Neuroscience investigation of reward processing in young adults at-risk for alcohol dependency

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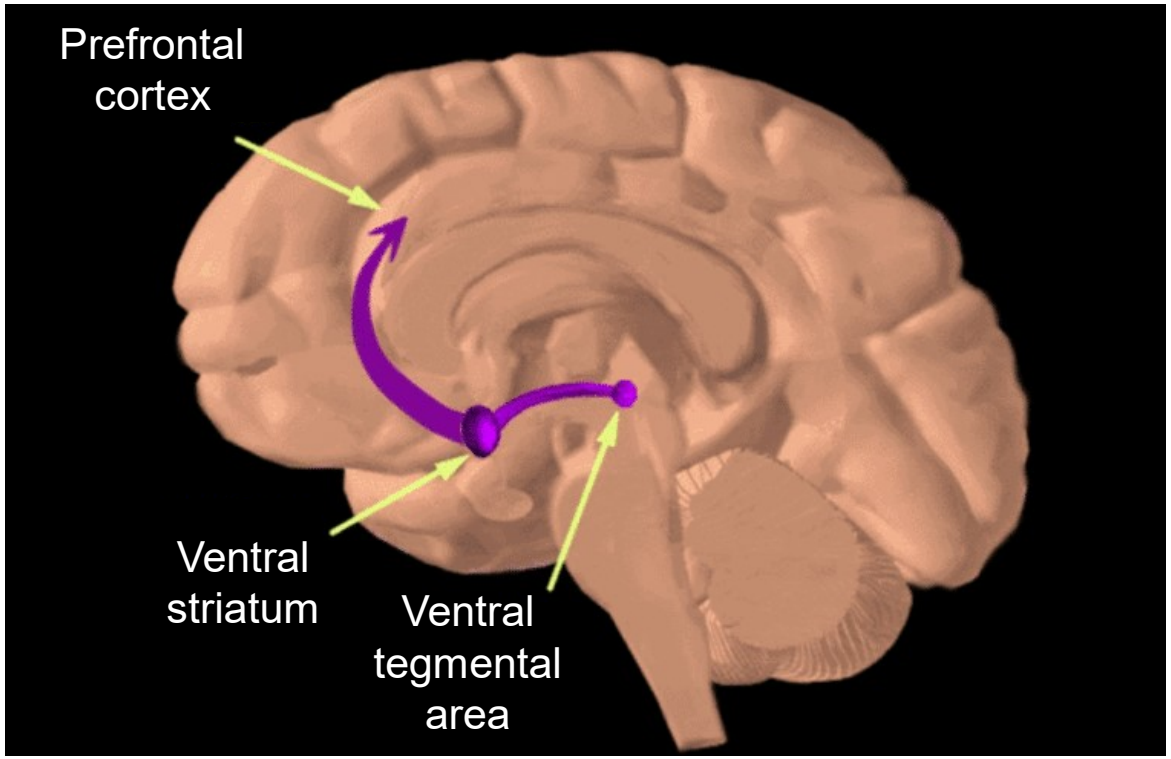
Background

Dysfunctional reward pathways underlie addiction
(Luijten et al., 2017; Meyer et al., 2016; Nestor et al., 2017)

Alcohol dependency: blunted ventral striatum activation during reward anticipation
(Beck et al., 2009; Nestor et al., 2017; Wrase et al., 2007)



