PSYC1022: The Psychology of Addiction

Topic 8: Positive reinforcement, craving & economic choice

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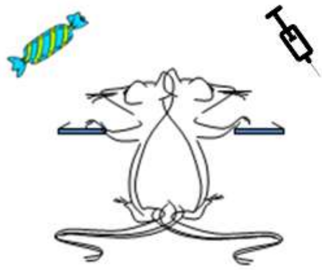
Outline:
- Drug self-administration
- Choice
  - Matching law
  - Bias
  - Demand curve
- Behavioural sensitisation
- Conditioned drug-like effects



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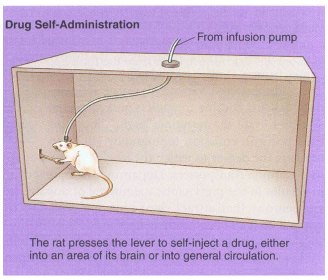
Self-administration

Evidence for positive reinforcement came from self-administration (SA) experiments (i.e. rat is given a lever which if pressed delivers drug dose into the blood or brain).

- Rats readily acquire drug SA behaviour, suggesting this is established by the positive reinforcing effects of the drug rather than because the rat has acquired a withdrawal syndrome, tolerance, or conditioned withdrawal/tolerance.

Drug SA similar to instrumental responses acquired to obtain other appetitive rewards.

- It stretches plausibility to argue that responding for natural rewards is primarily driven by withdrawal or tolerance. Thus, drugs appear to be like other natural rewards in reinforcing behaviours that lead to their procurement (Stewart, 1984)



The rat presses the lever to self-inject a drug, either into an area of its brain or into general circulation.

2

Self-administration

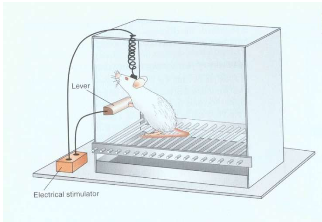
Electrical self-stimulation experiments: Rats readily acquire instrumental responses to obtain electrical brain stimulation

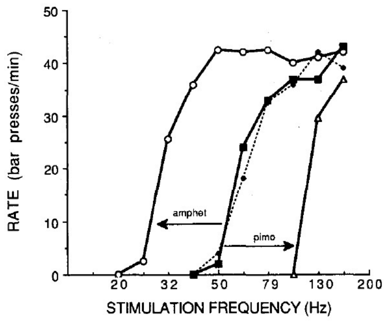
- Administration of addictive drugs increases sensitivity to the rewarding effects of electrical brain stimulation
- Thus, electrical and drug reinforcement have a common biological substrate.

Instrumental responding for electrical stimulation is pathological (continues for long periods, displaces pursuit of other rewards & is maintained despite the behaviour causing harm).

- In vulnerable individuals, drugs of abuse establish similar pathological SA behaviour

Thus, addiction can be driven by acting on the same positive reinforcement mechanisms as electrical self-stimulation, without withdrawal or tolerance.





Wise (2002)

3

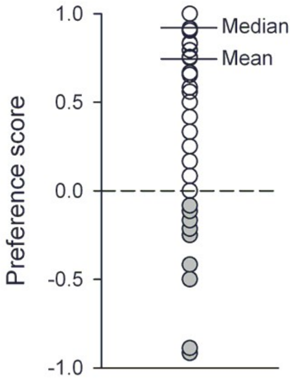
Choice

In drug SA paradigms, rats are given access to a single lever which if pressed delivers a dose of a drug. Typically, results in all animals acquiring SA

- SA paradigms do not model the situation of human users, who choose between the drug & other possible activities/outcomes.

Choice-procedure: rats have access to two levers, one of which produces the drug, whilst the other produces an alternative reward.

- Ahmed (2012): preference for cocaine over saccharin lever in a group of 184 rats
    - 20% of the animals developed a cocaine preference whereas the remainder preferred the saccharin.
- These findings are more consistent with epidemiological data on the prevalence of drug dependence in humans- ~20% of people who try drugs become dependent.



