

# 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?)

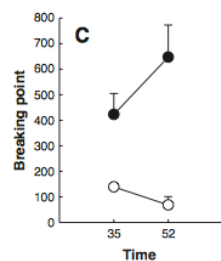
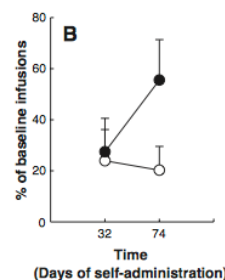
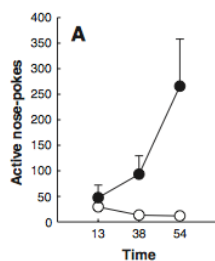
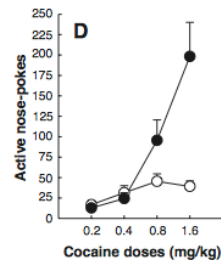
3



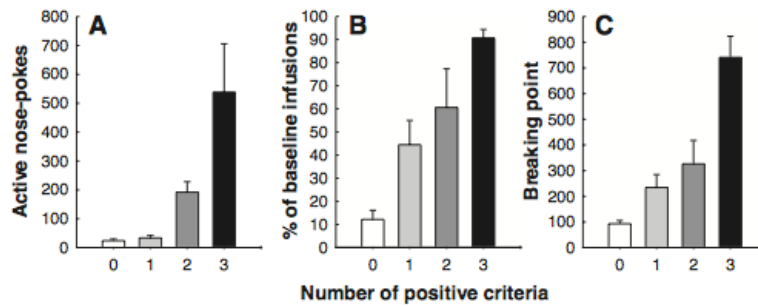
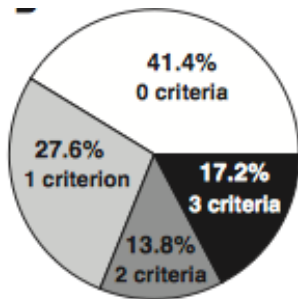
## Evidence for Addiction-like Behavior in the Rat

Véronique Deroche-Gamonet *et al.*  
*Science* 305, 1014 (2004);  
DOI: 10.1126/science.1099020

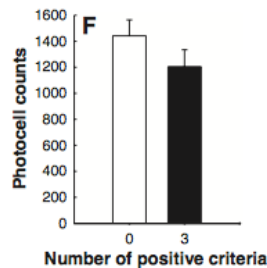
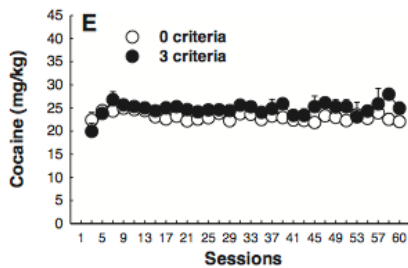
- animals will take drugs, but are they really *addicted*?
- “unfortunately our knowledge of the biological basis of addiction lags behind our knowledge of the mechanisms of drug taking, probably because convincing evidence of addiction in animals is lacking”
- Here: use intravenous self-administration of cocaine (nose-poking, FR5) in rats, for long periods (3 months)
- divide rats based on propensity to relapse (reinstatement)
- evaluate three DSMVI 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)



4



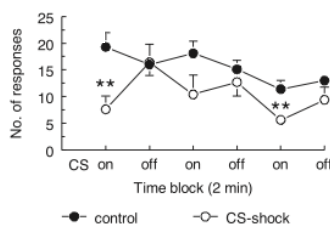
only 17% of rats got “addicted”  
intensity of addiction-like behavior proportional to # of criteria met



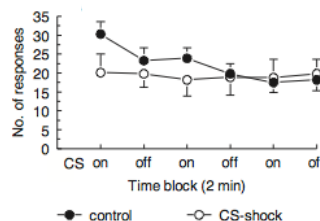
no difference between 0 and 3 criteria groups in total intake of drug or sensitivity to its unconditional effects (locomotion)

## progression from casual to compulsive drug use

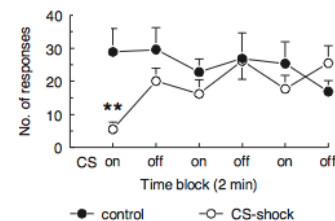
tone CS paired with footshock: will it inhibit cocaine seeking? sucrose seeking? after prolonged use? (classic conditioned suppression paradigm)



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.”

