimuli from attracting their attention. This leads to issues with the ability to maintain a train of thought for very long.

Questions raised

1. What causes the activation of inhibitory processes, and how do they know what to act on? (For instance, in selection tasks, how does the selection mechanism register the presence of distractors, and how does the inhibitory process selectively access their representations?)
2. What effect do inhibitory processes actually have on distractor representations? (For instance, does the claim that "distractors are actively inhibited" mean that information from non-target stimuli is simply not available to the organism?)
3. Are inhibitory mechanisms entirely top-down, simply radiating out from some "central inhibitor" towards activated representations, or can they adaptively respond, in a bottom-up fashion, to the state of activation of distractor representations?

-Quoted from Houghton et. al.

The premise

- Attention works together with the drive and emotional systems to integrate perception and action.
- Attention is the connection that allows parallel perceptual processes (eg. Vision) to be informative to serially controlled processes that affect behavior. (eg. Decision making)
- Attention works by parsing the incoming data to be used for guidance of actions out in the world. (Embodiment?)

Model specs

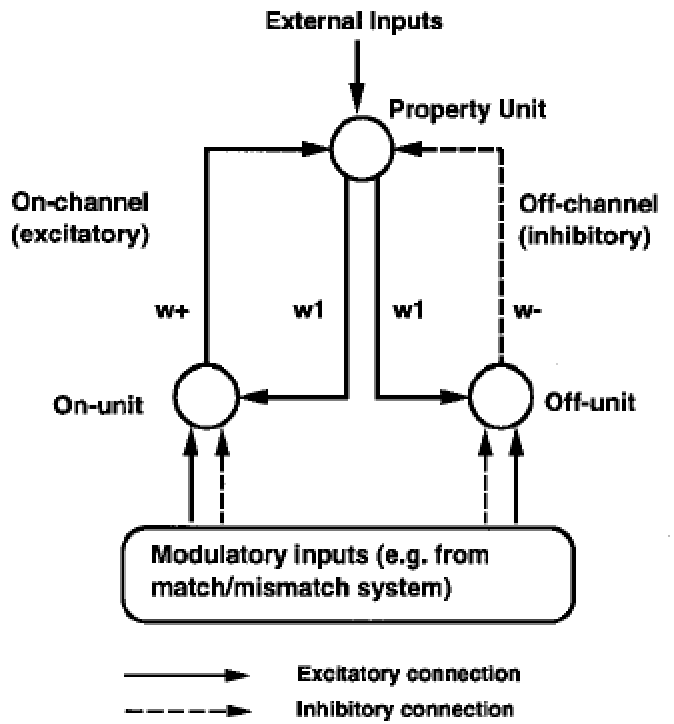


FIG. 2. In the model, “gain-control” circuits are distributed in topographic fashion throughout the representational substrate. Activity in a property unit (representing the presence of some feature in the input) activates two balanced feedback circuits, one excitatory (the On-channel), one inhibitory (the Off-channel). The activity level of the property cell can be suppressed or enhanced by changing the balance of activity in these feedback channels. The symbols w1, w2, in the figure are free parameters representing the strength of the feedback connections.

Model specs

- Objects are encoded as a connected set of nodes that represent the features of the object. (Note that Grandmother cells don't make sense here... well, go on; note it!)
- Inhibition and excitation can be controlled independently by adjusting w- and w+ respectively.
- Two mechanisms many reasons. (Distractors still available, competing stimuli can't all win, more fine adjustments.)
- Activation equation:

$$da_i/dt = Da_i + (1-a_i)I+ - (1-a_i)I-$$

Questions lowered

1. What causes the activation of inhibitory processes, and how do they know what to act on?

    Internally generated templates that are informed by perceptual networks.

2. What effect do inhibitory processes actually have on distractor representations?

    Inhibition lowers activation of distractor representation and causes an inhibitory rebound

3. Are inhibitory mechanisms entirely top-down, or can they adaptively respond, in a bottom-up fashion, to the state of activation of distractor representations?

    Survey says: Mostly bottom-up, but top-down processes help focus.