4

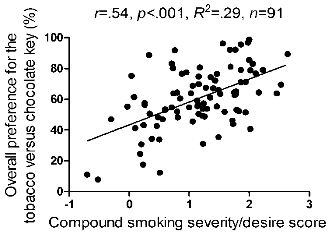
Choice

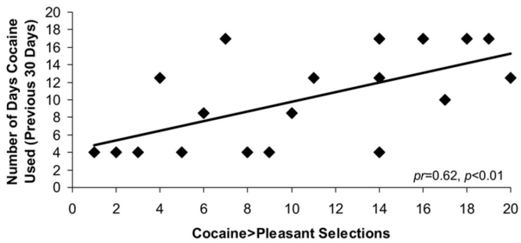
Choice procedures in humans indicate that severity of drug dependence is associated with ascribing a higher relative value to their drug of abuse over an alternative.

- Hogarth (2012): smokers could choose between two keys, one of which earned tobacco points while the other earned chocolate points.
- Moeller (2009): cocaine users could choose between two keys, one of which displayed cocaine pictures while the other displayed pleasant non-drug pictures.

In both studies, participants' level of dependence was positively correlated with preference for the drug versus the non-drug rewarded response.

- Supports positive reinforcement theory, drug dependence appears to be conferred by the individual ascribing a high reward value to the drug.





Choice: Matching law

Herrnstein's matching law (Herrnstein, 1970) states that choices are allocated between two options in accordance with the relative frequency of rewards earned by those choices. More formally:

$$\frac{B1}{B2} = \frac{R1}{R2}$$

Where B = behaviour, R= frequency of reward.

The ratio of behaviour 1 to behaviour 2 = the ratio of the frequency of reward for behaviour 1 to the frequency of reward for behaviour 2.

The allocation of behaviour by animals across two options conforms with the matching law, when the same rewards are used between the two options.

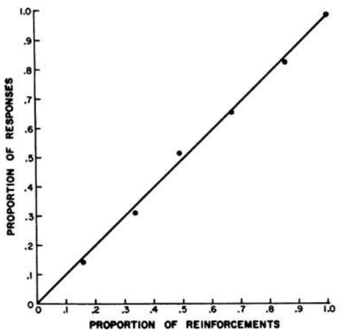


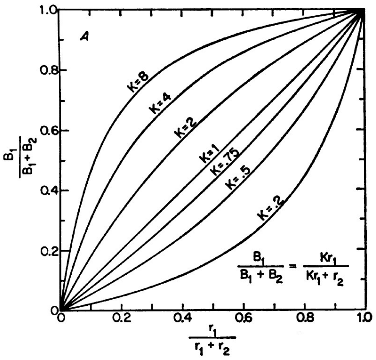
Fig. 4. The relative frequency of responding to one alternative in a two-choice procedure as a function of the relative frequency of reinforcement thereon.

Choice: Bias

Baum (1974): when a preferred reward is produced by one response, a *bias* (K) can add a constant proportion of responding to the favoured alternative.

- Figure shows the change in the matching curve given biases (K) for the two rewards.
- Where there is an equal preference for the two rewards (K=1) the curve shows perfect matching of behaviour to the ratio of reward frequency.
- But where there is a bias for the reward produced by behaviour 1 (K>1), there is an increased proportion of choice for this behaviour & vice versa when there is a bias for the reward produced by behaviour 2 (K<1).

The relative reward value that dependent individuals ascribe to the drug over natural rewards suggests that addiction is due to a preference for the drug reward which adds a constant to the proportion of behaviours directed at obtaining drug rewards (positive reinforcement).



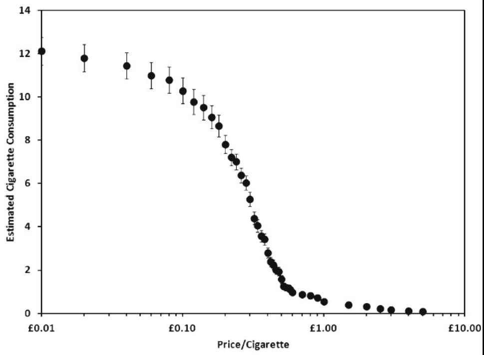
7

Choice: Demand curve

The choice to obtain a particular reward is also influenced by the cost of that reward (demand).

