by popular demand: Addiction II

PSY/NEU338: Animal learning and decision making: Psychological, computational and neural perspectives

drug addiction

- huge and diverse field of research (many different drugs)
- addiction = continued compulsive making of maladaptive choices despite adverse consequences to the user and even in the face of explicitly stated desires to do otherwise (DSM IV)
- not everyone who uses drugs will get addicted (15-17%), has characteristics of chronic disease
- fundamental problem: relapse (90% of addicts!)
- addictive drugs thought to access same neurophysiological mechanisms as natural rewards, just in an aberrant way
- e.g., drugs increase availability of dopamine (directly: amphetamine, cocaine or indirectly: heroin, nicotine)
is there a good animal model of drug abuse?

- many studies give animals drugs and see effects
- …also need a model of an animal choosing to take the drug, relapsing, even at a cost
- at minimum: compare to natural rewards to study differences not commonalities (?)

Model of relapse: Reinstatement
(what types of validity does it have?)

Evidence for Addiction-like Behavior in the Rat
Véronique Deroche-Gamonet et al.
Science 305, 1014 (2004);
DOI: 10.1126/science.1099020

- animals will take drugs, but are they really addicted?
- “unfortunately our knowledge of the biological basis of addiction lags behind our knowledge of the mechanisms of drug taking, probably because convincing evidence of addiction in animals is lacking”
- Here: use intravenous self-administration of cocaine (nose-poking, FR5) in rats, for long periods (3 months)
- divide rats based on propensity to relapse (reinstatement)
- evaluate three DSM VI criteria of addiction:
  A. persistence (in periods of no drug availability) - subject has difficulty stopping drug use
  B. substance abuse despite harmful consequences (add shock to drug, signal this to animal)
  C. motivation for drug (as measured through breaking point in progressive ratio schedule)
only 17% of rats got “addicted” intensity of addiction-like behavior proportional to # of criteria met

no difference between 0 and 3 criteria groups in total intake of drug or sensitivity to its unconditional effects (locomotion)

progression from casual to compulsive drug use

tone CS paired with footshock: will it inhibit cocaine seeking? sucrose seeking? after prolonged use? (classic conditioned suppression paradigm)

CS suppresses seeking after limited exposure to cocaine doesn’t suppress seeking after extended exposure (>1000 reinforcers) but still suppresses sucrose-seeking even after extended exposure
how can we make our computational models ‘addicted’?

- goal: the model inappropriately selects to take the drug (in face of other rewards)
- explain some phenomena of addiction: likelihood to select drug is sensitive to length of exposure to drug, size of other non-drug rewards, and cost (but ultimately the demand is inelastic, or at least not as elastic as that for natural rewards)
- Redish (2004) - addiction as a computational process gone awry
- predictions?
- note: “A neuropharmacologically driven increase in dopamine is not the sole effect of these drugs, nor is it likely to be the sole reason that drugs of abuse are addictive.”

is drug abuse a habit?

- drugs: initially used voluntarily due to rewarding/hedonic value, slowly transition to habitual and compulsive behavior (loss of control over behavior)
- conditioned reinforcers for drugs have super powers
- why are drugs compulsive? Everitt & Robbins: become S-R habits, and moreover, impair goal-directed system
- (does not explain elaborate, seemingly goal directed behavior for drug seeking - difference between drug taking and drug seeking?)
is drug abuse a habit?

Daw et al, 2011

learning in the two-step task

How should a reward for a rare transition affect your choices at the first (green) level?

Daw et al, 2011
habits versus goal-directed (model free versus model based)

Daw et al, 2011

model-free, doesn’t know about transition structure

model-based, respects transition structure

controls show both processes! (significant effect of reward & significant interaction)

binge eating disorder

stimulant abusers (meth/cocaine, abstinent > 1 week)

OCD

compulsive disorders all show less goal-directed behavior (even for natural rewards)
summary: what have we learned from addiction

• many studies treat addiction as simply learning from a stronger/more potent reward
• great! we get to learn about the reward system
• but: what about addiction?
• is there really a fundamental difference between addiction and learning from natural rewards? what are the scientific questions that need answering? not clear…
• (policy questions: what is the real difference between illegal and legal addictive substances?)