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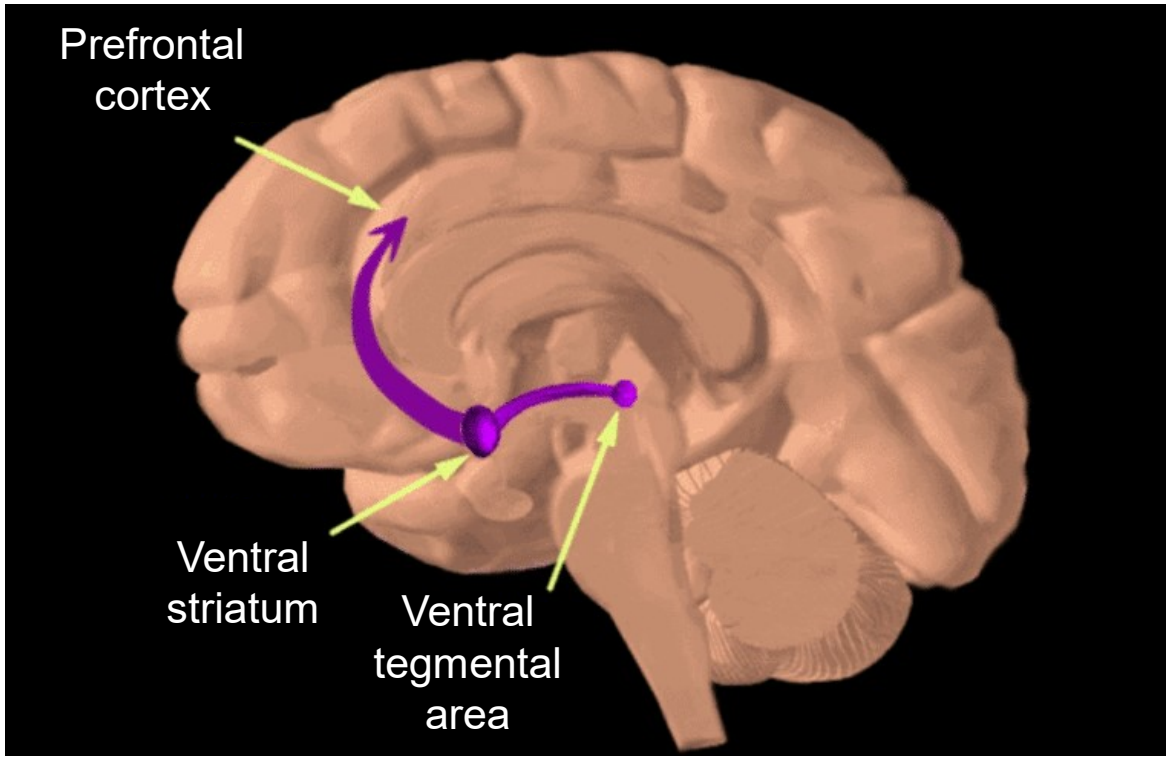
Research questions

Is dysfunction present in populations at-risk for alcohol dependency?

Can this dysfunction (within deep brain structures) be detected with cortically/surface recorded EEG?



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At-risk alcohol users have disrupted valence discrimination during reward anticipation

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Young adults (mean age 23.77 years)

Low Audit (LA) (n = 22, mean AUDIT score: 5.77)

High Audit (HA) (n = 22, mean AUDIT score: 13.82)

0 – 7 = low risk

8 – 15 = increasing risk

Alcohol use disorders identification test (AUDIT)

AUDIT is a comprehensive 10 question alcohol harm screening tool. It was developed by the World Health Organisation (WHO) and modified for use in the UK and has been used in a variety of health and social care settings.

Questions	Scoring system					Your score
	0	1	2	3	4	
How often do you have a drink containing alcohol?	Never	Monthly or less	2 to 4 times per month	2 to 3 times per week	4 times or more per week	
How many units of alcohol do you drink on a typical day when you are drinking?	0 to 2	3 to 4	5 to 6	7 to 9	10 or more	
How often have you had 6 or more units if female, or 8 or more if male, on a single occasion in the last year?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
How often during the last year have you failed to do what was normally expected from you because of your drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
How often during the last year have you needed an alcoholic drink in the morning to get yourself going after a heavy drinking session?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
How often during the last year have you been unable to remember what happened the night before because you had been drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
Have you or somebody else been injured as a result of your drinking?	No		Yes, but not in the last year		Yes, during the last year	
Has a relative or friend, doctor or other health worker been concerned about your drinking or [illegible] cut down?	No		Yes, but not in the last		Yes, during the last year	