- Demand curves represent the amount of a particular reward that consumers will purchase or consume at a given price.
- If a drug has a low price, more will be consumed, but as the price increases, consumption decreases, until the 'breakpoint' at which users will cease to consume the drug.

Drug consumption levels are sensitive to price, thus increasing the tax or minimum price of licit drugs, or prohibiting illicit drugs so as to increase their street price, is considered a way of reducing the frequency of drug use in the population.



Chase et al. (2013)

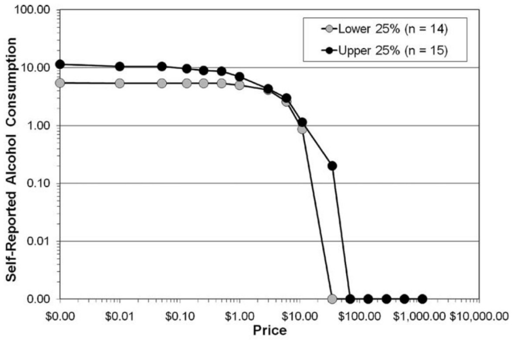
8

Choice: Demand curve

Mackillop et al. (2010): examined the demand curve for alcohol reported by heavy drinkers.

- The upper group (heaviest drinkers) reported a higher *intensity* of demand
- But, the two groups showed the same *elasticity* & the same *breakpoint*
- Illustrates that the heaviest drinkers are rational & differ from the lower level heavy drinkers only in the amount they would consume within the inexpensive to normal price boundary.

Suggests that alcohol dependence may be driven by a bias in preference for alcohol, rather than an abnormal consideration of costs.



9

Choice: Decision theories

Vlaev et al. (2011)

Most economic decision theories assume that the brain calculates:

1. The value of each reward
2. The probability of the response producing that reward
3. The costs associated with the reward.

These values are combined to calculate the *utility* of each possible course of action & the reward with the greatest utility is pursued.
Thus, drug dependence may be driven simply by the drug being considered as having a higher reward value, which endows this reward with higher utility, and thus drug-administration increases in frequency as a proportion of total behaviour.

Theory
Expected utility theory
Revealed preferences theory
Reference-dependent preferences model
Stochastic expected utility theory
Multi-attribute utility theory
Prospect theory
Cumulative prospect theory
Rank-dependent utility theory
Disappointment theory
Transfer of attention and exchange (TAX) model
Neural value models
Bentham's utilitarianism
Inequity aversion theory
Comparison income model
Generalised exemplar model of sampling
Regret theory
Componential-context model
Stochastic difference model
Decision field theory
Multialternative decision field theory
Leaky competing accumulator model
Perceived relative argument model
Trade-off model of intertemporal choice
Range-frequency theory
Bayesian inference model
Decision by sampling theory
Priority heuristic
Fast-and-frugal heuristics
Elimination by aspects theory
Query theory
Reason-based choice
Fuzzy trace theory

10

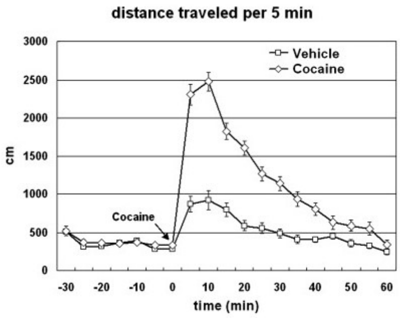
Behavioural sensitisation

Observed when the locomotor response to a drug is augmented following a history of chronic exposure to that drug

- Administer cocaine or saline daily for 18 days
- Give all rats a single test dose of cocaine & compare the distance the animals in each group travel after the injection

Park et al (2010): the cocaine pre-treated group showed a greater distance travelled in response to the cocaine injection compared to the saline pre-treated group.

