# Human emotions

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Systems and Theoretical Neuroscience Course, 11/9/18

# Outline

- Innate behaviours in humans
- Are emotions Pavlovian responses?
  - Theories of emotions
- Disorders of emotion

# Innate behaviours

- Darwin
  - The Expression of Emotions in Man and Animal
  - Emotions = innate response strategies to evolutionarily important situations
- Pavlovian conditioning
  - Not for all responses

- Basic emotions
  - Innate, universal response categories
  - Innate behaviours in humans?

Hershberger, 1986

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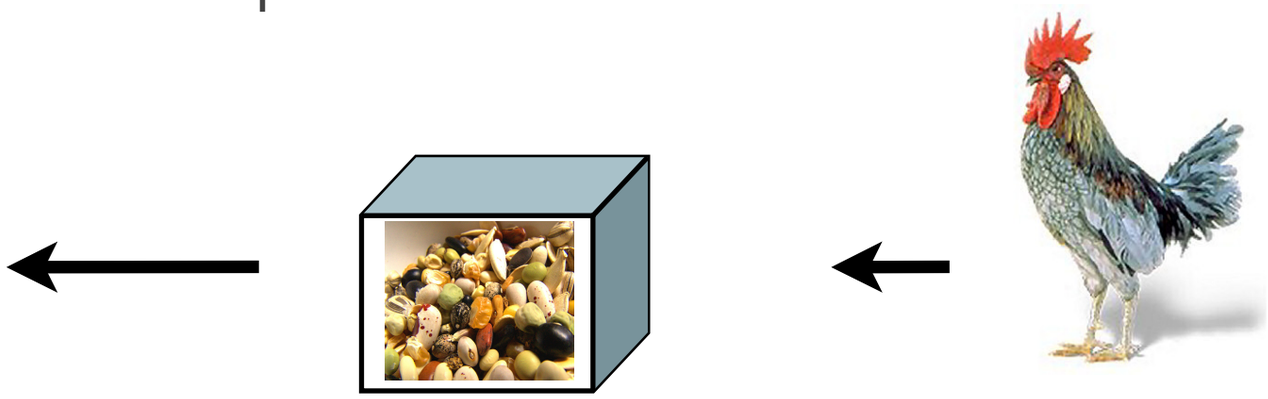

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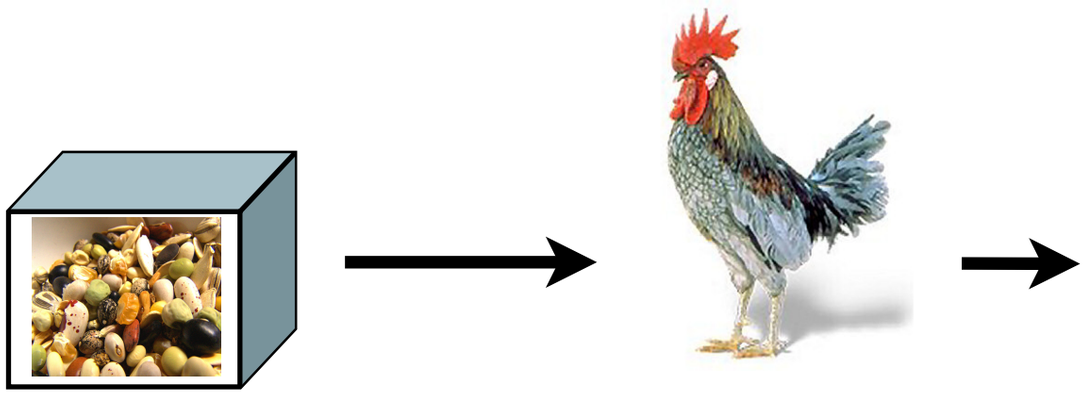

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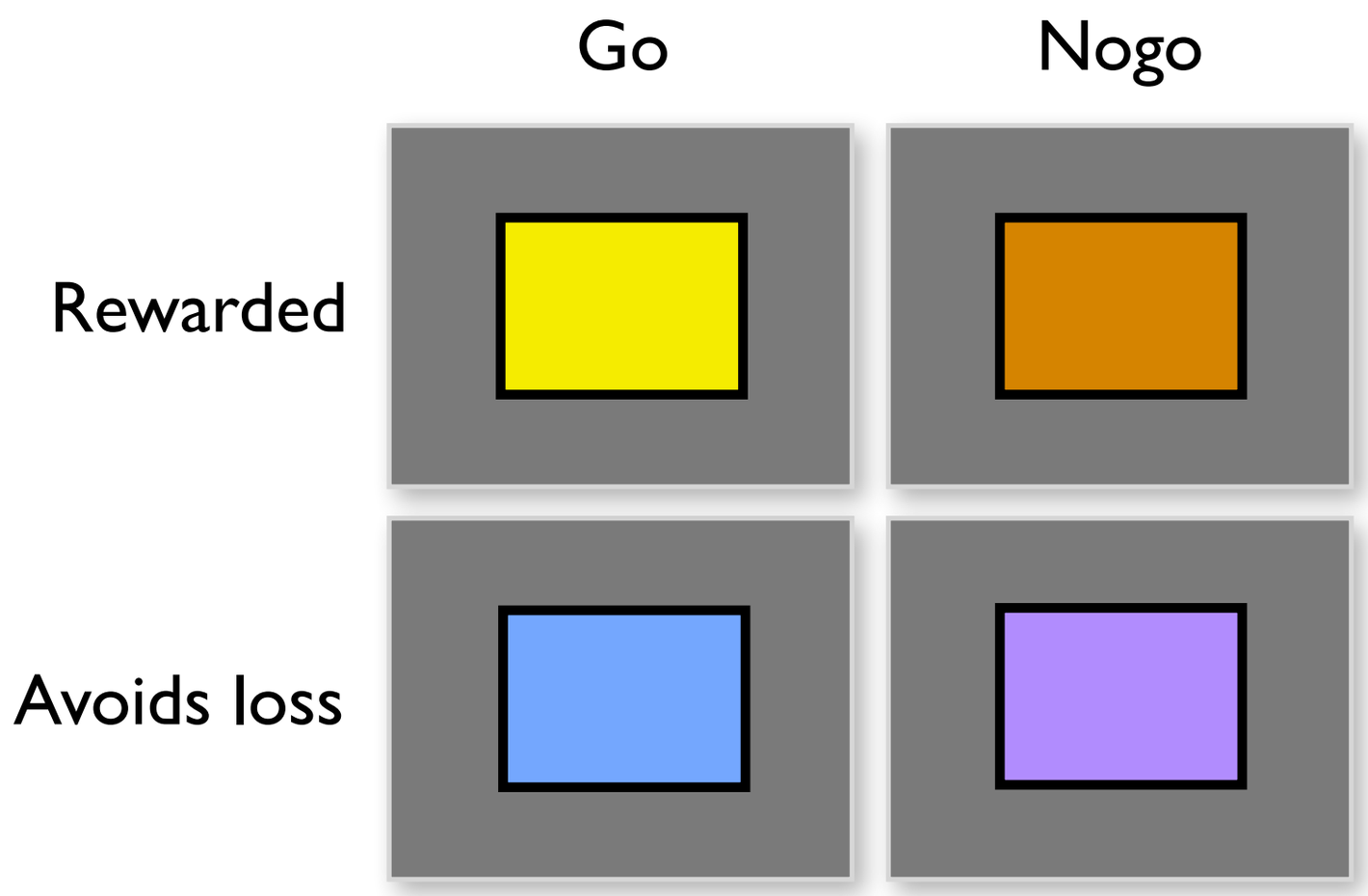
Hershberger, 1986

# Affective go / nogo task




Guitart-Masip, Huys et al. *2012*

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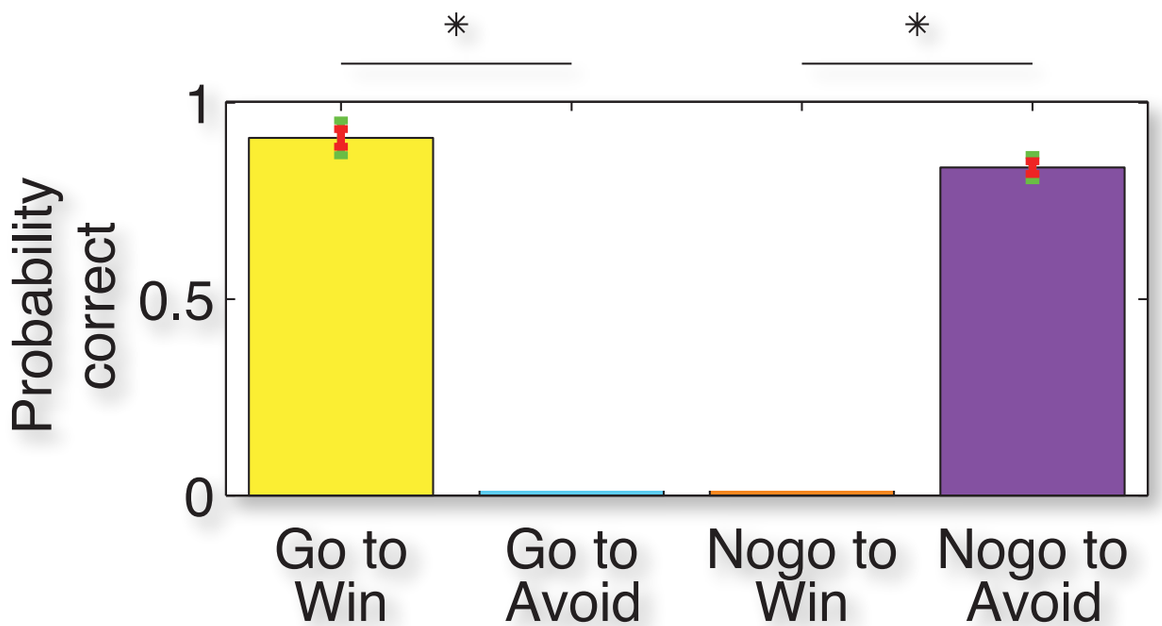


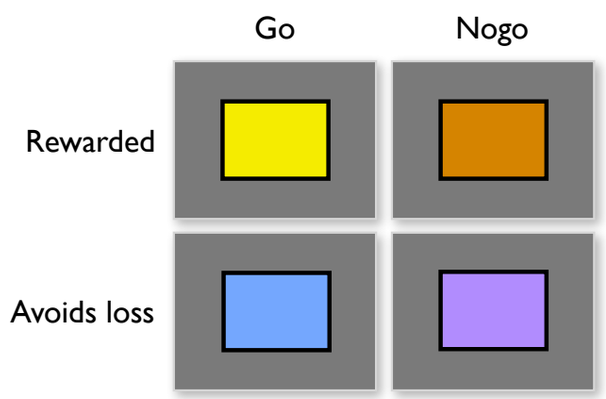


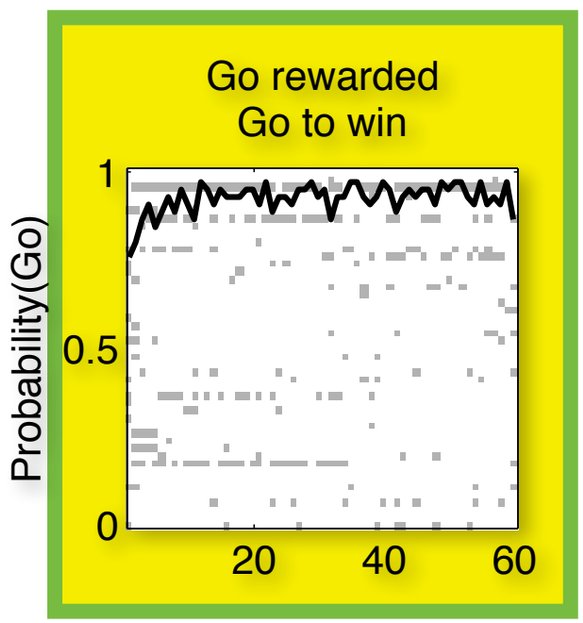


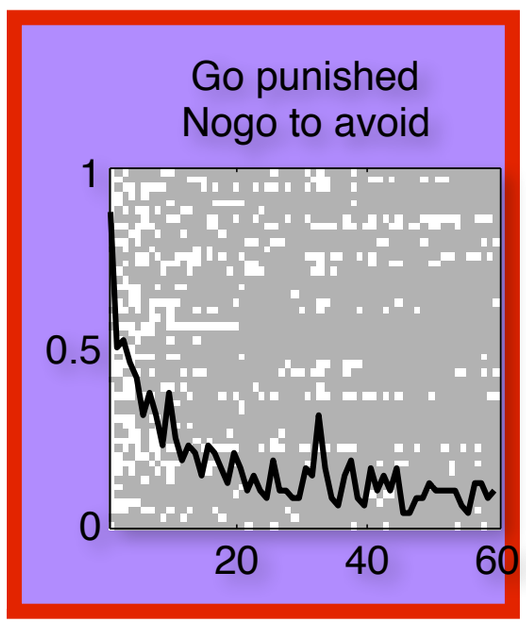


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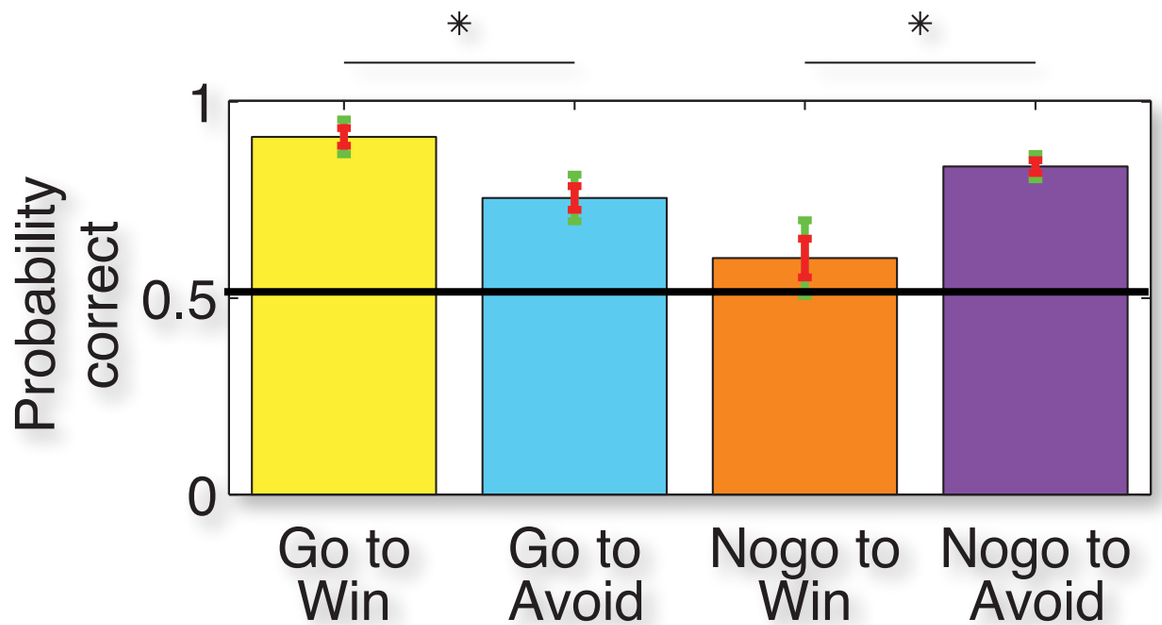
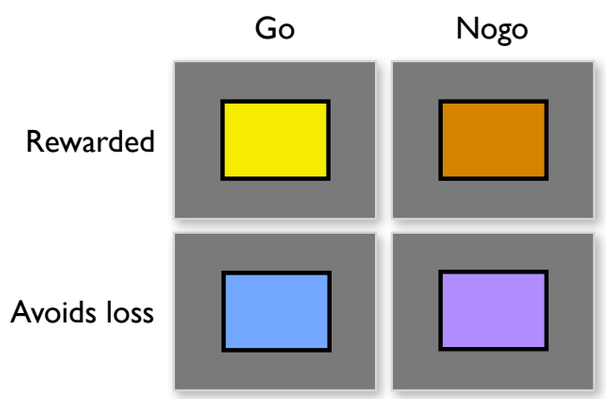
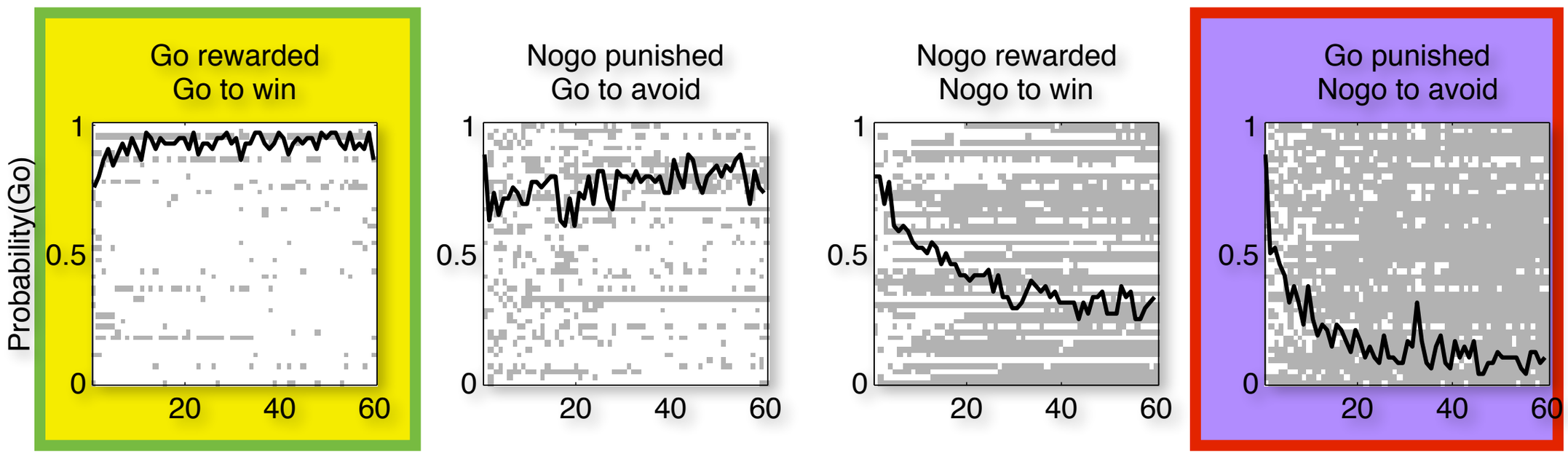