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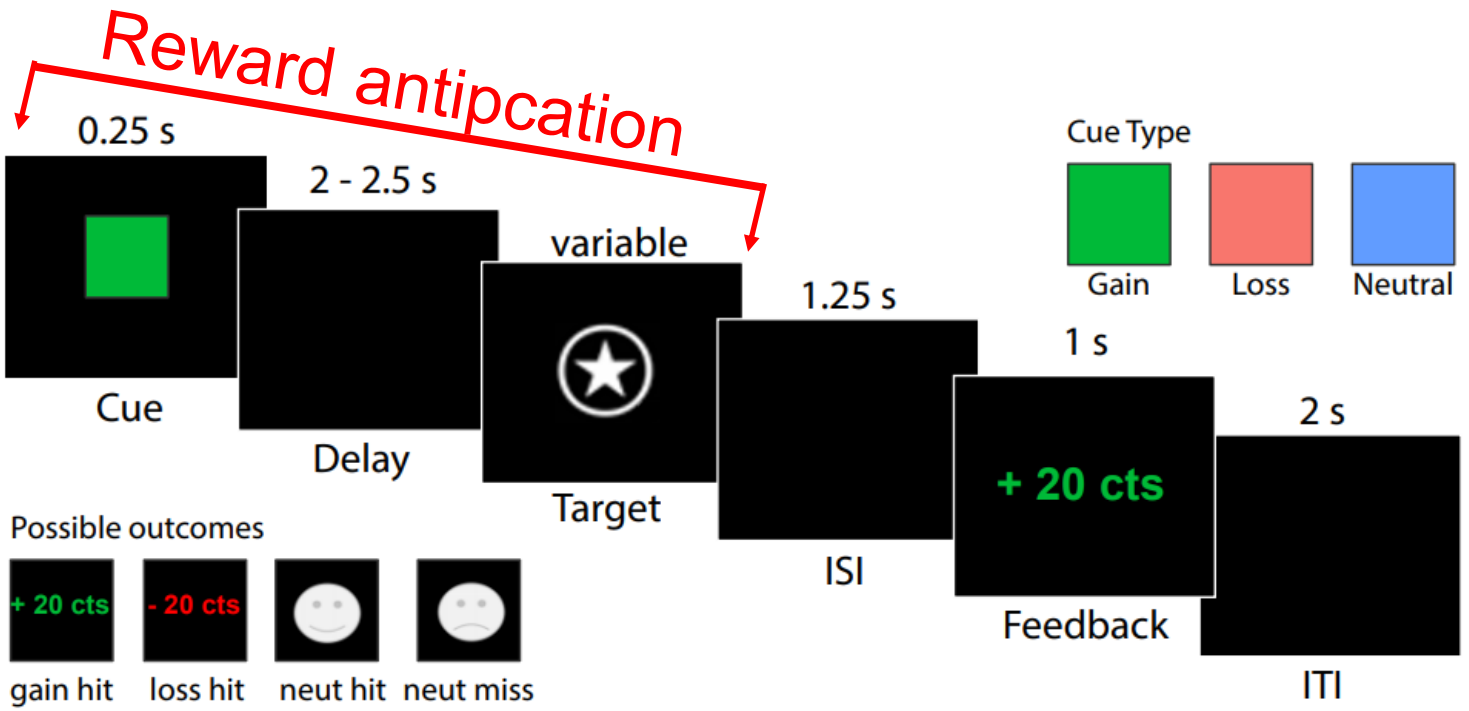
EEG monetary incentive delay (MID) task



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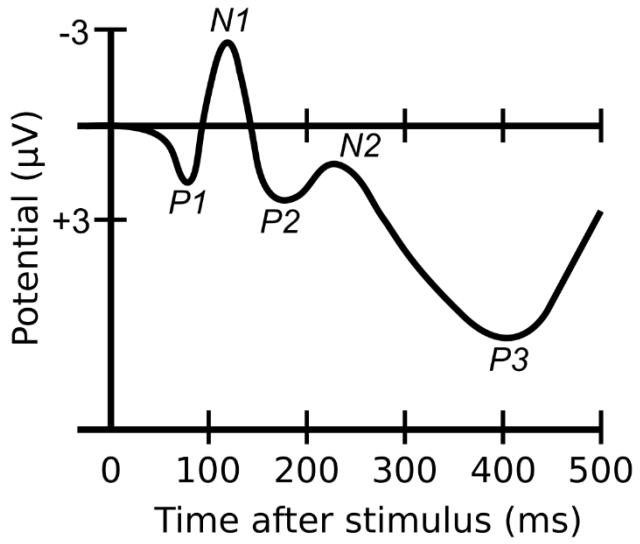
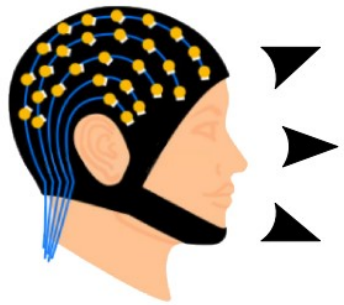
Event related potential (ERP)

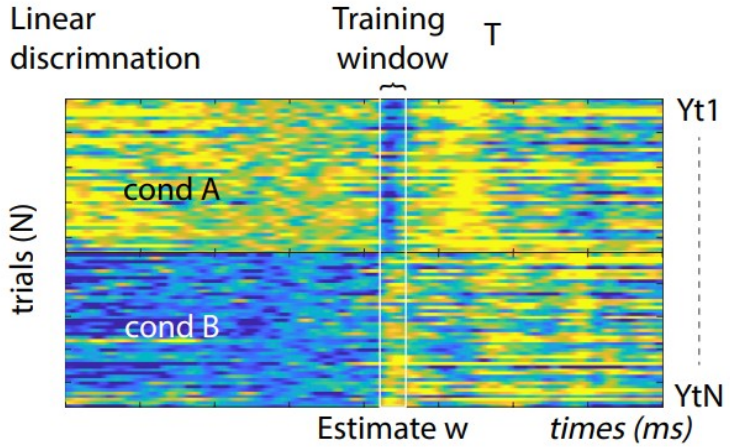


Compares trial averaged amplitudes of conditions, across specific time windows

P3 (400 – 550 ms) correlates with ventral striatum activation during monetary incentive delay task
(Pfabigan, 2014)