- Not due to residual drug because a sensitized response to a test dose has been shown to persist for years after the last dose.
- Originally called 'reverse tolerance' because if tolerance had occurred, the locomotor effect should have been reduced. Thus, tolerance cannot provide a universal account of processes operating in addiction.



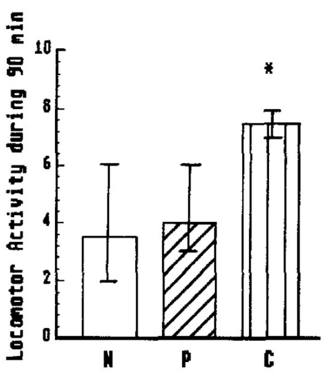
11

Conditioned drug-like effects

Conditioned hyperlocomotion: a form of Pavlovian conditioning, where drug-administration contexts (CS) elicit an increase in locomotion (CR) in the absence of drug administration.

Walter & Kuschinsky (1989): Rats in the conditioned group (C) placed into locomotor testing apparatus for 15 min, removed & administered nicotine & then replaced in the apparatus for 60 minutes. Rats in pseudo-conditioned group (P) were treated in same way except they were removed from testing apparatus, injected & put inside their home cage. Drug-naive group (N) were exposed to the testing apparatus in the same way as the conditioned group, but injected with saline.
Test: rats placed into the testing apparatus & locomotor activity was measured

- the testing apparatus alone elicited a conditioned locomotor excitation effect only in the conditioned group (C). This conditioned response is the same as that produced by nicotine itself (as in behavioural sensitisation)
- contradicts conditioned tolerance/withdrawal theories which argue that drug conditioned stimuli should elicit a drug-opposite conditioned response.

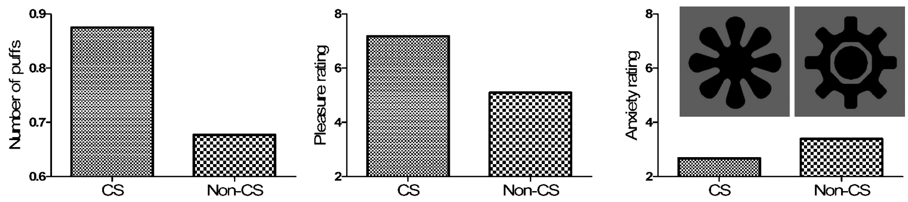


12

Conditioned drug-like effects

Hogarth (2010): Smokers first learned to predict the earning of tobacco points in the presence of a shape (CS), but not a different shape (Non-CS). Then, these stimuli were presented while smokers were smoking “ad libitum”.

- CS increased the number of puffs consumed compared to the non-CS (Pavlovian motivating effect on drug consumption).
- Would the CS also elicit a drug-like increase in pleasure (consistent with positive reinforcement theory), or a drug-opposite increase in anxiety (consistent with withdrawal & tolerance theories)
    - the CS increased pleasure & decreased anxiety compared to the Non-CS
- Supports positive reinforcement theory in suggesting that drug cues elicit a drug-like rewarding effect, which plays a role in motivating drug consumption, rather than producing an aversive state which might be corrected by drug consumption (i.e. negative reinforcement).



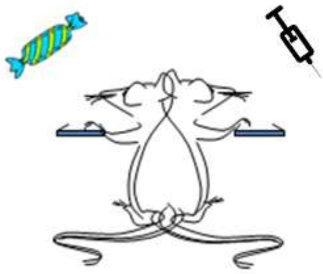
13

Summary

The empirical evidence discussed in this lecture provide support for the role of positive reinforcement substance abuse.

Knowledge & understanding of:

- Drug SA procedures used to model human drug use in the laboratory.
- Choice procedures developed to provide a more valid model of human drug use.
- factors that influence choice: matching law, bias and demand.
- Characteristics of behavioural sensitization & how it is assayed in the laboratory.
- Pavlovian conditioning in substance use- how CSs, such a drug-paired contexts and cues, can elicit CRs & facilitate drug consumption.



14