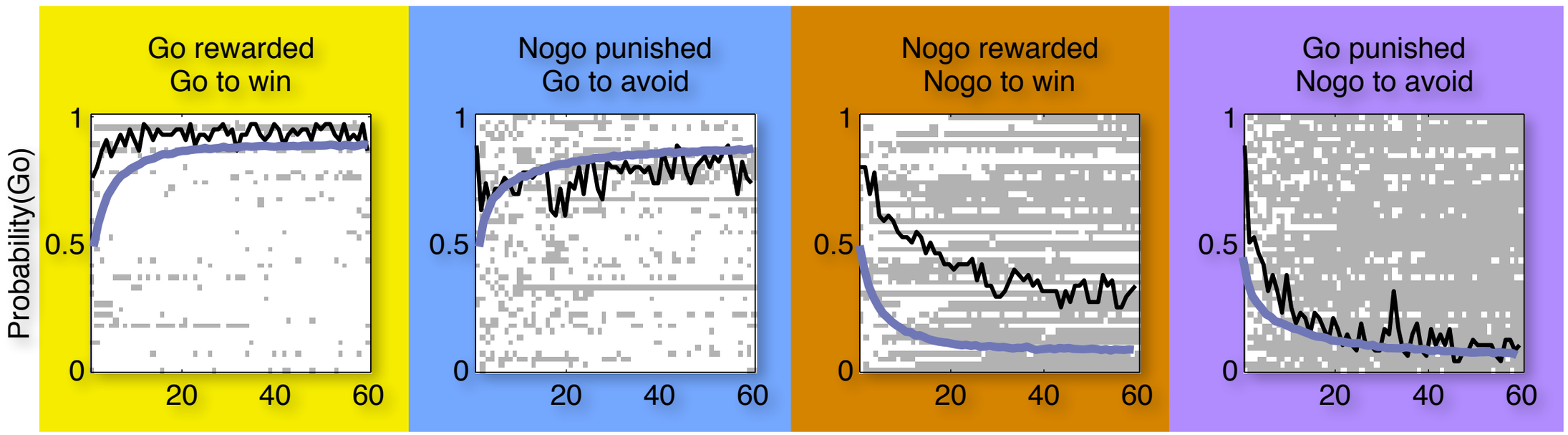

Guitart-Masip, Huys et al. *2012*

# Models


- Basic

$$p_t(a|s) \propto \mathcal{Q}_t(s,a)$$

$$\mathcal{Q}_{t+1}(s,a) = \mathcal{Q}_t(s,a) + \alpha(r_t - \mathcal{Q}_t(s,a))$$




Guitart et al., 2012 J Neurosci

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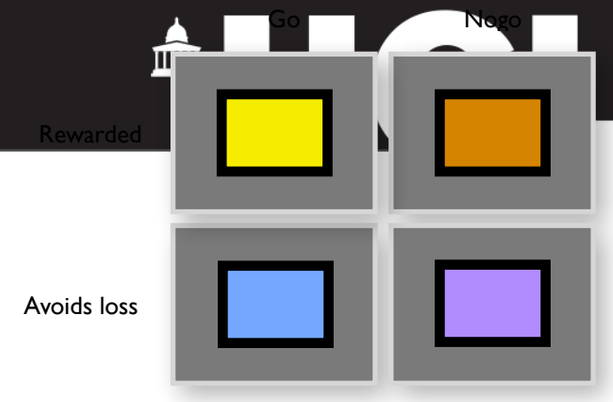
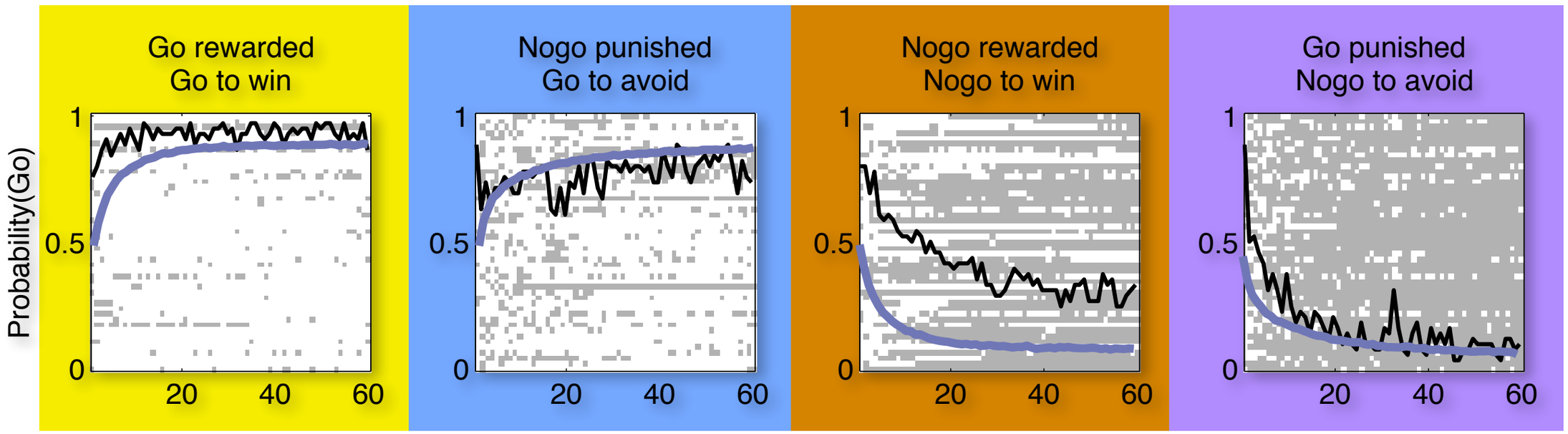



- Basic + bias

$$p_t(go|s) \propto \mathcal{Q}_t(s, go) + bias(go)$$
$$p_t(nogo|s) \propto \mathcal{Q}_t(s, nogo)$$
$$\mathcal{Q}_{t+1}(s, a) = \mathcal{Q}_t(s, a) + \alpha(r_t - \mathcal{Q}_t(s, a))$$



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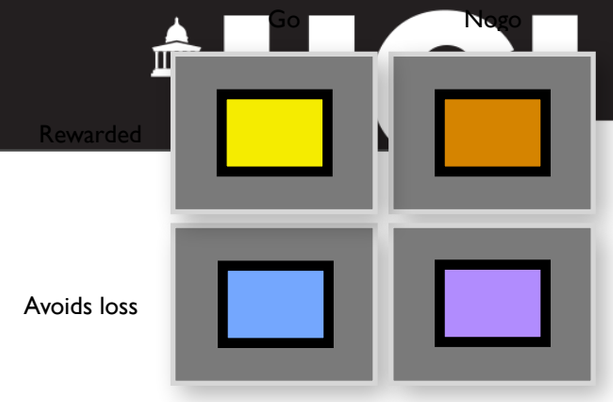


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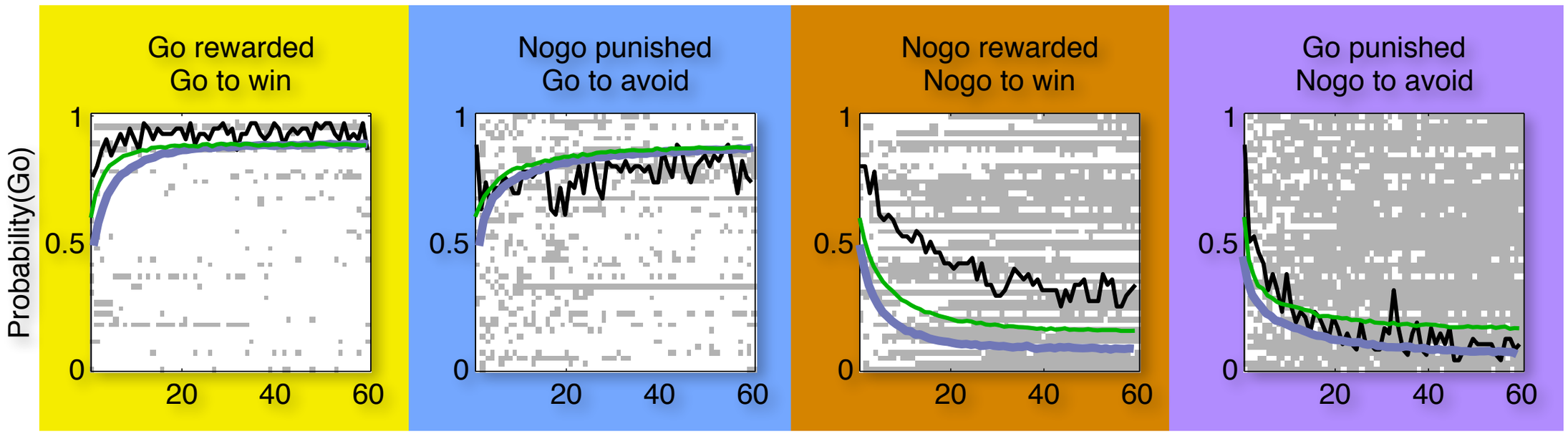

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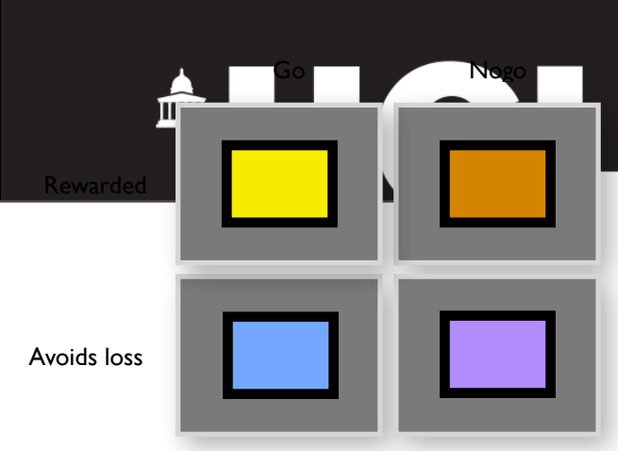


- Basic + bias + Pavlovian influence

$$p_t(go|s) \propto \mathcal{Q}_t(s, go) + bias(go) + \pi \mathcal{V}_t(s)$$
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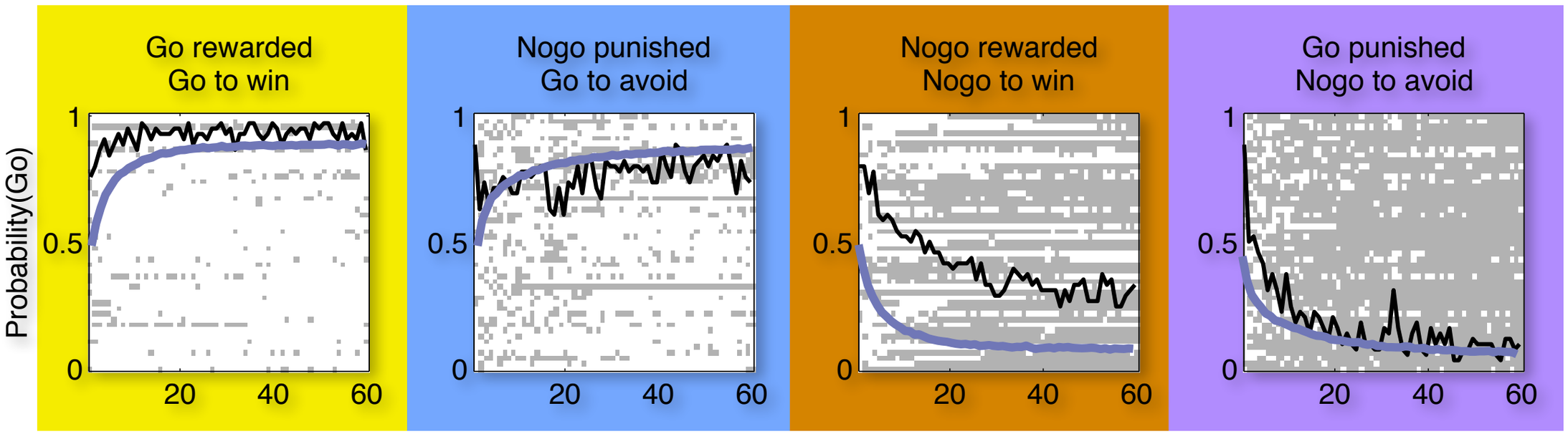

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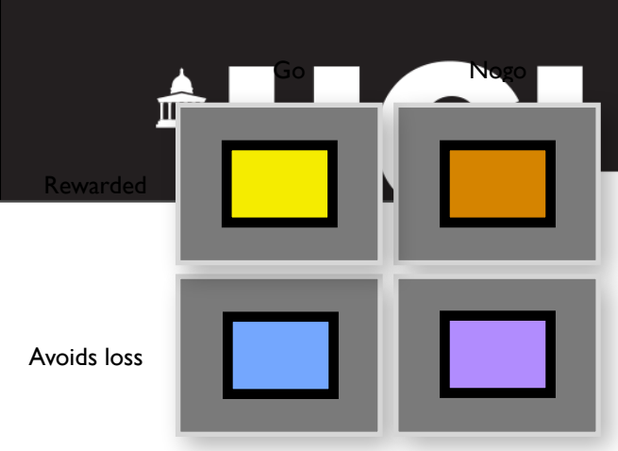


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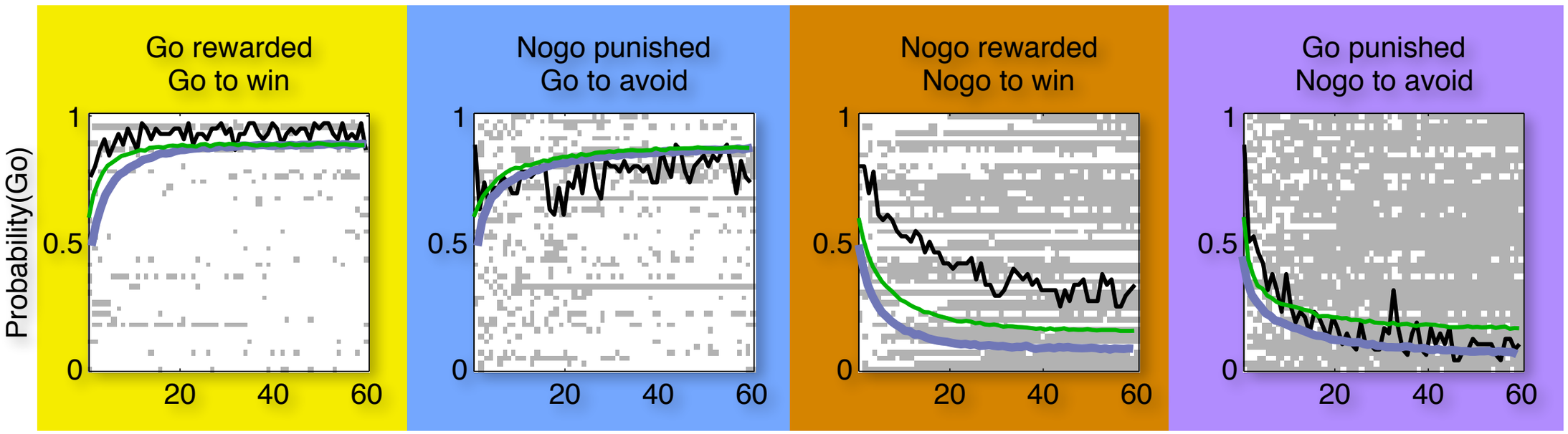