Machine learning discrimination





Uses single trial information to look for time windows of maximum separation between conditions

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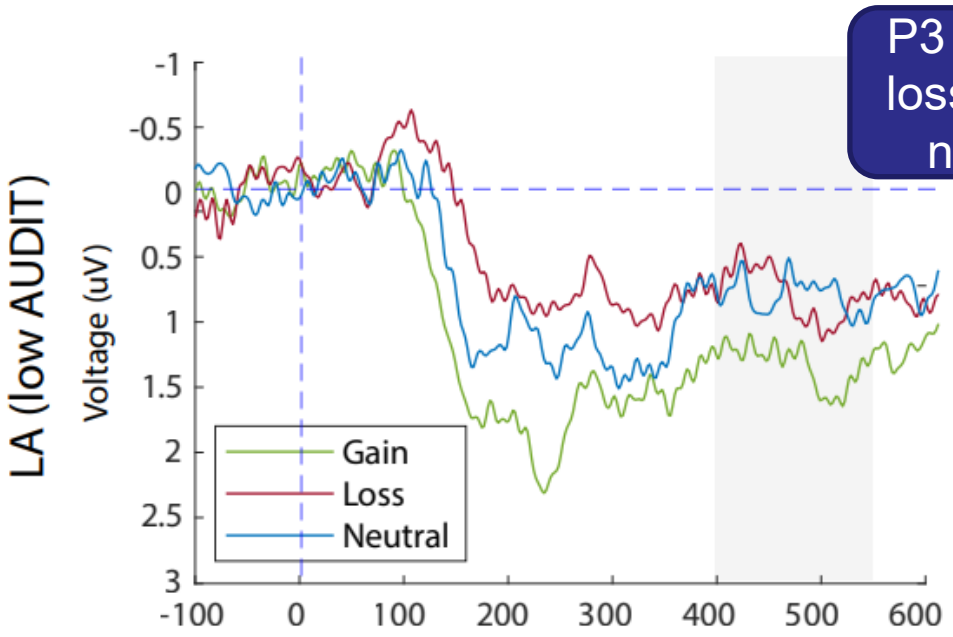
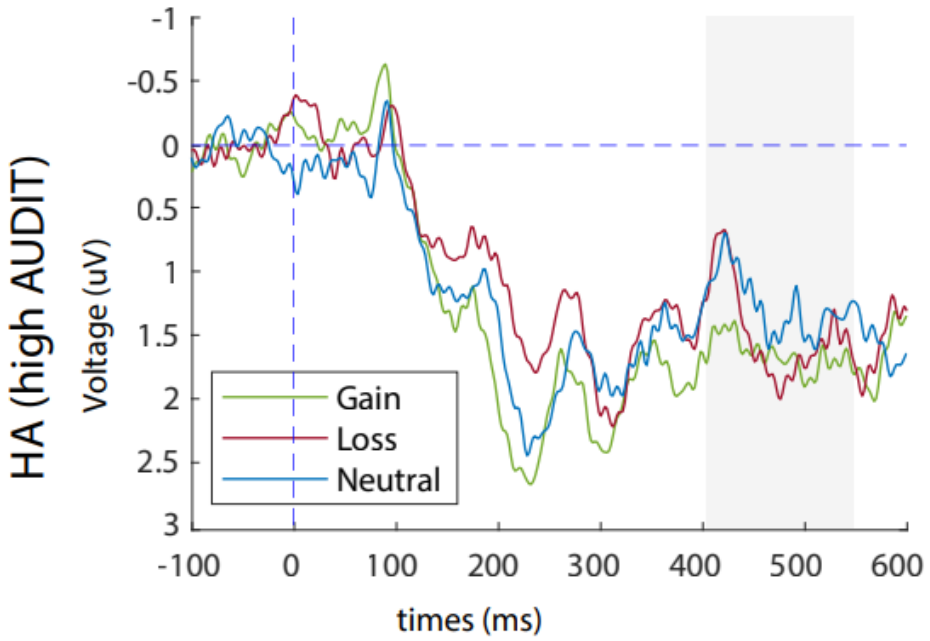
P3 ERP Results

P3 gains > losses and neutral





3 (condition) x 2 (group) mixed ANOVA revealed no significant differences between the groups for the cue-P3 amplitude ($F(1, 42) = 1.35$, $p = 0.25$).

