Gage was fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operations, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, although untrained in the schools, he possessed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart businessman, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly that his friends and acquaintances said he was ‘no longer Gage’. – Dr. John Martyn Harlow
themes I –

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Overall, attention appears to involve changes in the neural dynamics of multiple brain regions. Does this reflect the fact that the brain is extremely complex and best studied by considering the system as a whole, or does it reflect the fact that attention is defined in so many different ways?

Normally, we think of attention as altering the responsiveness of the cerebral cortex to different types of sensory input. That is, we think of attention as a sub-cortical process that impacts what happens in the cortex or thalamus. In the case of the parietal cortex and prefrontal cortex, we seem to have two systems of the cortex itself that regulate attention. Each of these structures is nevertheless impacted by subcortical inputs (e.g., from basal forebrain or locus coeruleus) and, remarkably, appear to impact activity in the same subcortical structures. Thus, attention is a cyclical process (i.e., a chicken-and-egg type process) that is continuous where what has been attended will affect, to some extent, what is attended to subsequently.

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Acetylcholine and norepinephrine appear to be intimately involved in both altering the strength of responses of neurons to stimuli when they are attended and in altering, dynamically, the ‘strength’ of different synaptic inputs to a neuron.

The ‘hemineglect’ syndrome arises from damage to the right parietal cortex and impacts the left side of not just egocentric frames of reference (e.g., the left visual field or left side of the body), but also the left side of objects (i.e., in an object-centered frame of reference).

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Locus coeruleus NE neurons impact attention in a rather ‘global’ fashion as their axonal projections may be, even from the same neuron, to multiple regions of the brain. As NE neurons are clustered into primarily one nucleus, they appear to operate as a unified group to impact widespread regions of the brain simultaneously. High NE seems to result in a greater breadth of attention (i.e., searching behavior) which can present as an inability to maintain focus on some one feature of the environment. Low NE may induce a different attentional deficit, namely an inability to move attention away from what is currently attended.

The basal forebrain appears to be much more complex than the locus coeruleus. There are at least three types of cortically-projecting neurons and these neurons group into different nuclei whose axonal targets are more restricted than those for LC neurons. As such, they are poised to control aspects of attention in a more fine-tuned, region-specific manner (e.g., heightening attention to visual as opposed to touch stimuli).

Both NE and basal forebrain neurons ‘learn’ fast in that they exhibit rapid changes in their responses to stimuli when the novelty or relevance of those stimuli has changed.
we discussed three types of neurophysiological change that appear to accompany attention. Name and describe each. Feel free to draw, but be sure to add labels.

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Adapted from Chafee and Goldman-Rakic, JNP, 1998
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above: schematic of an attractor network where each square corresponds to a specific activity pattern among a population of neurons – red dots denote ‘basins’ into which activity patterns are more likely to fall – moving out of such attractors demands a ‘push’ to get over the hills separating different attractors