

# The Neural Basis of Decision-Making

- Cambridge Uni
- Jack O'Doherty

Phineas Gage

H Damasio (1994) - reverts area where lesion  
happened (most impacted)

↓  
Ventromedial Prefrontal Cortex

Bechara (1994-2000)

patients with ventromedial prefrontal cortex  
lesion

↓  
Iowa Gambling Task

↓  
patients were bad in choosing advantageous  
deck as opposed to control group

↓  
no lesion  
lesion elsewhere

↓  
In economics (central idea): learn by trial - error

44 A rational agent with make choices to  
maximize utility



- Utility can be subjective

- Positive and negative reinforcers

→ ~~avoid~~ anything an animal will work to:  
Attain      Avoid

→ Primary reinforcers → innate value  
Stereotyped answers (e.g. food, pain)

→ LEARNED REINFORCERS

Value through learning (money)  
et.

### DECISION MAKING

→ 3 armed bandit problem → try sequentially through trial and error 3 machines

Internal representation in head about average reward I'm winning on ≠ machines

based on past experience  
use this to predict future

Representation of ≠ utilities

I need to understand that  
Some things are rewarding / some things aren't

Disincentive

given experience utility

→ How can we study this -  
give individual ≠ things

Measure -	(direct)	(indirect)
→ Skull open	(Na) ↓ electrical activity	3 markers of ↑ Brain Activity ↑ blood flow ↑ glucose consumption ↑ O <sub>2</sub>

fMRI

≠ magnetic properties

← deoxyhaemoglobin

↑      ↓  
MRI signal is  
lower      higher  
darker      brighter

then compensation



experiments → ① w/ food  
                    ↓ ② w/ money  
                    |

## Reward and Punishment

FAIR I → Correlation Revised value

Correlation questionnaire

Brighter is with ↑ money

(ventro medial orbito frontal region)

Intel

③ attractive forces

⑨. Music  $\rightarrow$  Nature 1998

Experienced Utility

Wine  
→ Experienced Utility in the brain can be modulated by contextual regions

## Decision Utility

Computational Model  $\rightarrow$  RL

how do we learn to make a prediction of the utility for a particular action -

Computational model  $\rightarrow$  RL

We make a prediction and then it's confirmed or NOT  $\rightarrow$  by experience utility

We encode a degree of response  
→ ~~the~~ vegetation - reality

Prof Walfram Schulte — linked to logarithmic version

## ✓ DECISION UTILITY

how → judge request expectation of future research  
evidence of living

vmPFC  $\rightarrow$  codes for expectation of rewards  
expected Value

Prediction  $\downarrow$  error  
Basal ganglia

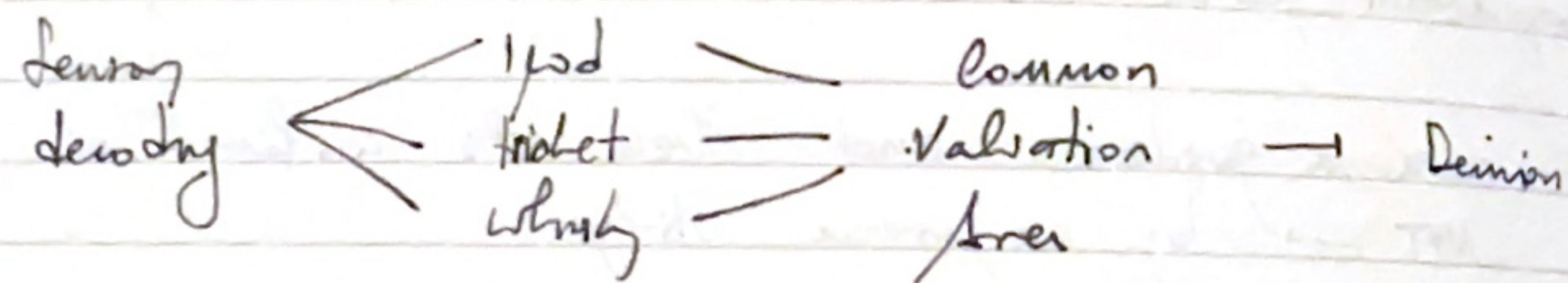
valve  
↓  
exposed  
↓  
valve of the  
I got

A diagram illustrating the Value Iteration process. At the bottom, the text "what I expect to get" has an arrow pointing up to "decision". From "decision", three arrows point upwards to "can be target", "can be learned", and "VMP context". From "can be learned", an arrow points up to "RL" (circled). From "can be target", an arrow points up to "expected Value".



how does the brain make choices to  $\neq$  types of rewards -

Valuation



neuron willingness to pay

overlapping area with WTP across all items  
with WTP for all items

we code things in the same utility scale -

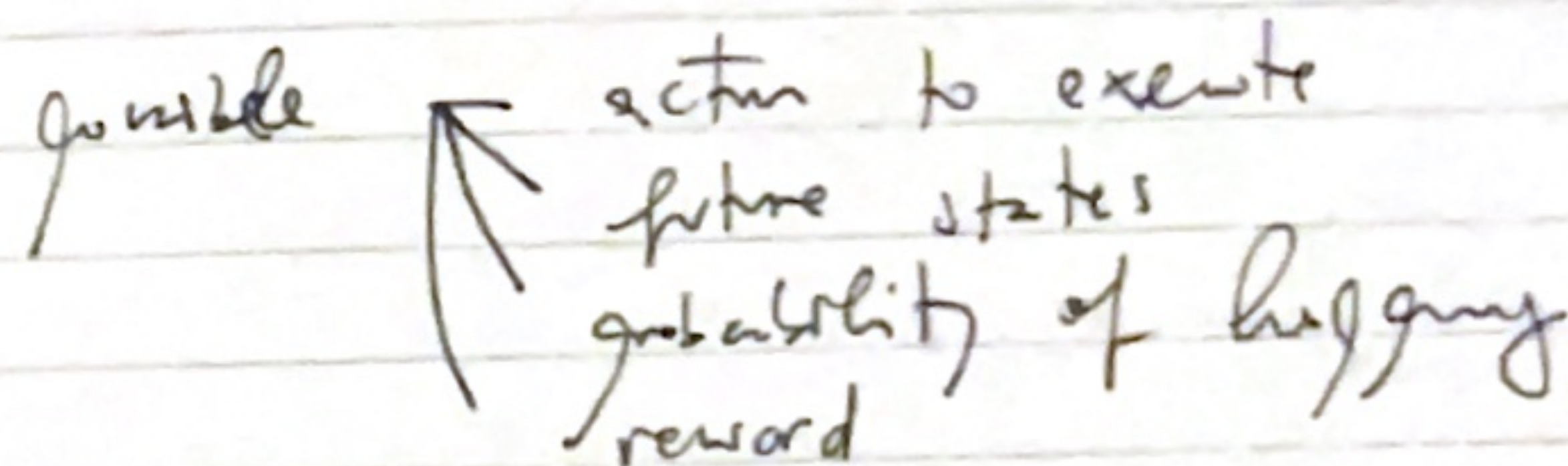
↑ activity in vmPFC → ↑ risk seeking

↑ activity in lateral regions when → ↑ risk averse

MDP - Markov Decision Process

mathematical framework to make decisions under uncertainty

MDPs maximize future reward



MDPs what to do in every state

→ Solution → Policy

↓  
\* Value iteration → Utility of State  
(potential future reward)

iterative utility computation

\* Policy iteration - Which to do