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Machine Learning Method Overview

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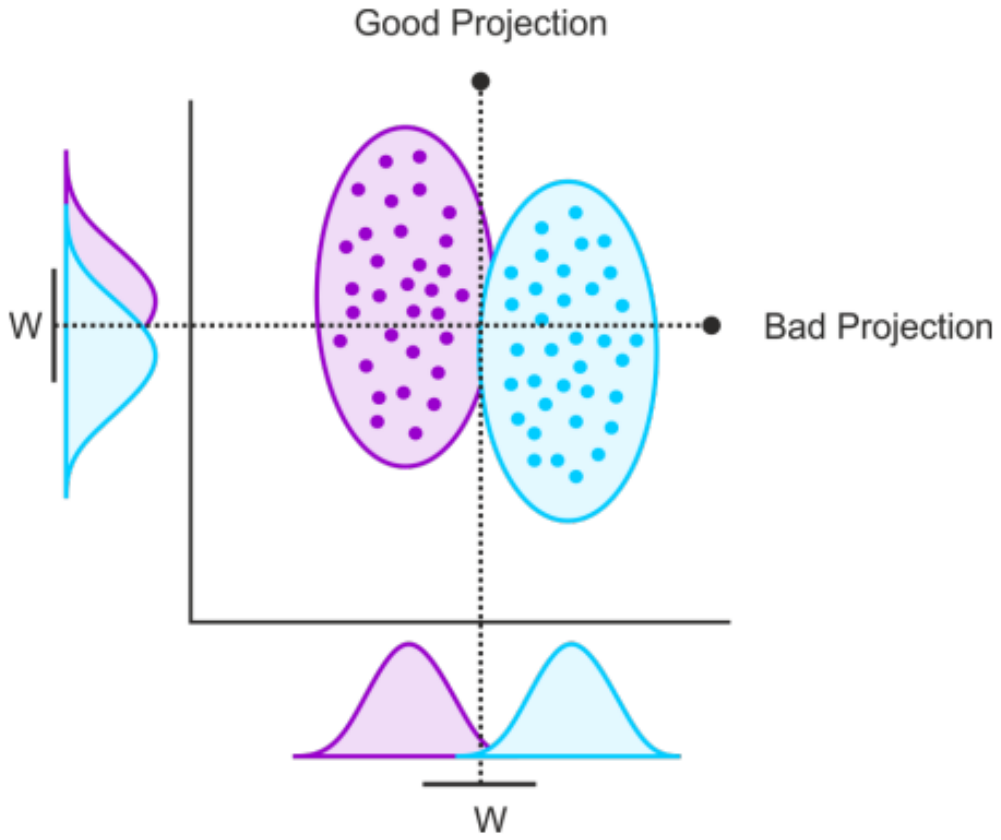
Machine learning method

Linear classifier finds best separation between two conditions

Valence = Gain vs Loss cues

Salience = Incentive (gain & loss) vs Neutral cues



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Machine learning method

What is EEG Single Trial Variability (STV)?

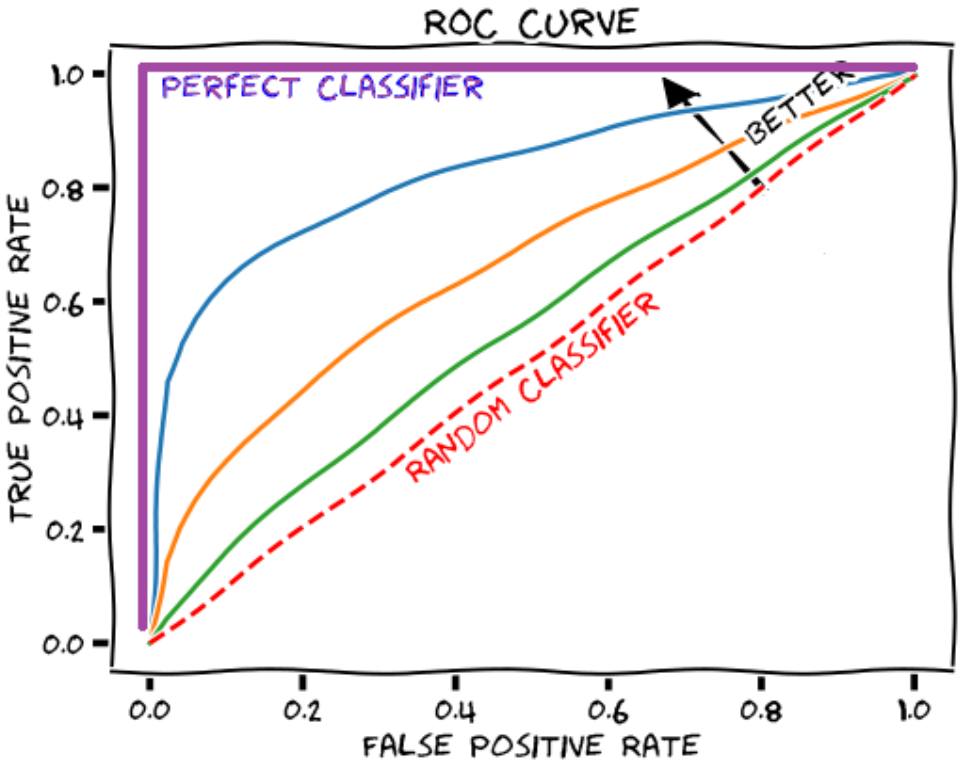
EEG-STV index of how each condition is encoded on individual trials