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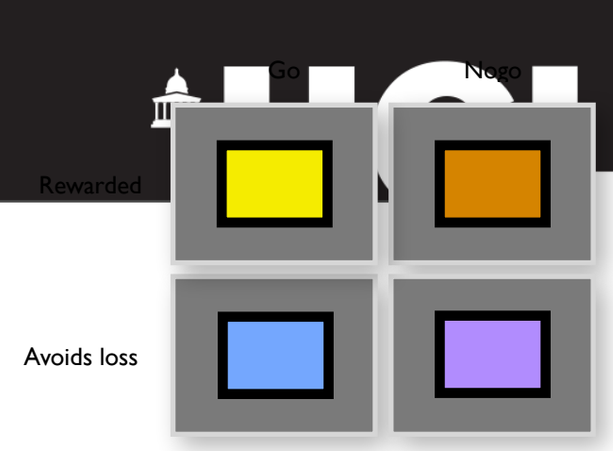


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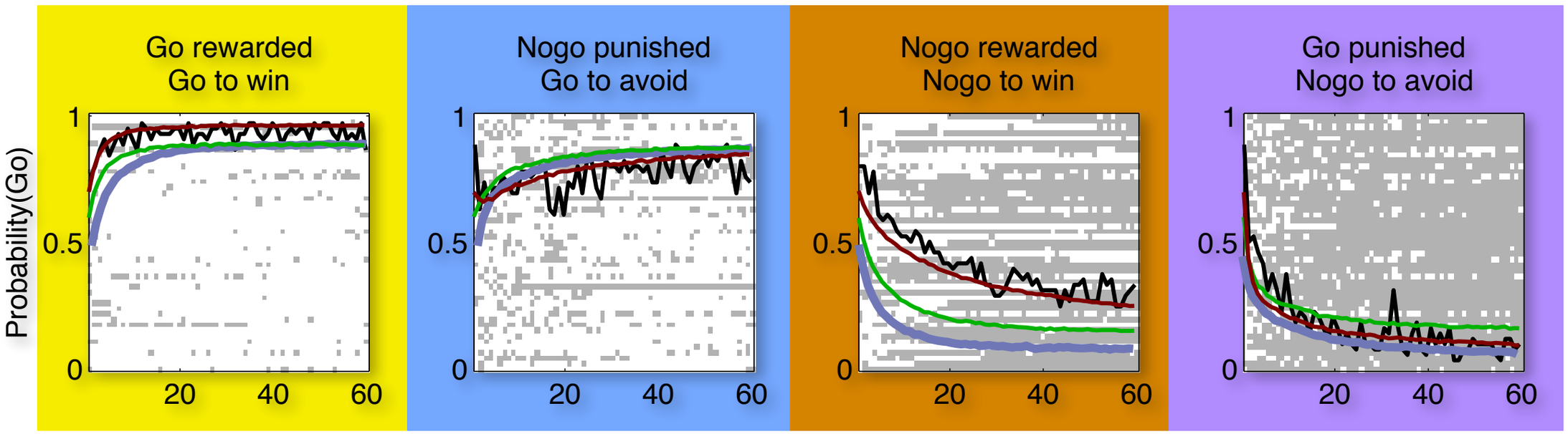
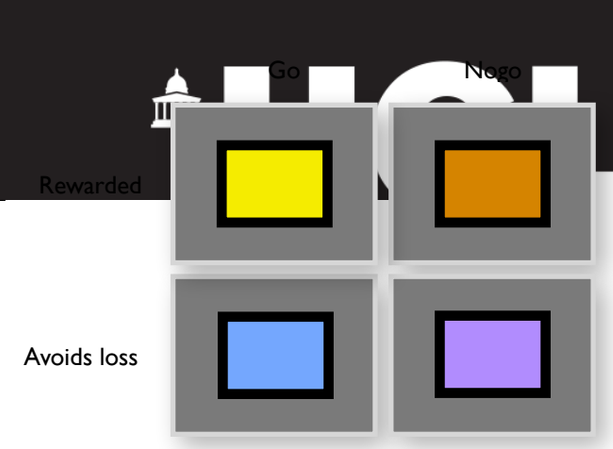
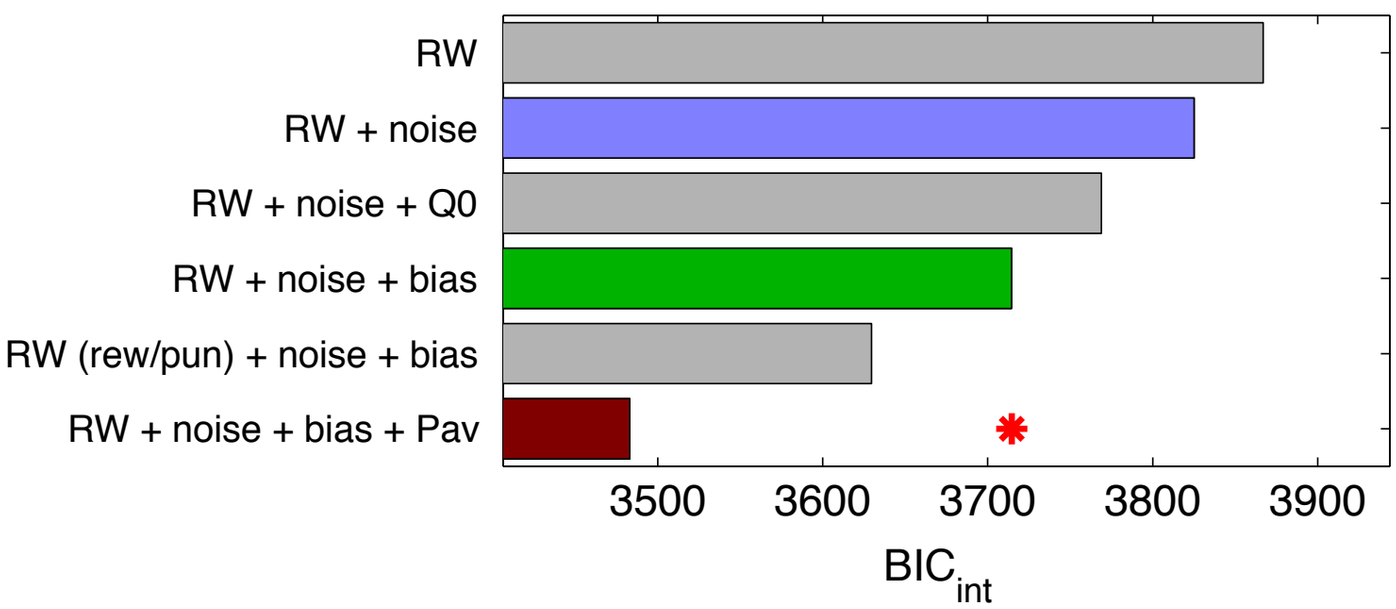
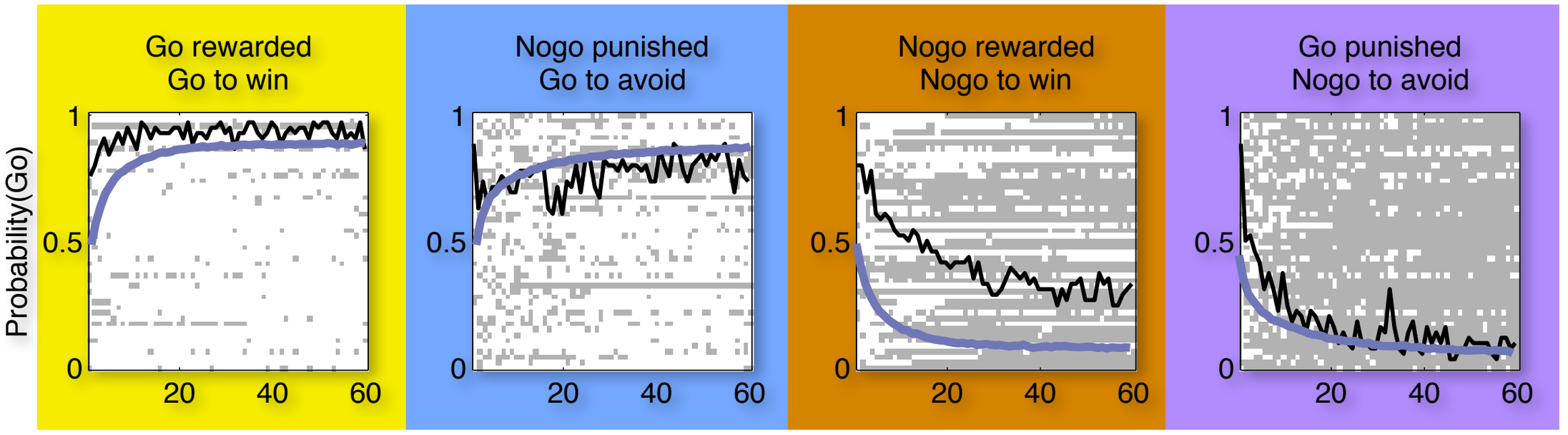


# Model comparison: overfitting?



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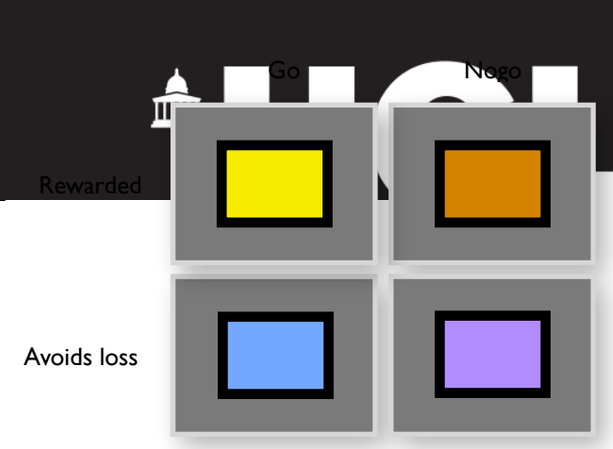