Multiple distractors

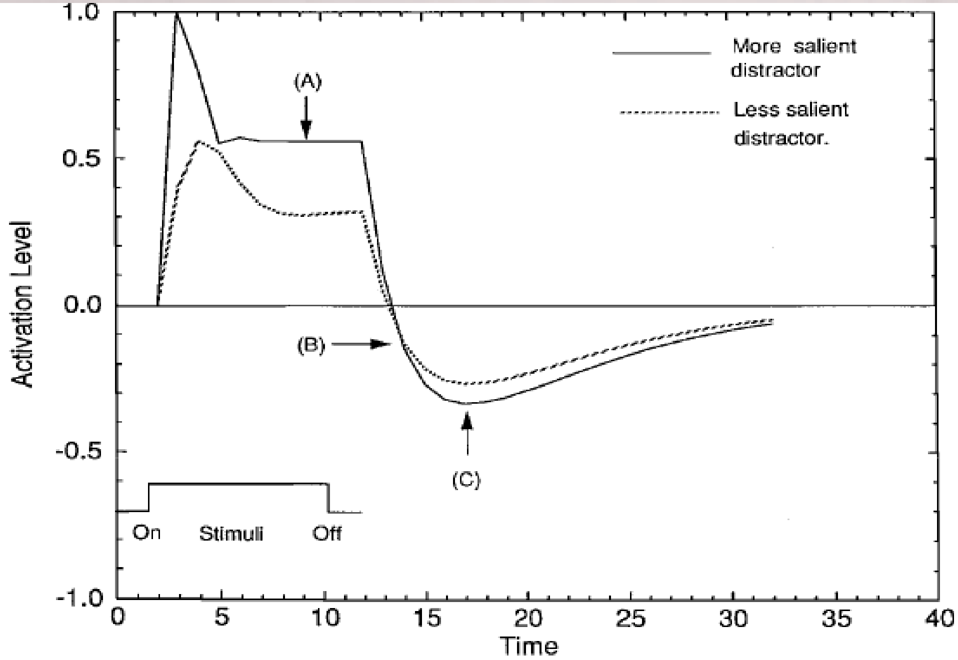


FIG. 6. The time course of activation for two distractor stimuli differing in intensity or salience (Experiment 3). The weaker stimulus is represented by the dashed line, the stronger by the solid line. The stronger stimulus, though still suppressed, achieves a higher activation and is likely to produce greater interference. At stimulus offset the stronger stimulus suffers a greater inhibitory rebound, due to the inhibitory feedback system also operating at higher intensity. If we assume that when a number of distractors are present each achieves a lower internal activation level (due, say, to competitive processes in perceptual modules) than when only one distractor is present, then the solid line can also be taken to represent the situation with only one distractor, and the dashed line the activation profile of a number of competing distractors (Experiment 2).