Can be related to other things changing **trial-by-trial basis**

- Reaction time
- fMRI signals
- cardiac signals

Machine learning method

How well can the brain discriminate between two conditions of interest?



- **Classifier performance**
- **Area under ROC = "AZ value"**
- **Larger AZ → more accurate the classifier → better separation between conditions**

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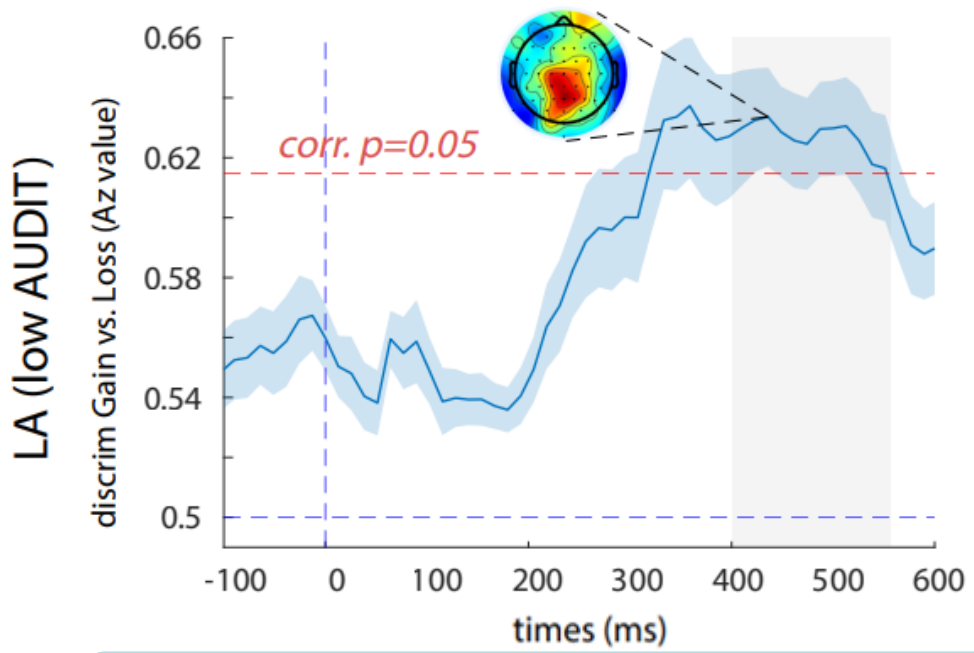
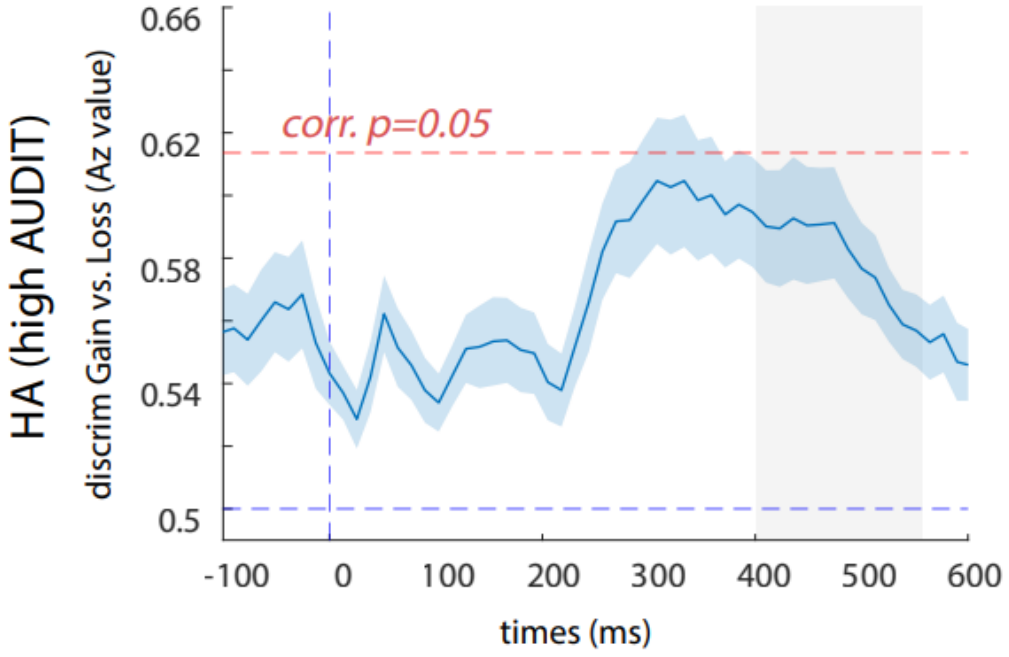
Machine learning results (valence)