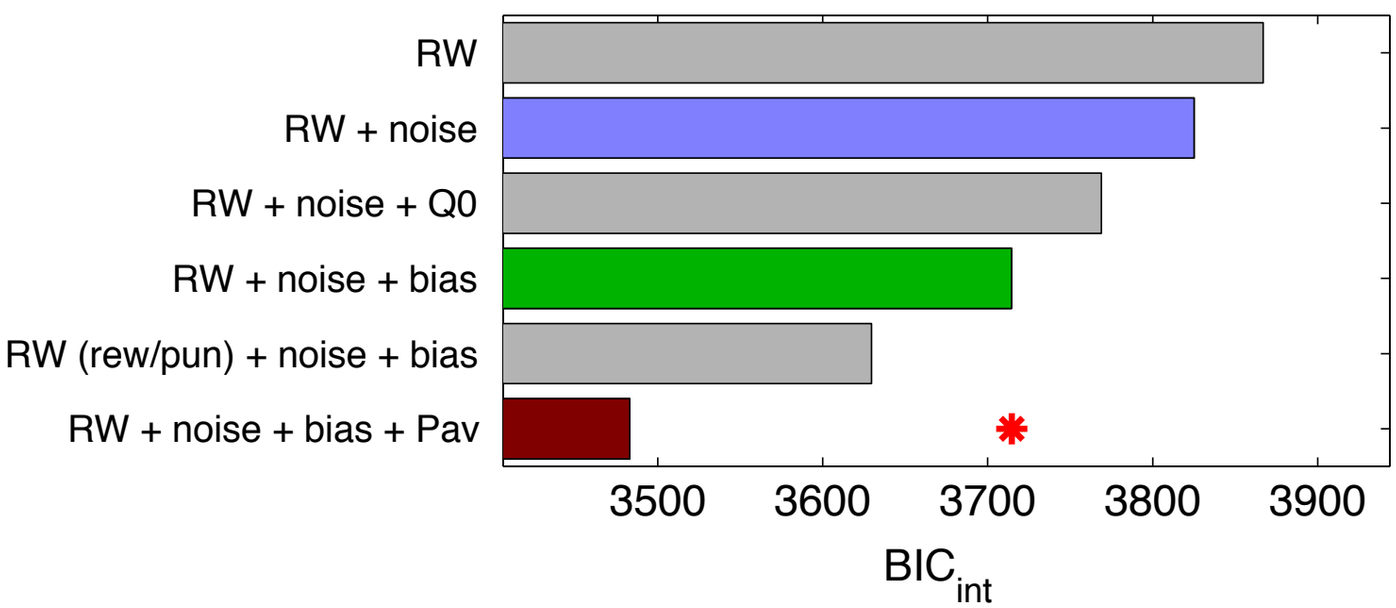


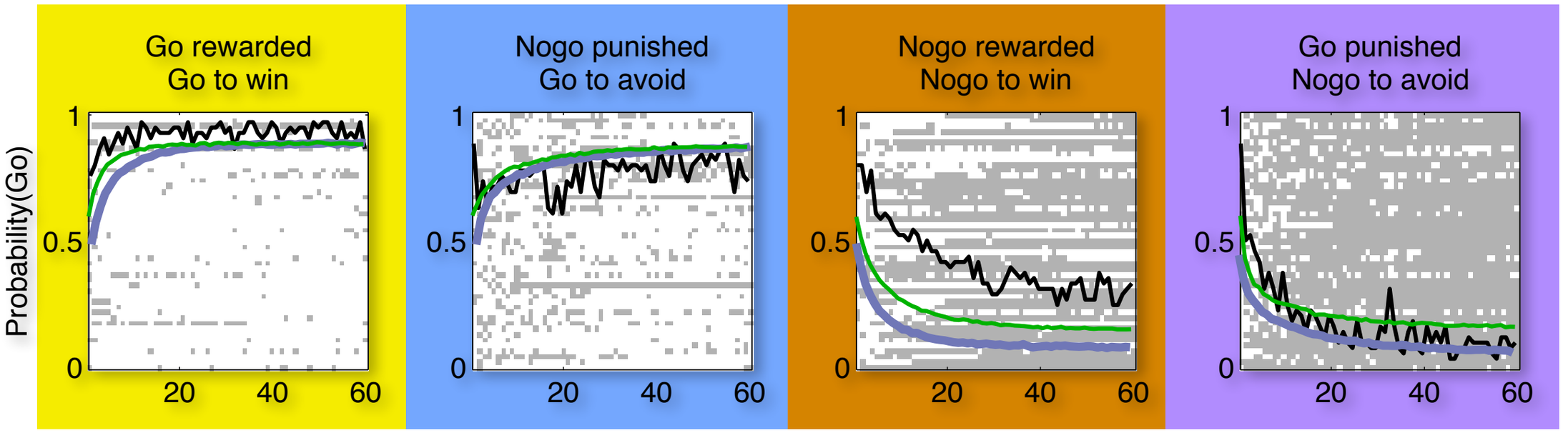

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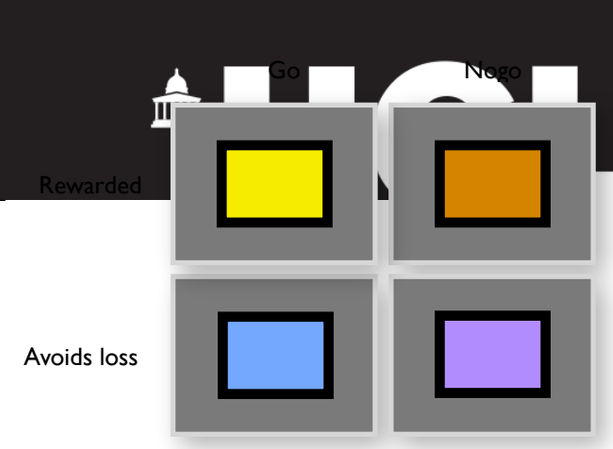
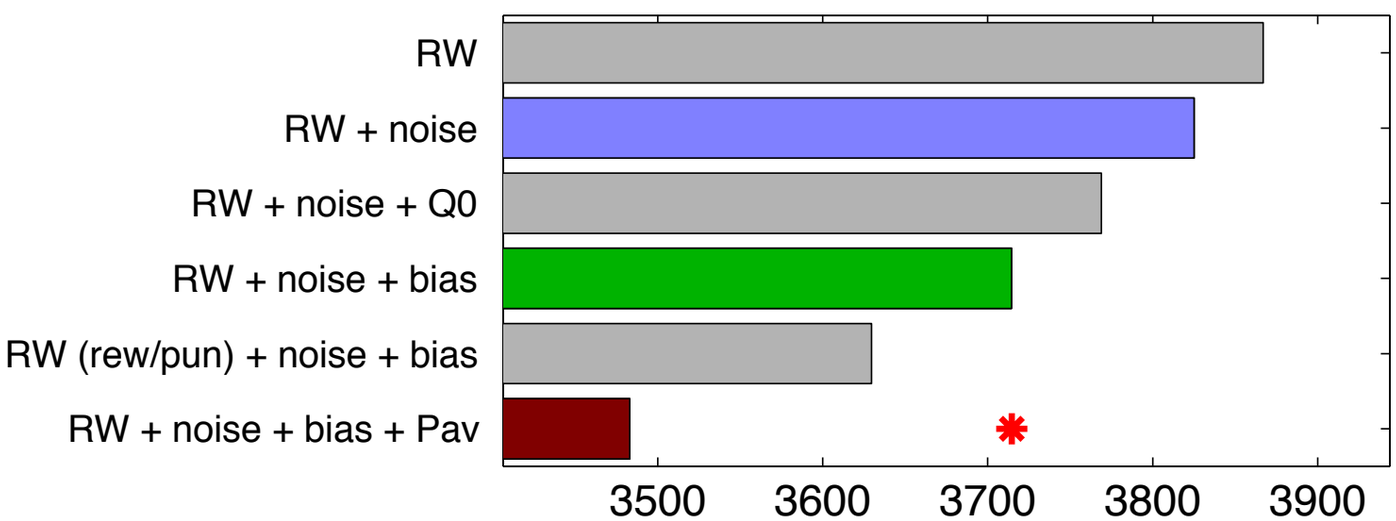
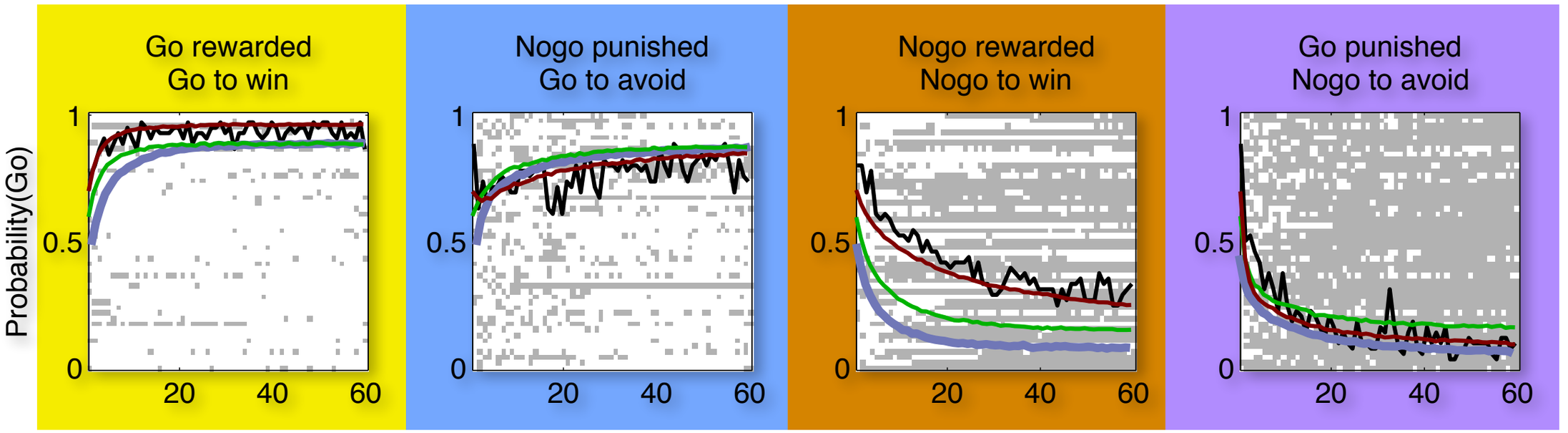
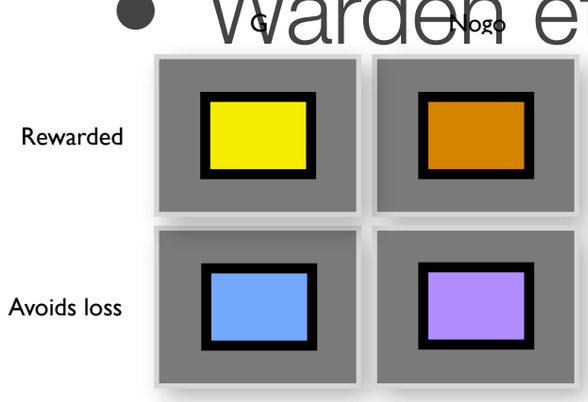


# Top-down control

- Behavioural inhibition vs inhibitory control
- raphe vs vmPFC?
  - vmPFC activation when pruning is overriden.
  - Inhibitory control of behavioural inhibition?
  - Warden et al. 2012 Nature



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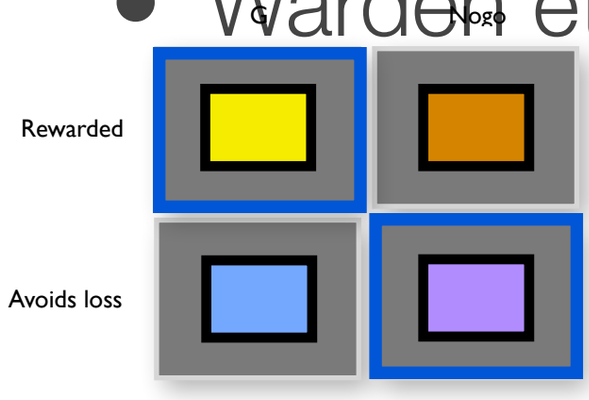


congruent

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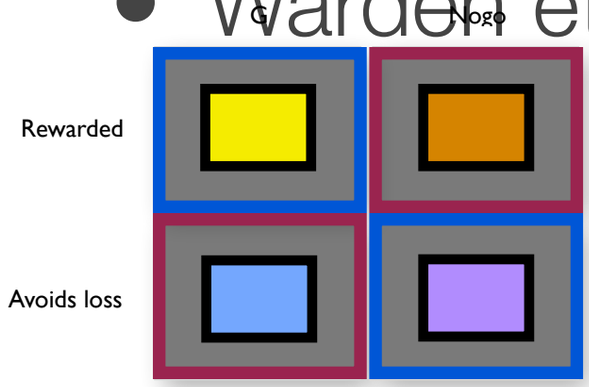


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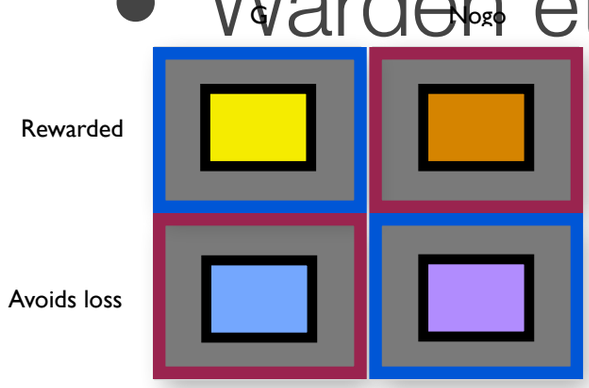


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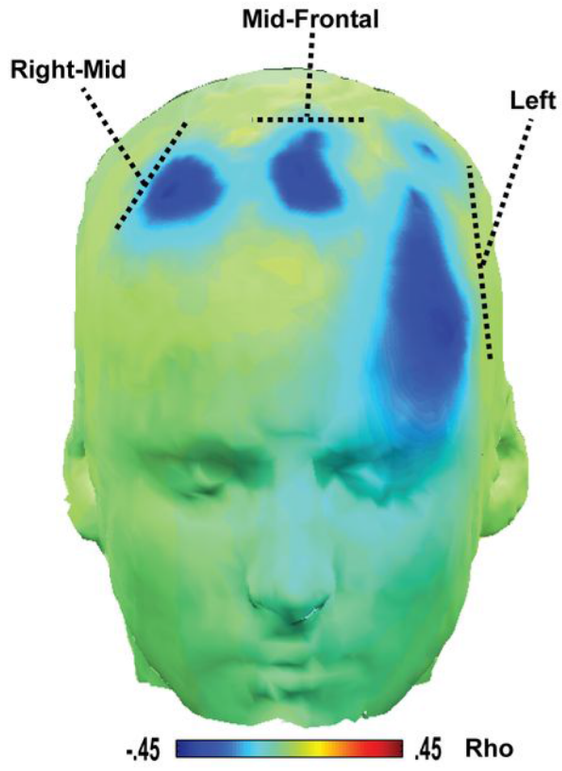


Cavanagh et al. subm.

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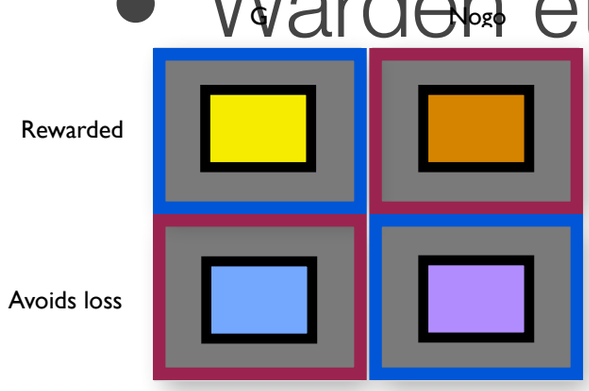


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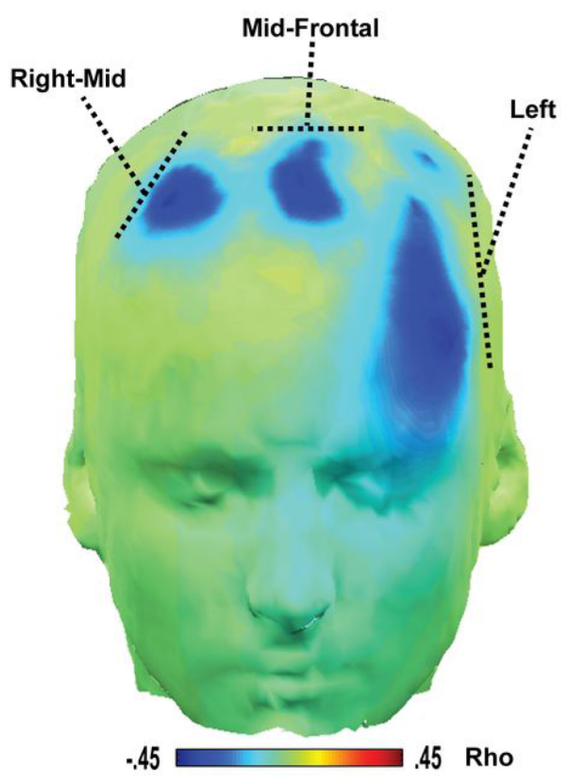
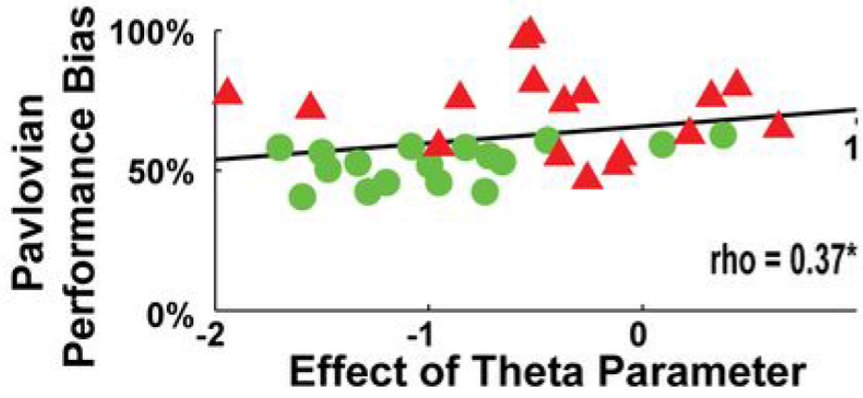
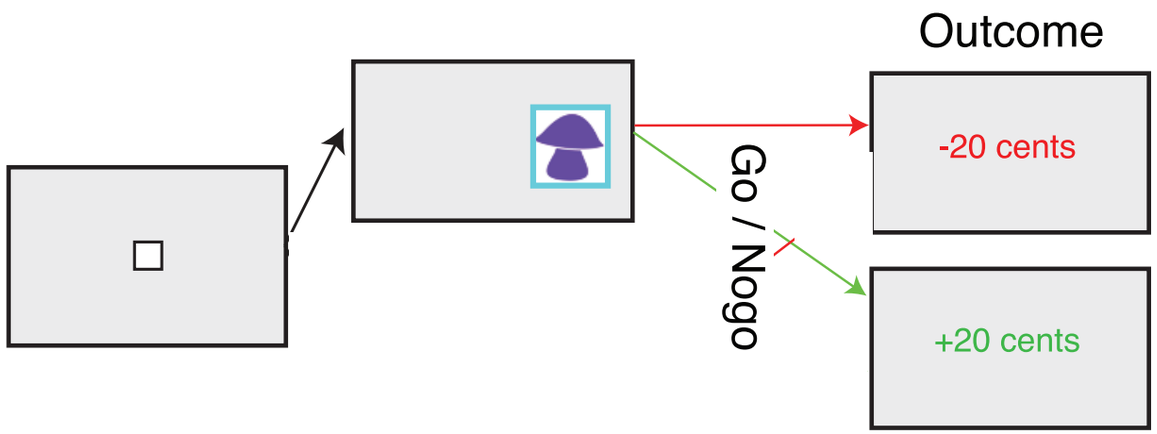



Cavanagh et al. subm.

