EC 490

Lecture 4: The brain: general dynamics

1. On p. 53, O'Shea says that "the three divisions of the brain can be thought of as a hierarchy in which the forebrain controls the midbrain which controls the hindbrain." This is not straightforwardly false, but it's problematically simplistic. The hindbrain performs some tasks – regulating breathing, for example – with which more recently evolved brain structures can interfere only in the most crude and temporary way. To take another example, the forebrain can influence heart rate only by roundabout paths; it does not simply 'control' the hindbrain. As a final example, an addict is a person in whom the midbrain has gained control of consumption behavior, having neutralized action of inhibitory circuits from the forebrain.

2. Nevertheless, the important point here is that the brain is three different machines, which evolved millions of years apart under very different selection pressures, yoked together and required to make the best of their inelegant fit. It isn't surprising in light of this that human economic agency, defined in terms of behavioral consistency and perfect use of information, is at best an approximation to reality. (We should add that it is often a very useful approximation.)

3. Since we have a coming lecture devoted to neuroanatomy, I'll pass over further attention to O'Shea's Chapter 4.

4. It is useful to read O'Shea's chapter on visual processing to gain an idea of the extent of computation that stands between raw transduction of sensory information and the kinds of representations on which the brain bases behavioral

responses. Visual processing is the best understood cognitive activity in the brain, because it's relatively encapsulated from other processes and because its input and output can be rigorously characterized in models; thus we can precisely model data transformations that would take us from the input to the output, and then go in search of brain activities that implement the transformations in question. Most of the other kinds of neural processing we understand well are based in hindbrain or midbrain, because these parts of the brain are also relatively encapsulated. They are also much more clearly anatomically differentiated, which gives us a huge lead in forming good hypotheses about the ways in which tasks are partitioned into sub-tasks. For these reasons, neuroeconomists have so far learned more about valuation in older parts of the brain than in frontal cortex.

5. The core activity of the brain is learning. Learning in the brain cannot be understood independently of understanding memory. The brain learns valuations at multiple time scales: from 'What is the relative value of immediate consumption alternatives?' to 'What indicators have the relatively best track record as predictors of longer-run reward?' Expanding the empirical reach of neuroeconomics will revolve mainly around understanding how these different sorts of valuation are integrated or, where they are not integrated, how competition between them is resolved in behavior.

6. Going beyond O'Shea's text, here is a very rough map of what we now know about the neuroanatomy of value computation. (We'll greatly refine this picture during the second half of the course.) Pleasing sensations, mainly evaluated in anterior cingulate, are one kind of reward the brain values. But they are only one among many and their attractiveness is often outweighed by competing rewards. The more general kind of reward for which there are reliable

proxies in neural activity is that which arouses attention and preparation to initiate motor activity aimed at consumption. This is processed in a circuit that begins in the midbrain (ventral tegmental area) and projects to orbitofrontal and striatal areas, especially nucleus accumbens. The primary neurotransmitter for the reward circuit is dopamine. The reward circuit is strongly connected to the amygdala, a part of the 'limbic' area that plays a key role in emotional response, though it is misleading to call it 'the seat of emotion'. (Emotional response is widely distributed in the brain.) The amygdala sometimes inhibits reward system response, which may be associated with fear. At other times amygdala signals excite dopamine release in midbrain. Finally, frontal areas appear to exercise a generally inhibitory role in limiting the reward system's influence on immediate behavior. Serotonin and GABA are the principal neurotransmitters associated with such inhibition. All of these systems, separately and in their interrelations, exhibit learning of relationships between stimulus cues (as predictors) and outcomes. Indeed, learning to time motor response preparation to maximize chances of capturing fleetingly available rewards seems to be a primary function of the dopamine circuit.