Group of low-risk drinkers can discriminate between gain and loss cues



Group of hazardous drinkers cannot discriminate between gain and loss cues

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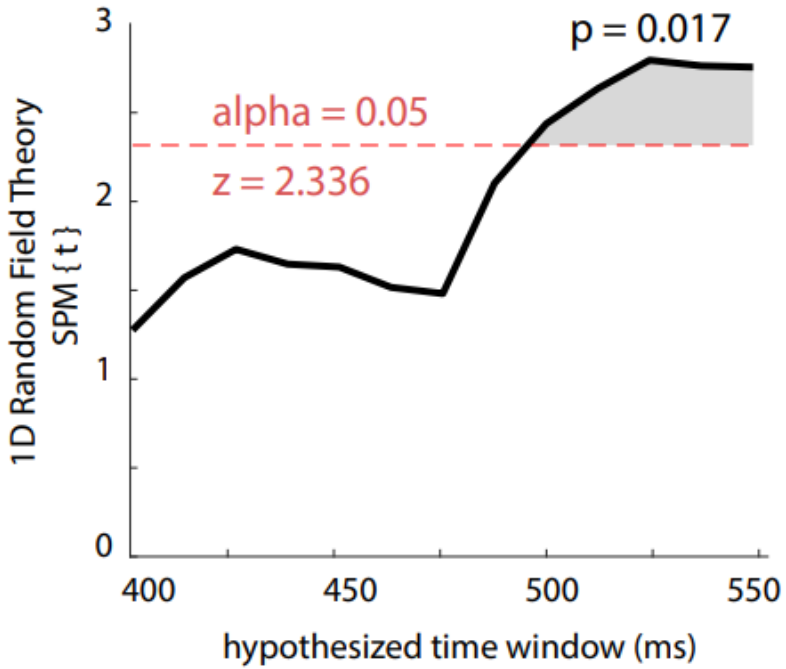
Machine learning results (valence)

Hypothesised P3 time window - between group comparison



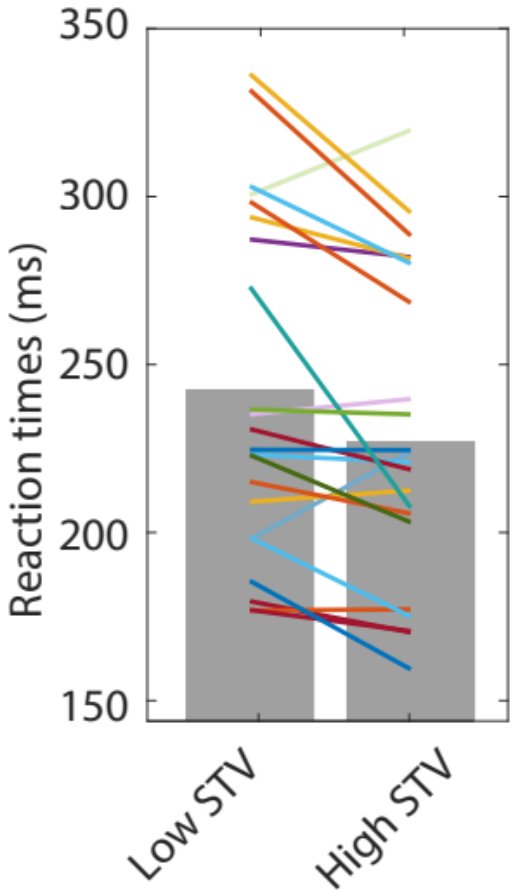
Significant difference between LA-Az and HA-Az from 480 – 550 ms