# Pavlovian-Instrumental transfer

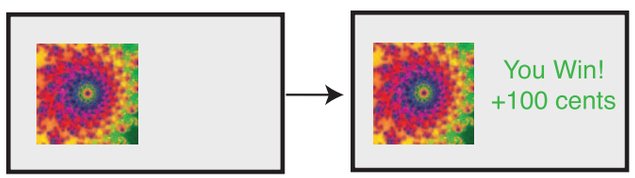
**A**: Instrumental training
Mushrooms as instrumental stimuli



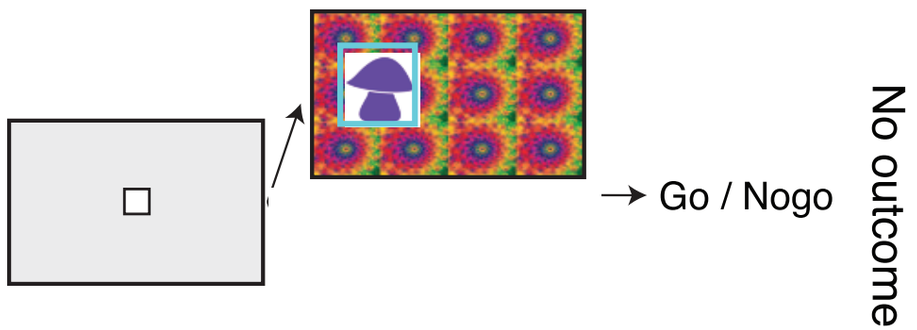

Click in the central square to start trial

Move cursor & click in blue square (go) or do nothing (nogo)

**B**: Pavlovian training
Fractals and tones as Pavlovian stimuli




**D**: Pavlovian-instrumental transfer
Instrumental mushroom stimuli on background of Pavlovian fractal stimuli

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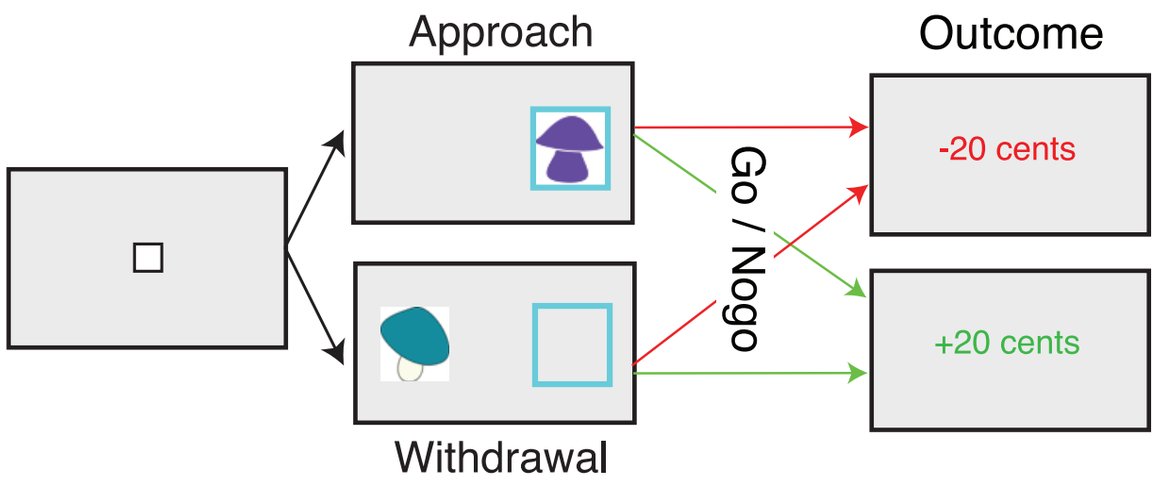


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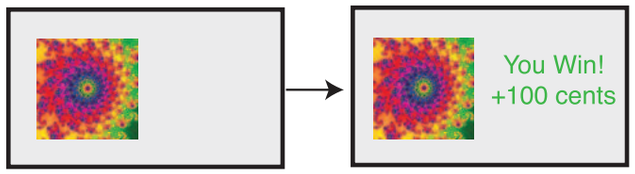


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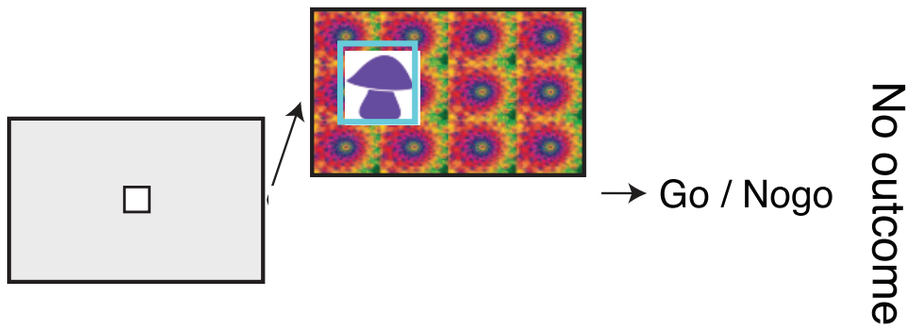


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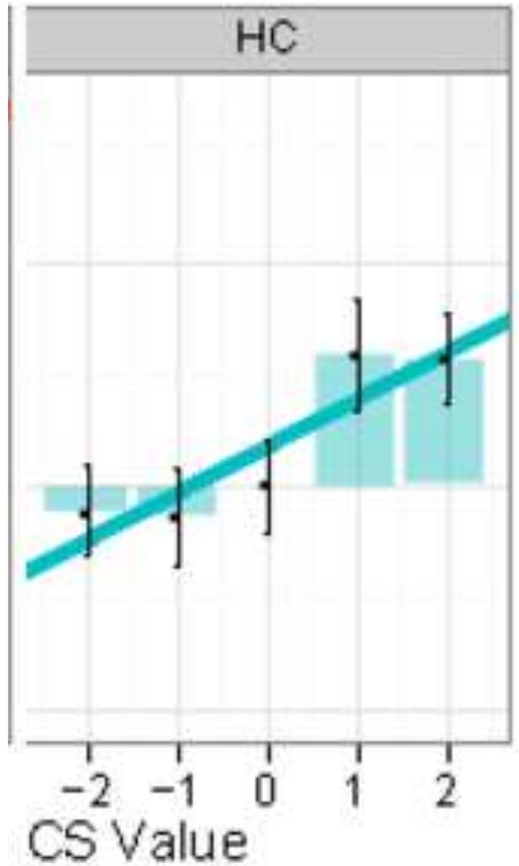
# At group level PIT is stronger in patients




Garbusow et al., 2016

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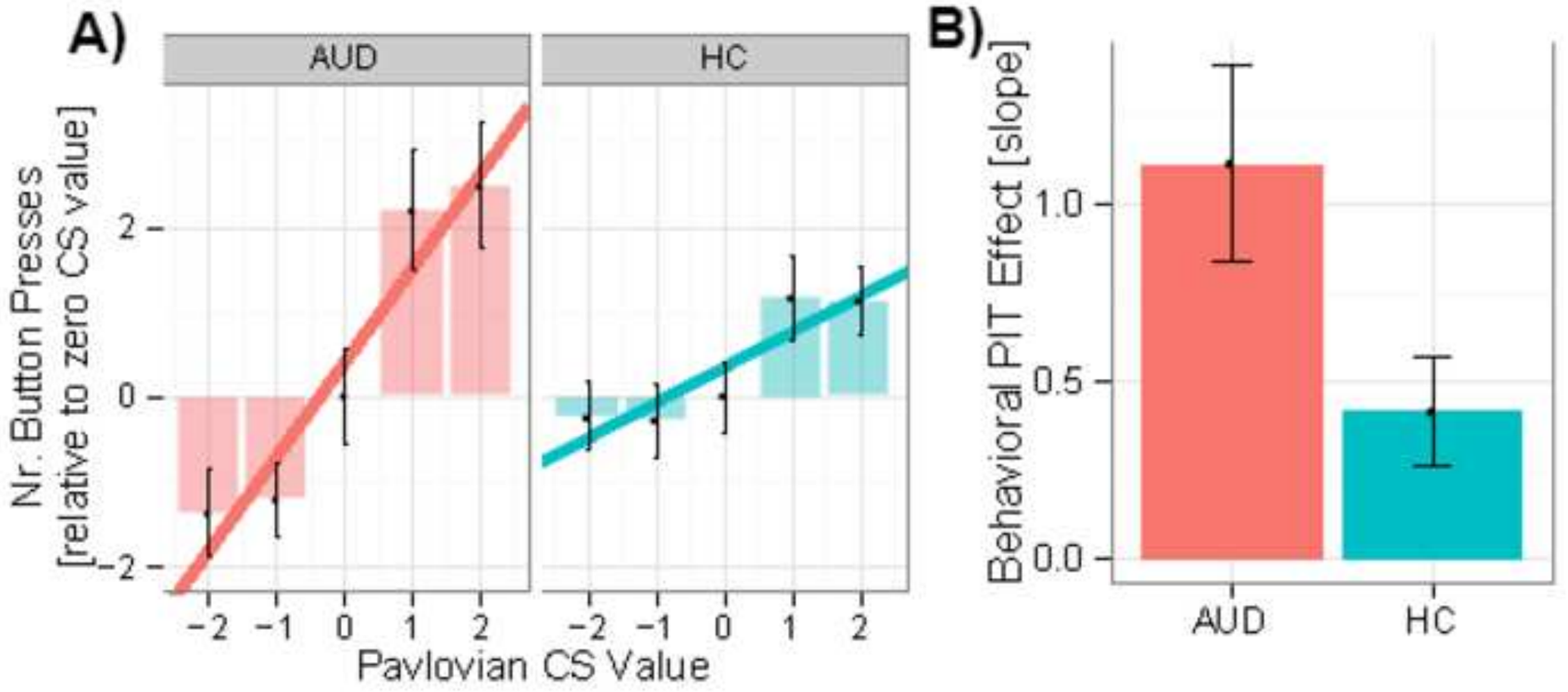


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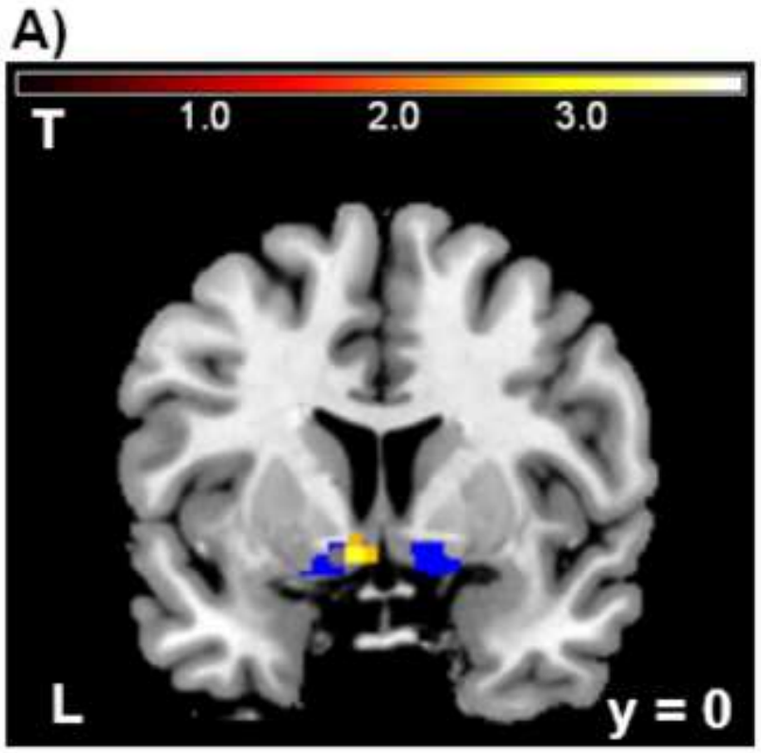
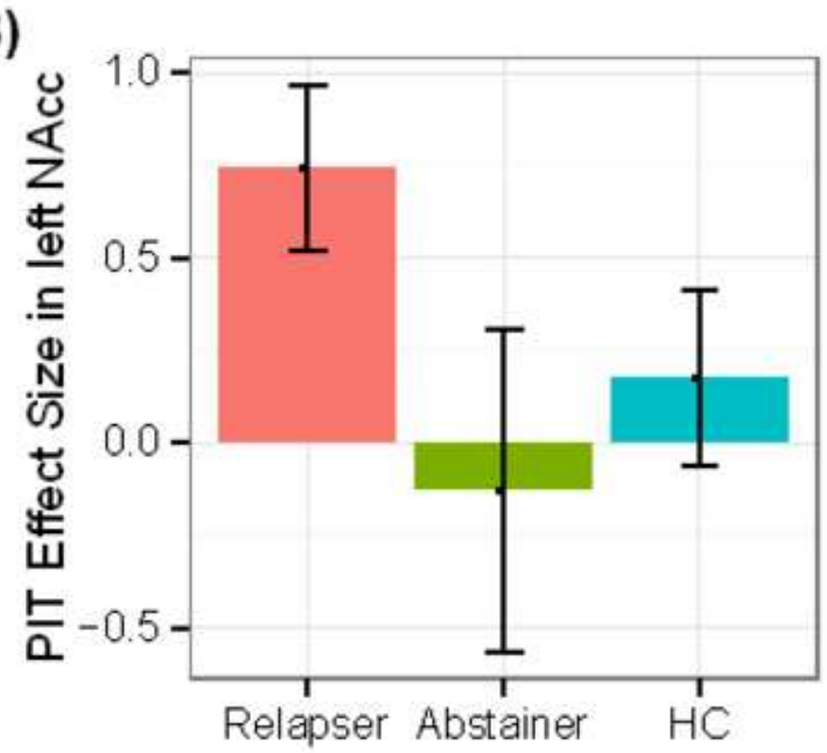
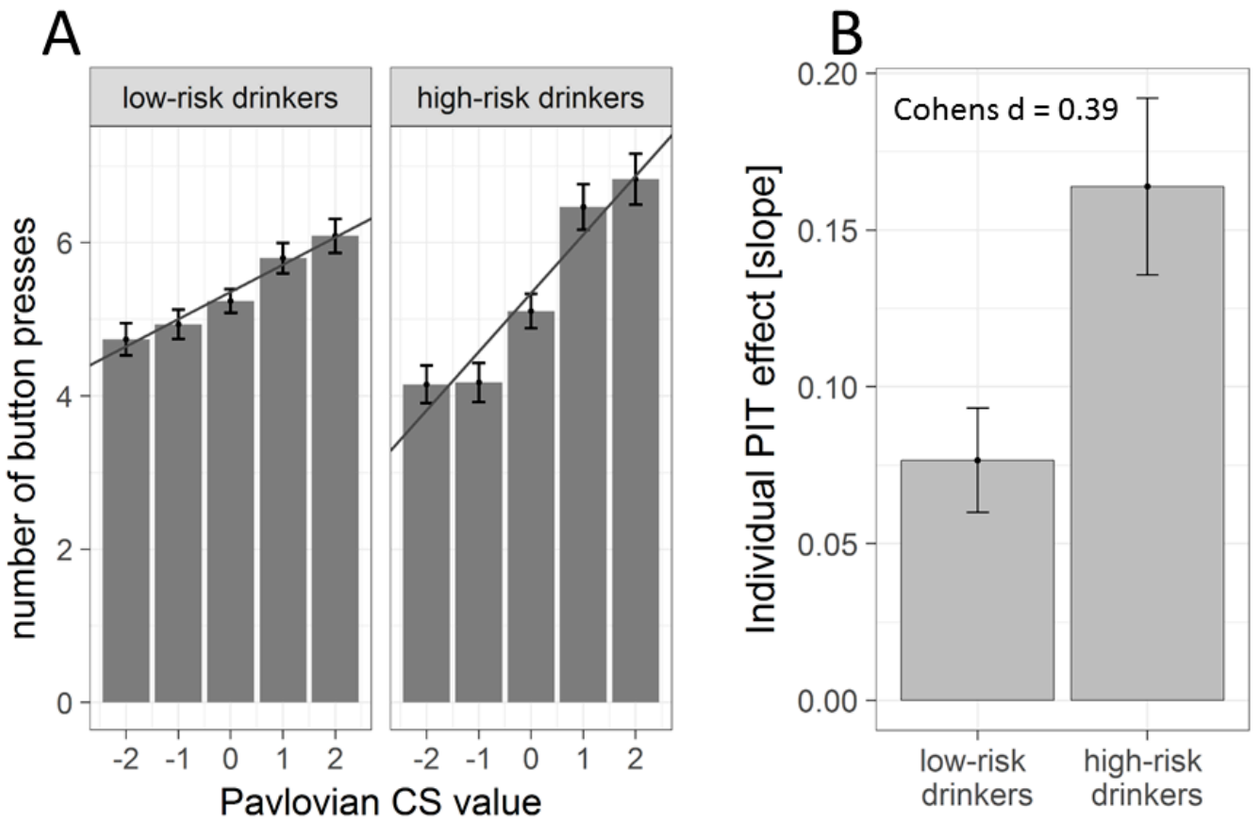
# NAcc PIT in relapsers only