Experiment

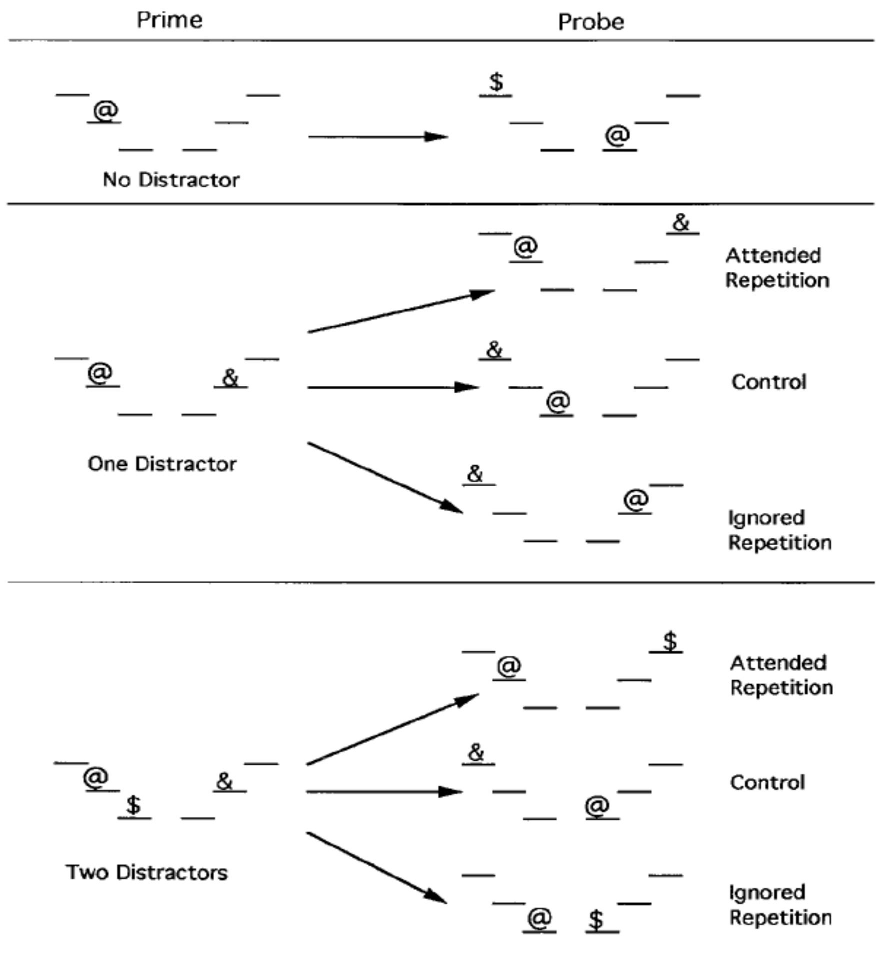


FIG. 10. The conditions tested in Experiment 2. The response to the target in the prime display is analysed when the target is alone (no-distractor) and when one and two distractors are present. The probe displays contain control and ignored-repetition conditions, as in Experiment 1, and attended-repetition conditions where the target appears in the same location in the prime and probe displays.

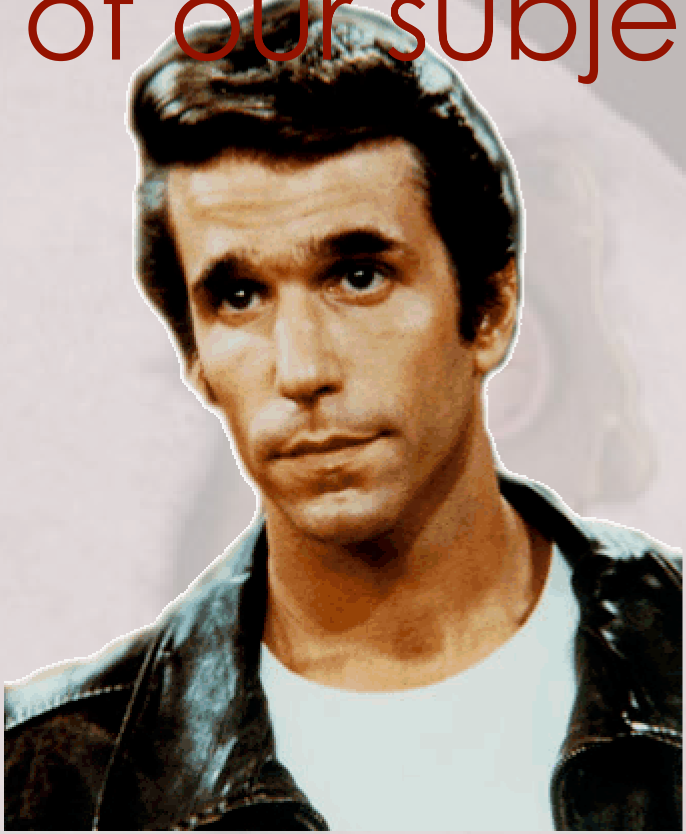
Conclusion

- Results were significant and showed that there is increased interference and decrease in negative priming with more distractors.
- The model works well to describe the way inhibition is used along with excitation to selectively attend to perceptual objects.
- The whole phenomena suggests a brain that operates on the edge of chaos.

Video from one of our subjects

TARGET

DISTRACTOR



Reference:

Houghton, George. Tipper, Steven P. Weaver, Bruce. Shore, David I. *Inhibition and Interference in Selective Attention: Some Tests of a Neural Network Model.* Visual Cognition, 1996, 3 (2), 119-164.