Concrete evidence of hypoactive/blunted reward anticipation in high risk drinkers

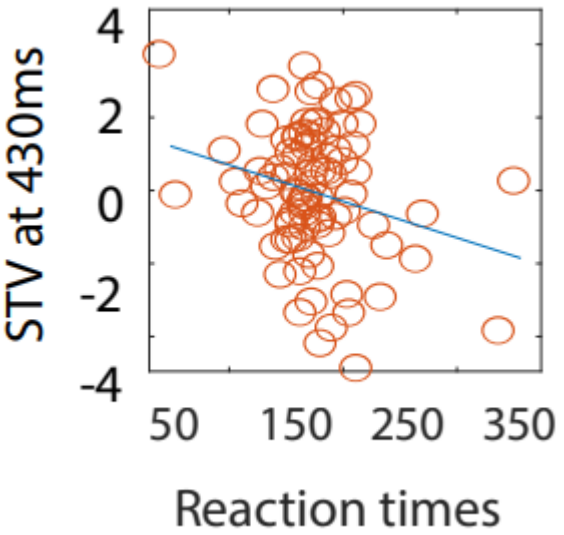
Is there a relationship between brain and behaviour?

Higher STV (i.e., larger difference in EEG signal between gain and loss cues) → faster reaction time to target

Low AUIDT group



Single subject



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Key findings

Disrupted valence (gain vs loss) processing in hazardous drinkers

Temporally: 480 - 550ms

Spatially: unknown? Combined fMRI-EEG needed

No evidence of disrupted salience (incentive vs neutral) processing

Temporally: any time between cue and target onset

Ongoing research & next steps

Alcohol dependent vs control populations

Longitudinal research

How do valence and salience EEG markers change over time? Do these relate to transition to alcohol dependency? Can they be used in relapse prediction?

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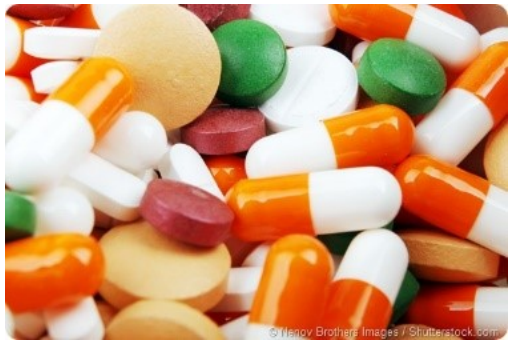
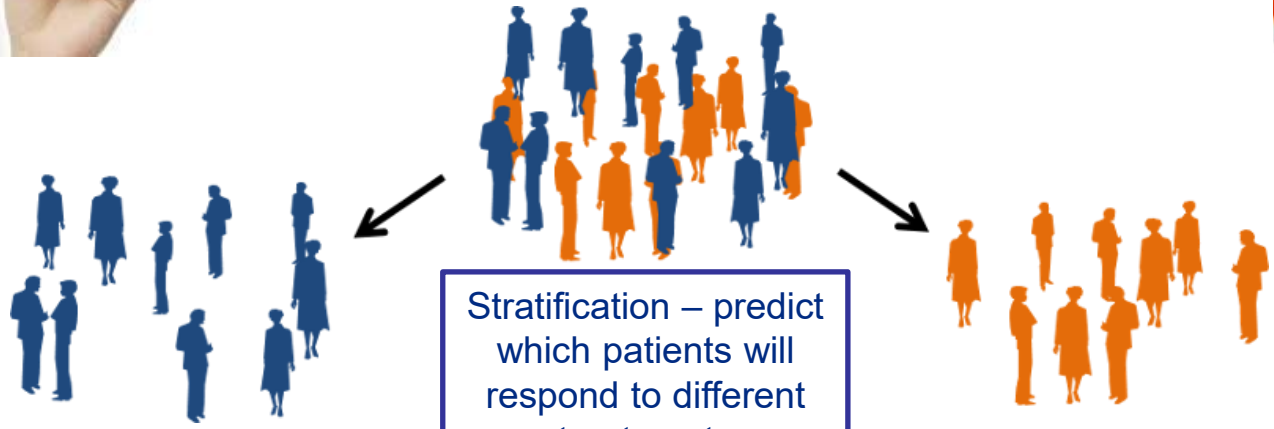
Application for EEG markers

High signal-to-noise ratio → statistically meaningful results for individuals



Reduced cost of drug development, employ EEG instead of fMRI



Stratification – predict which patients will respond to different treatments

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