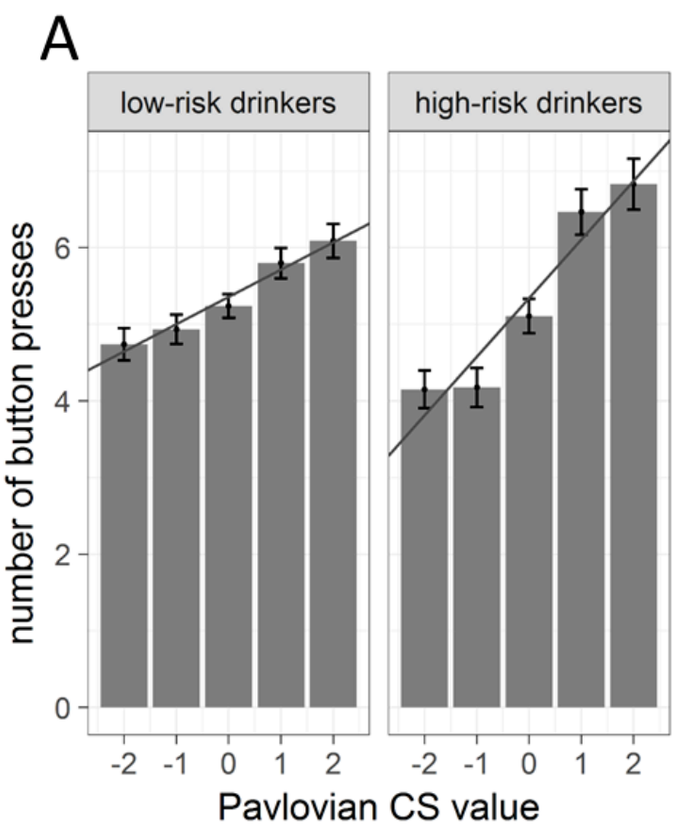

Garbusow et al., 2016

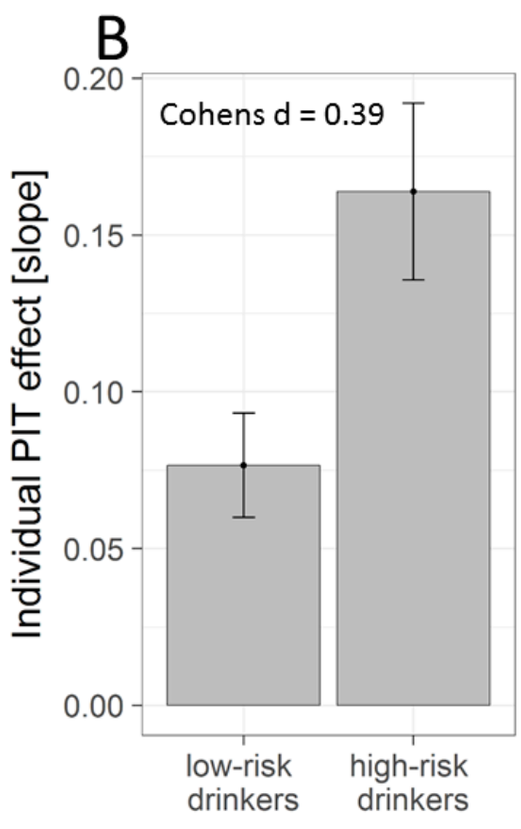
# PIT in at-risk young males

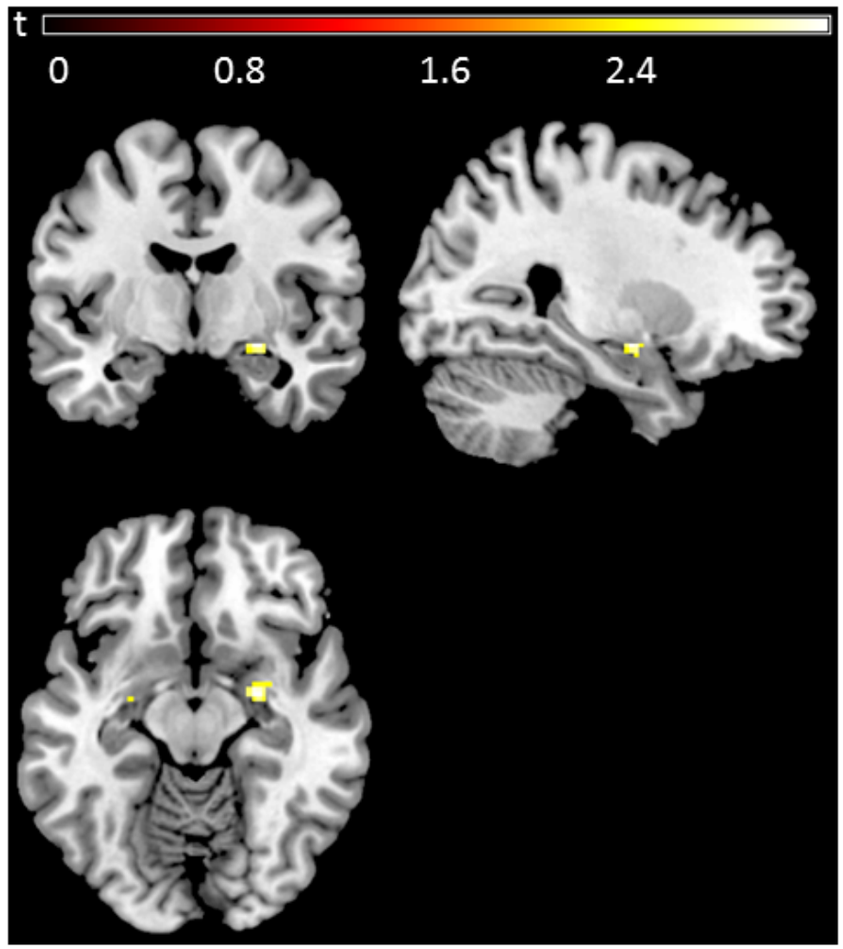



Garbusow et al., submitted

# PIT in at-risk young males



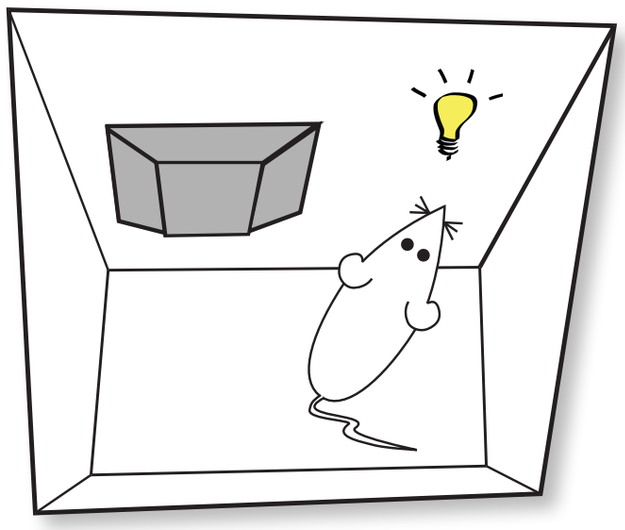




Garbusow et al., submitted

# Addictive Pavlovian values

A



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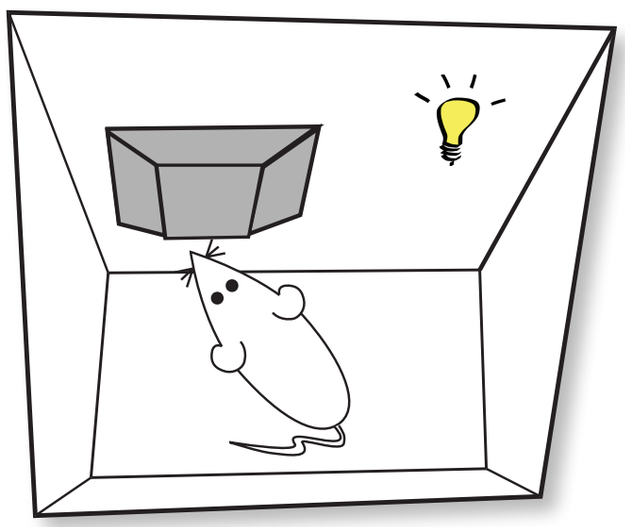
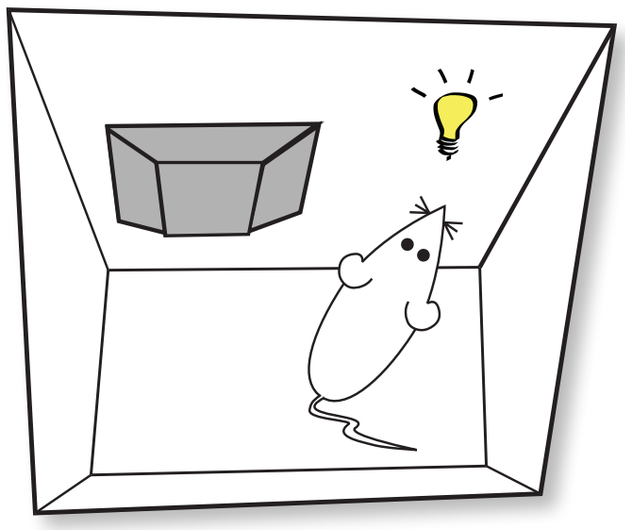


Flagel et al., 2011 Nature, Huys et al., 2014 Prog. Neurobiol.

# Addictive Pavlovian values

A



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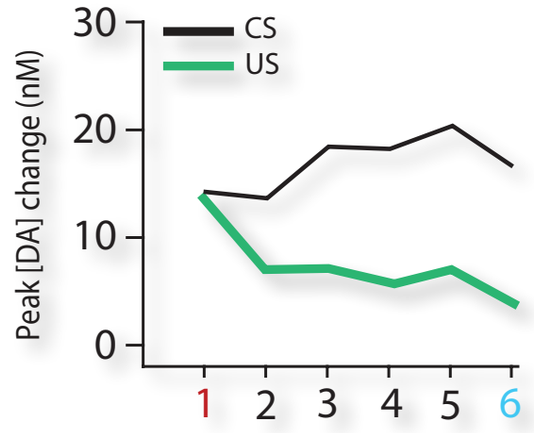


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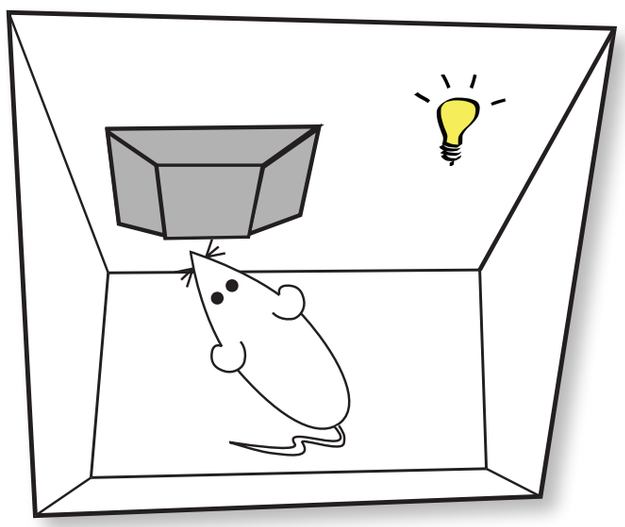

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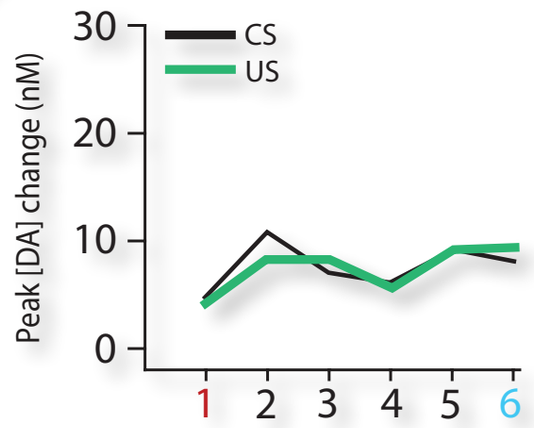
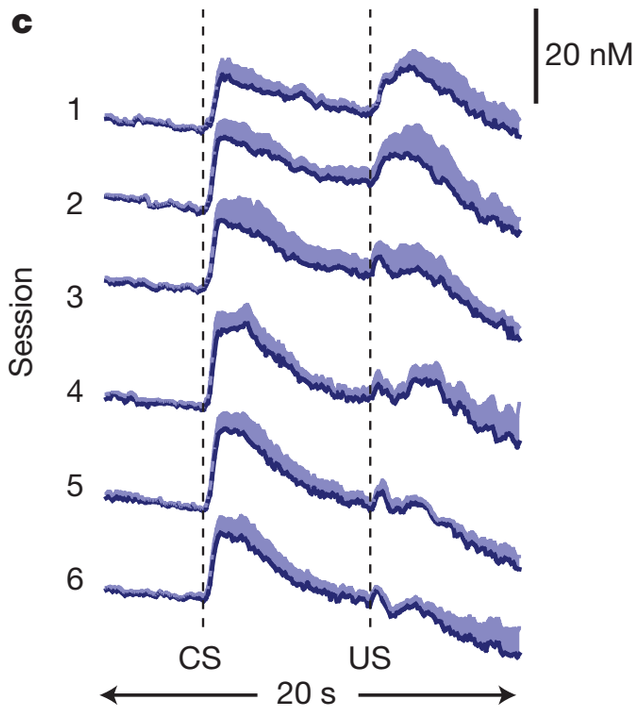


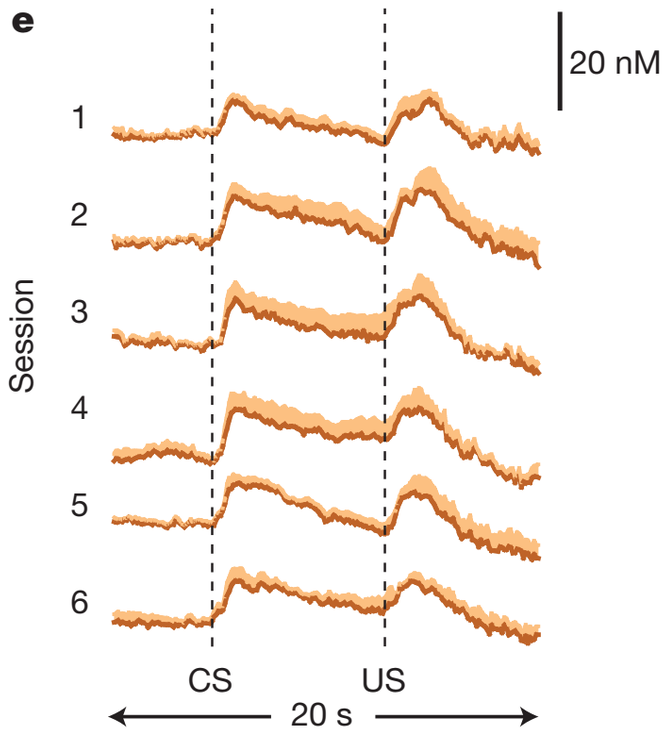

Flagel et al., 2011 Nature, Huys et al., 2014 Prog. Neurobiol.