7

Everitt & Robbins (2005)

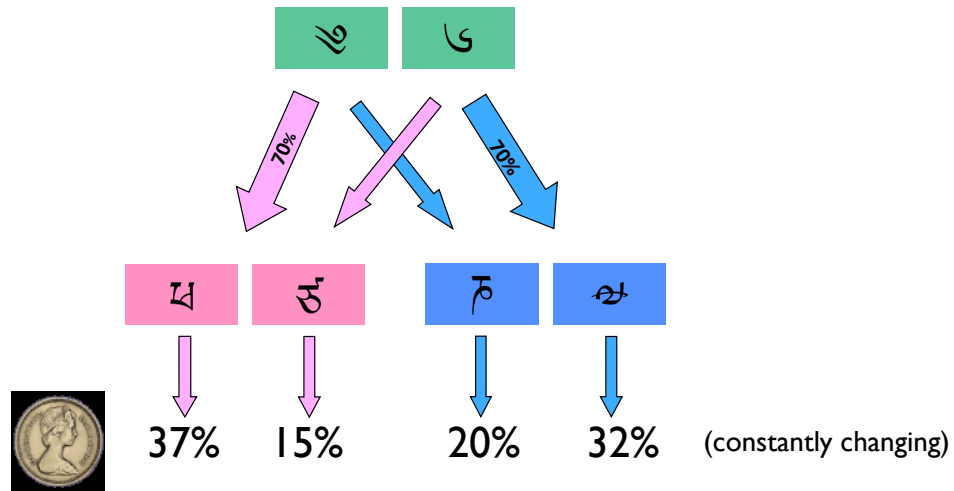
Neural systems of reinforcement for drug addiction: from actions to habits to compulsion  
Nature Neuroscience

## 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?)

8

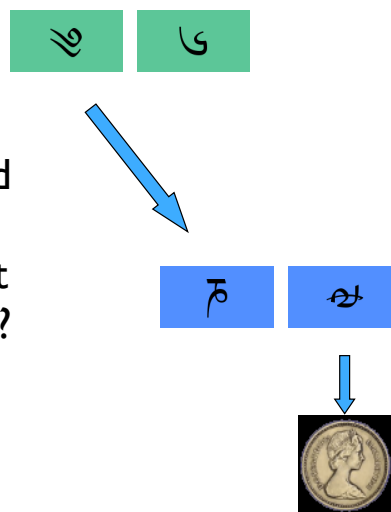
# is drug abuse a habit?



Daw et al, 2011 9

# learning in the two-step task

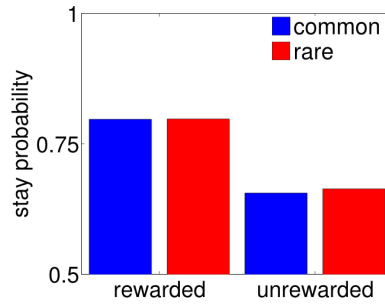
How should a reward for a *rare* transition affect your choices at the first (green) level?



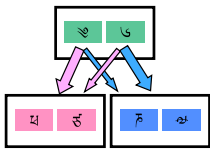
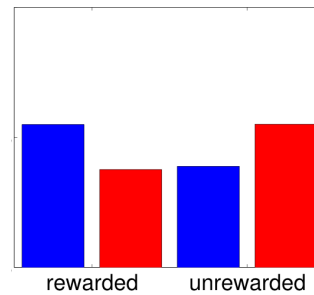
Daw et al, 2011 10

# habits versus goal-directed (model free versus model based)

model-free, doesn't know about transition structure

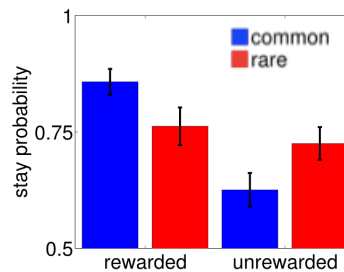


model-based, respects transition structure



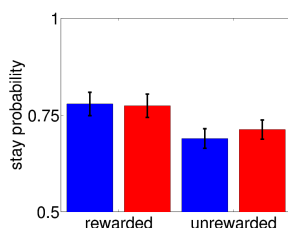
Daw et al, 2011 11

# habits versus goal-directed (model free versus model based)

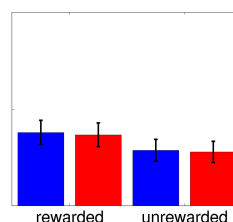


controls show both processes! (significant effect of reward & significant interaction)

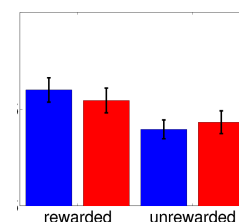
binge eating disorder



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?)