# DA-dependent learning in STs

## Sign trackers




## Goal trackers

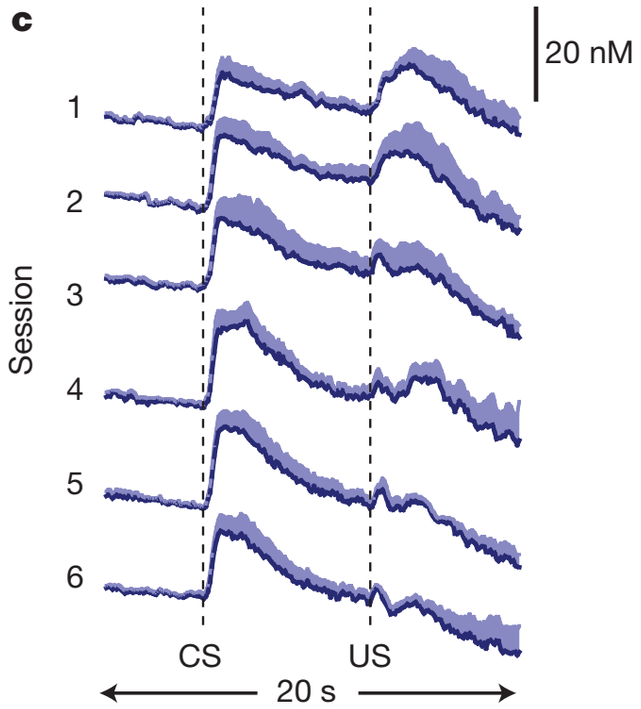



$$\delta = r - Q$$

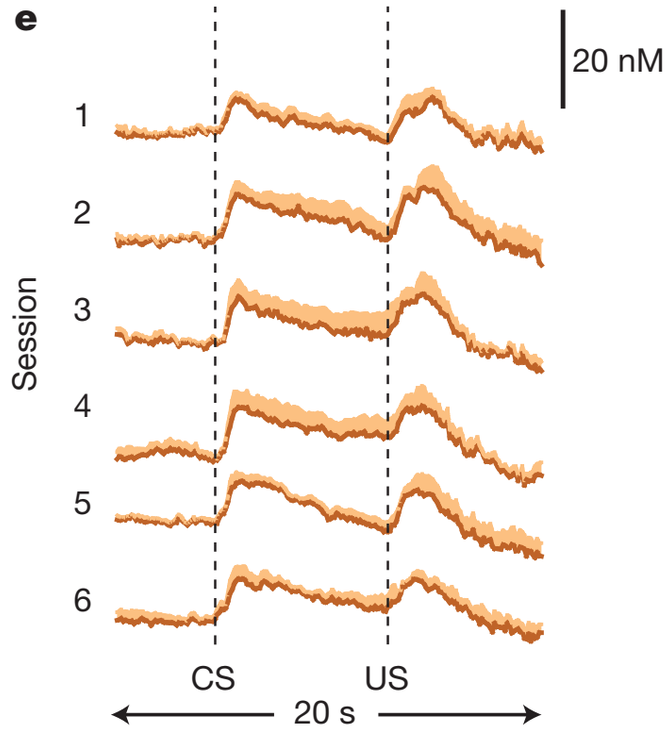
Flagel et al., 2011 Nature

# DA-dependent learning in STs

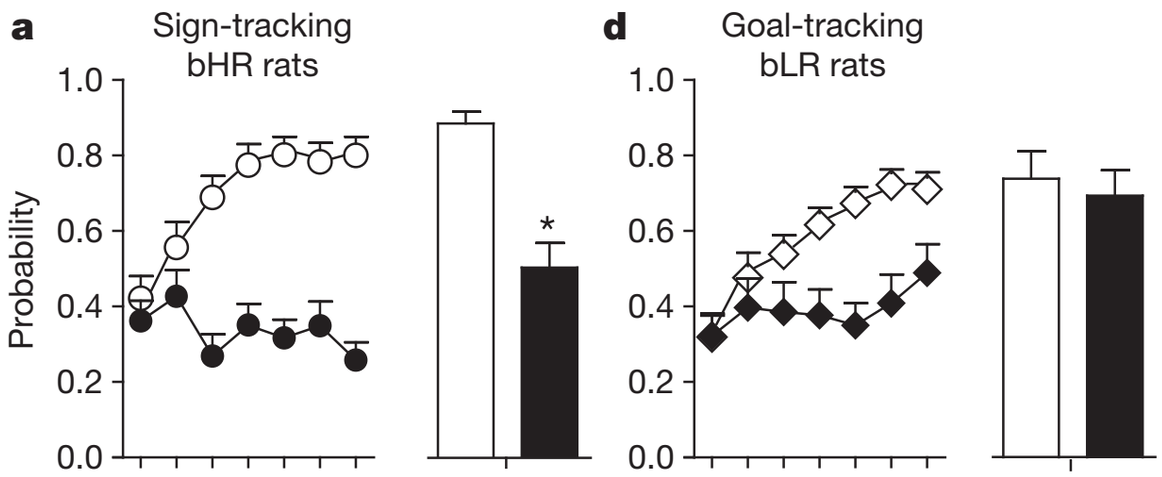
## Sign trackers




## Goal trackers




$$\delta = r - Q$$

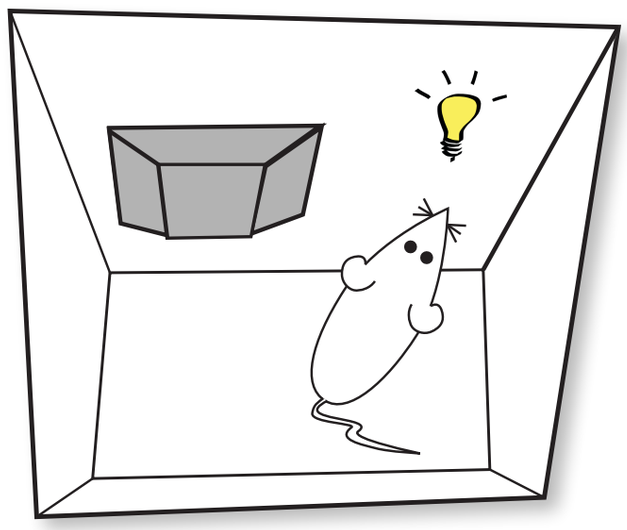



Flagel et al., 2011 Nature

# Pavlovian state values: sign tracking

## Sign trackers

A



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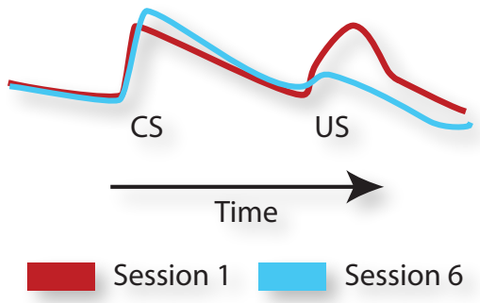


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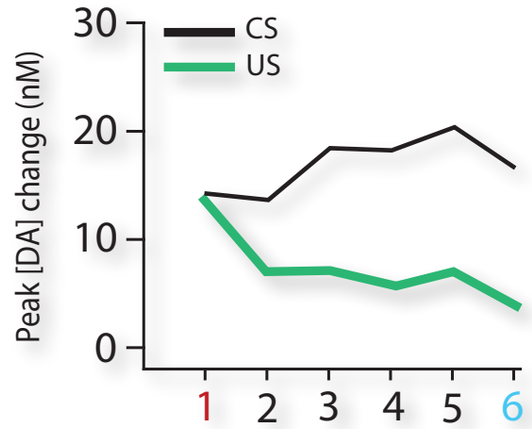
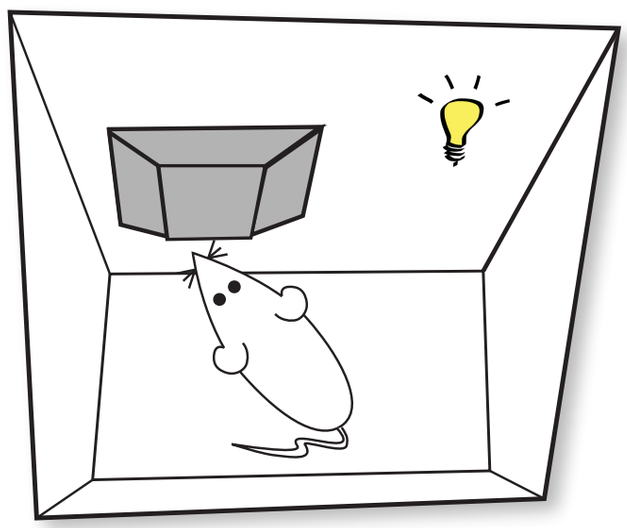



## Goal trackers

D



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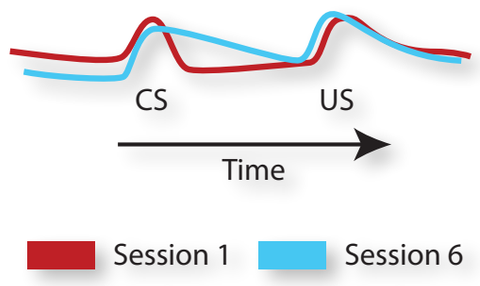


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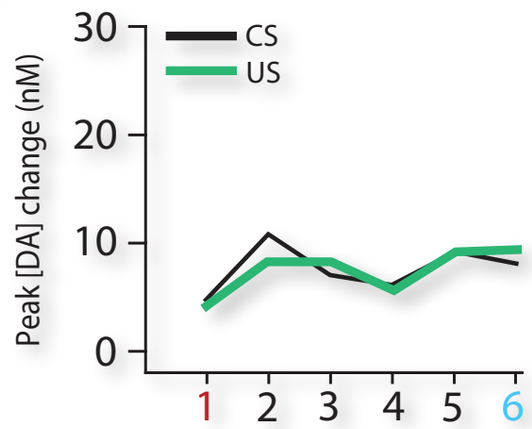
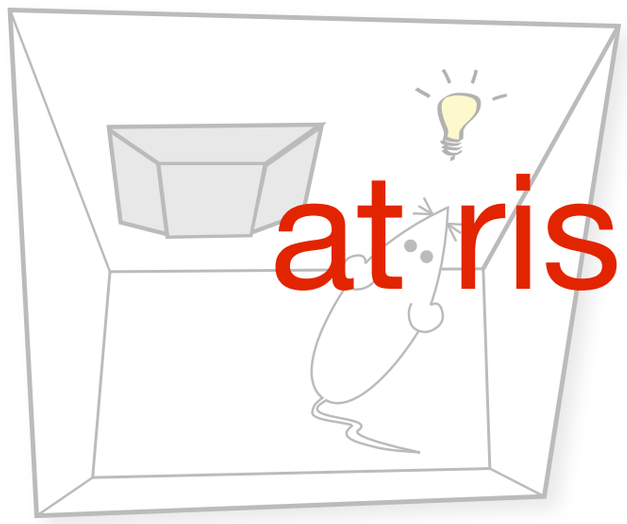



Flagel et al., 2011 Nature

# Pavlovian state values: sign tracking

## Sign trackers

A



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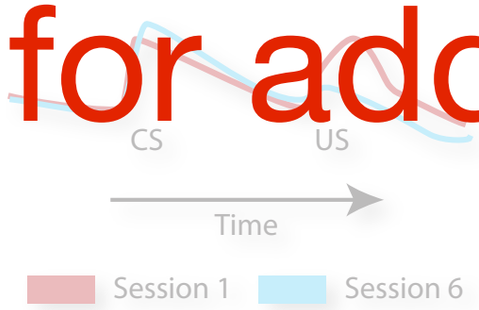


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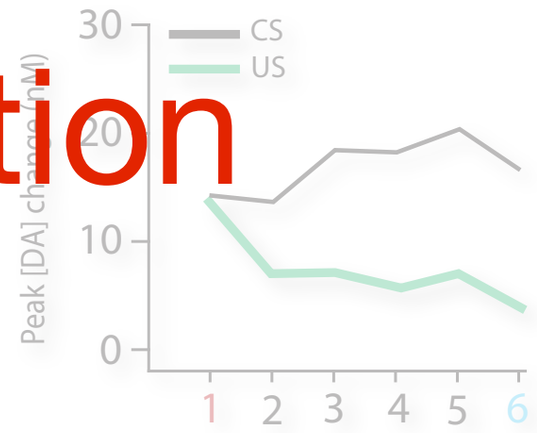
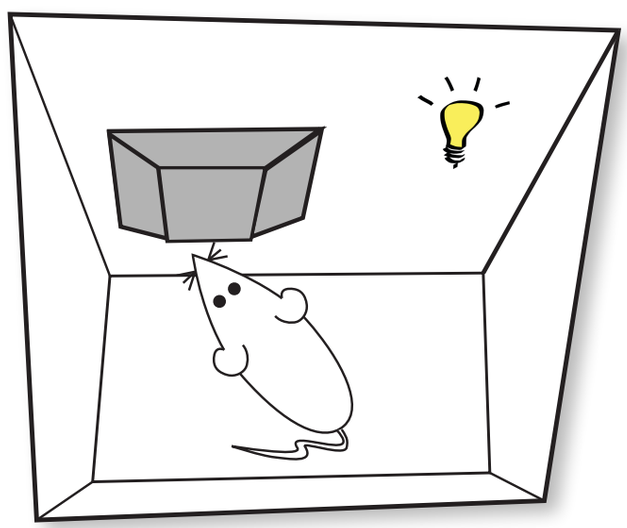



at risk for addiction

## Goal trackers

D



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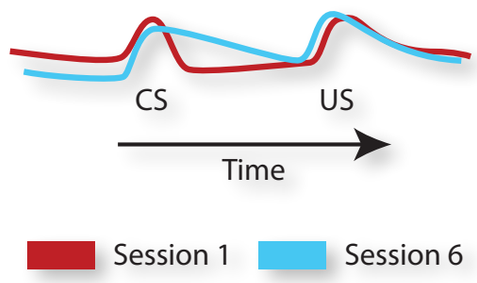


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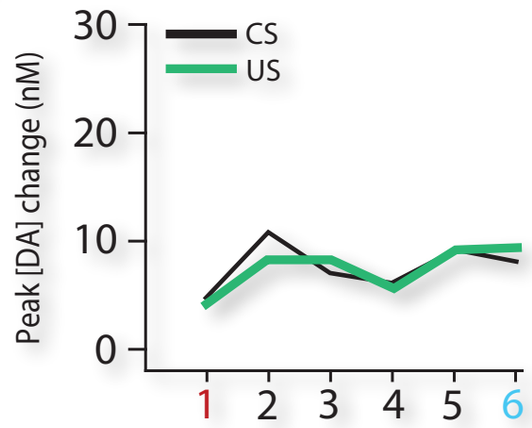
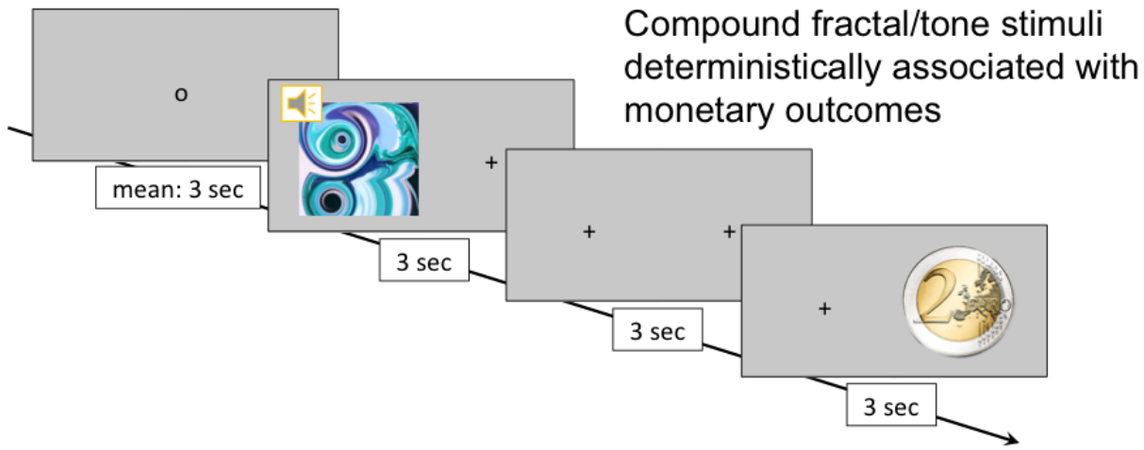



Flagel et al., 2011 Nature

# Sign-tracking in humans?

Experimental Paradigm
Pavlovian Conditioning

n=129

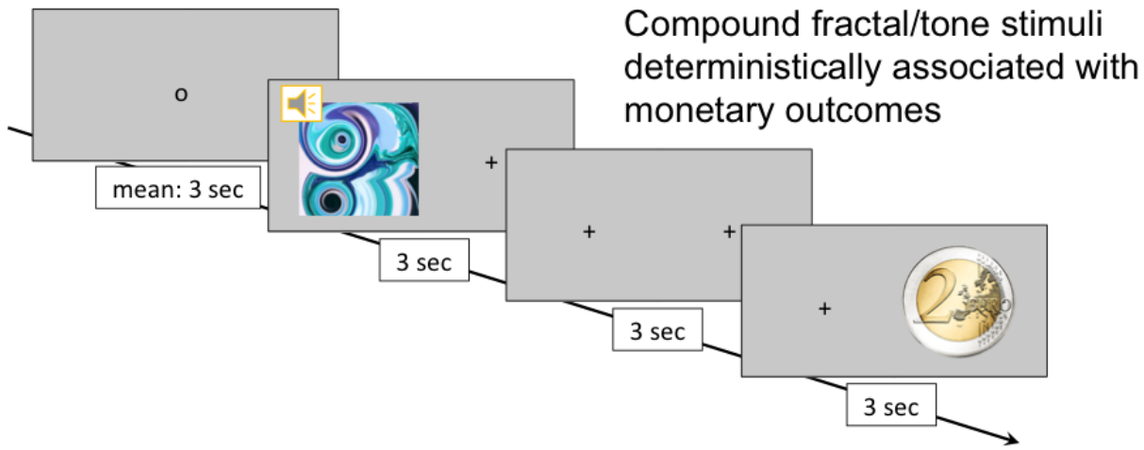


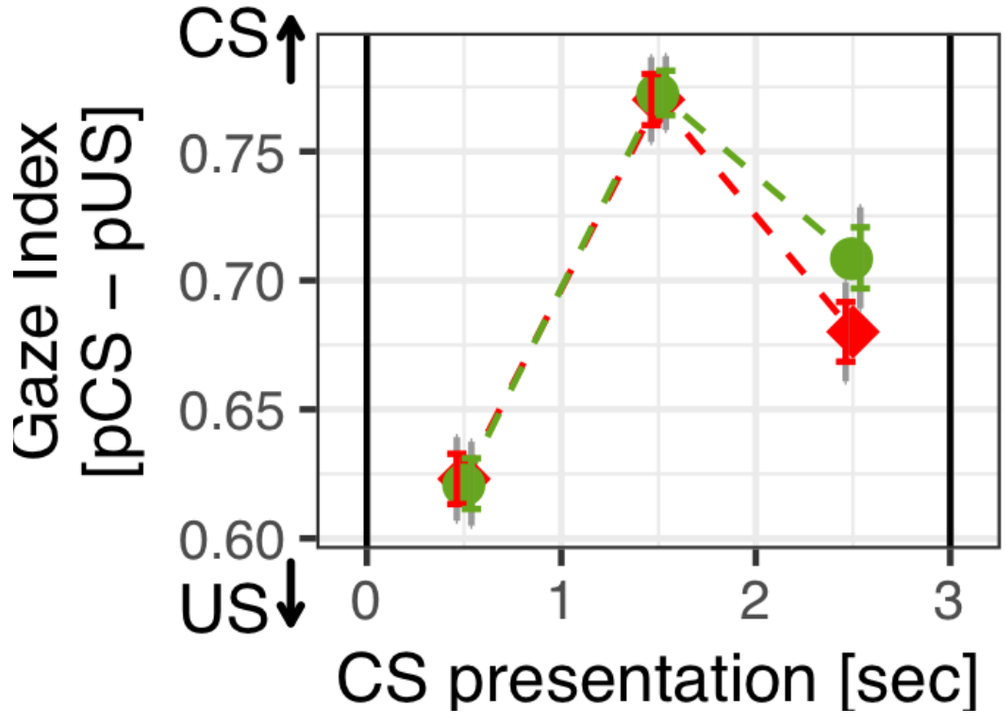

Schad, …, Huys (2017) in prep

# Sign-tracking in humans?

Experimental Paradigm
Pavlovian Conditioning

n=129



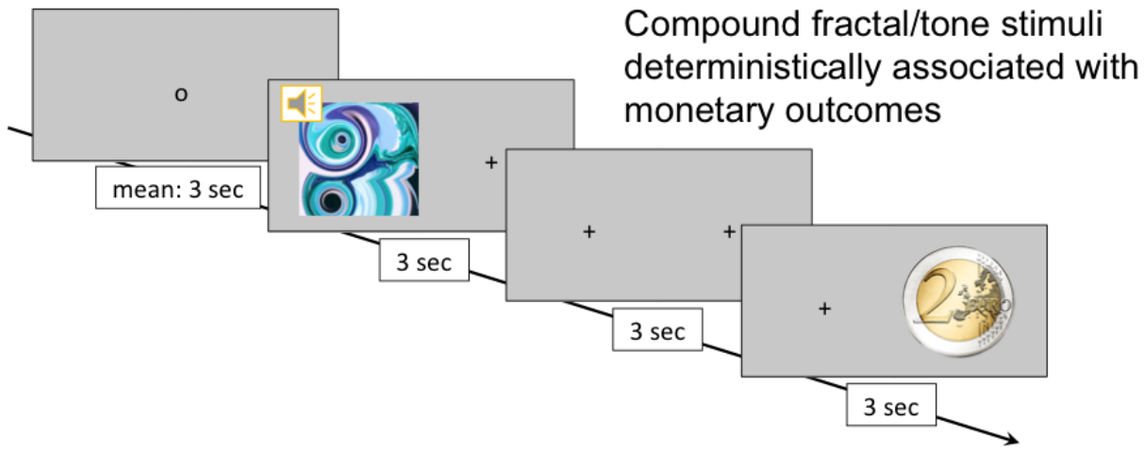



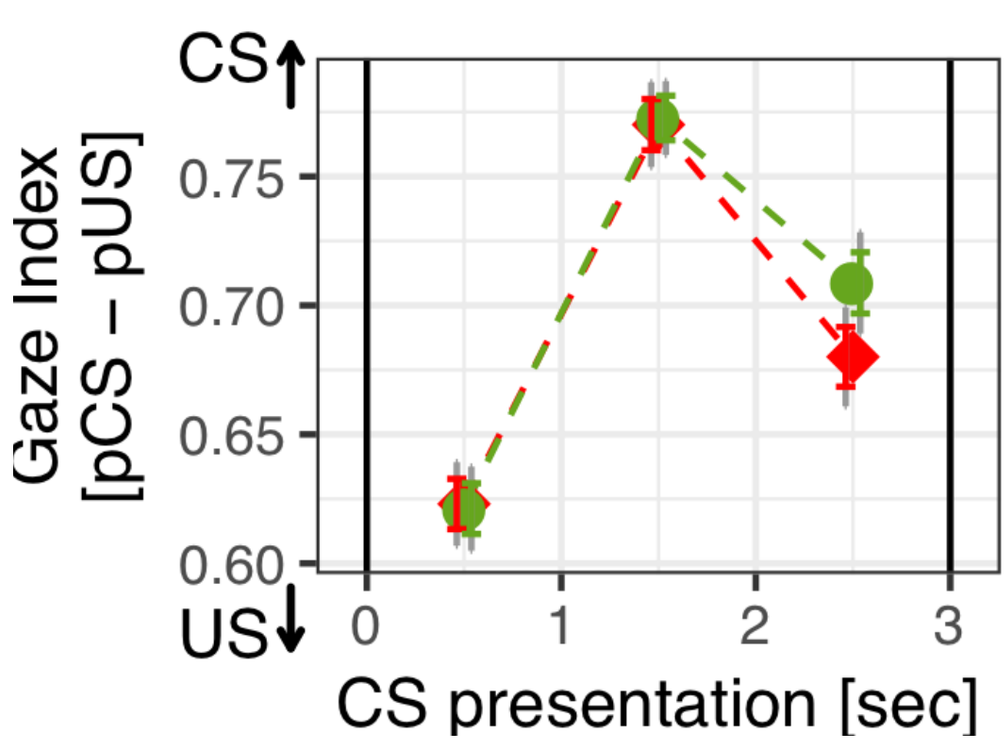

Schad, …, Huys (2017) in prep

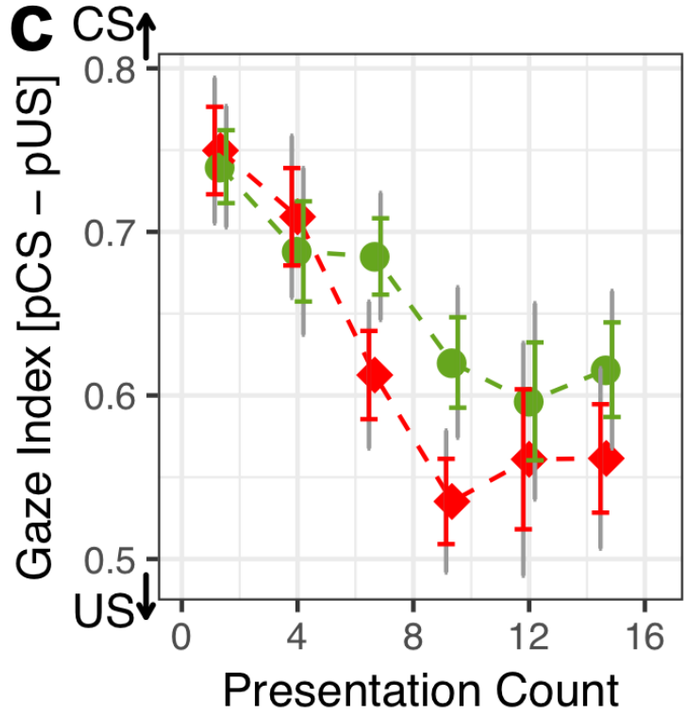
# Sign-tracking in humans?

Experimental Paradigm
Pavlovian Conditioning

n=129

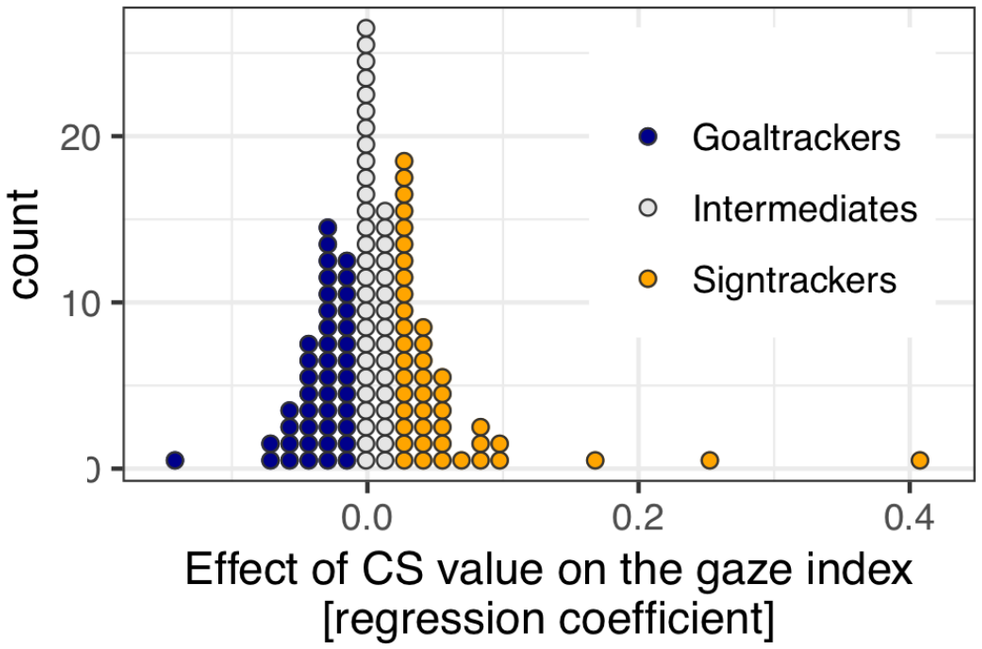


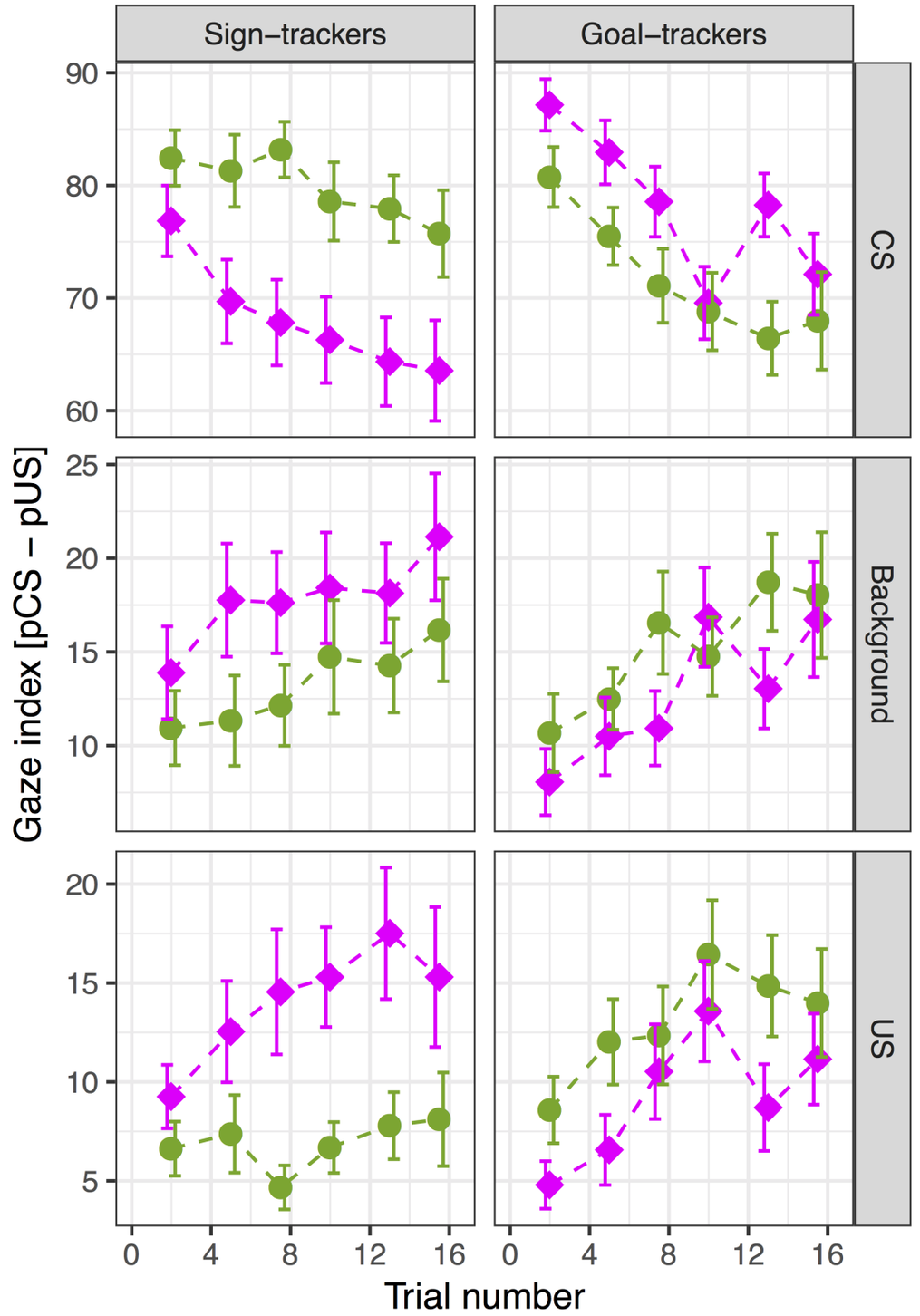



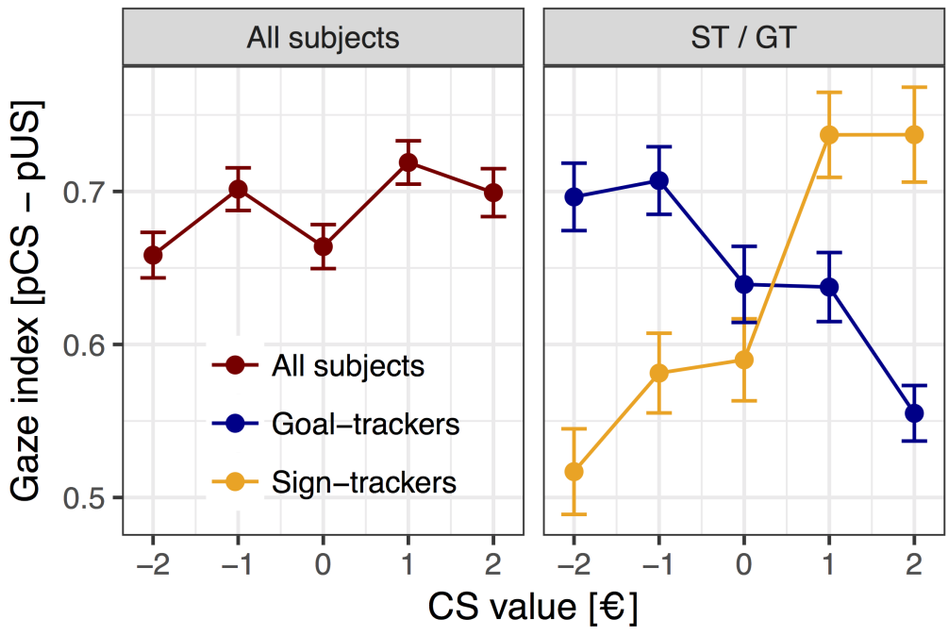




Schad, …, Huys (2017) in prep

# Distinguishing STs and GTs

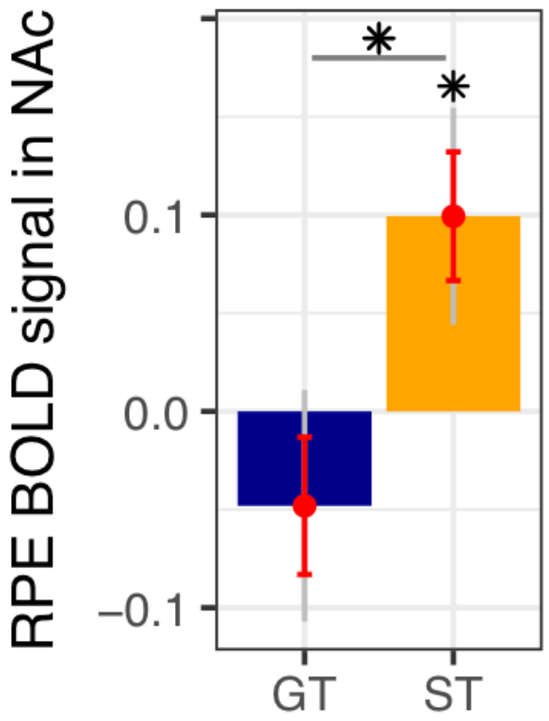


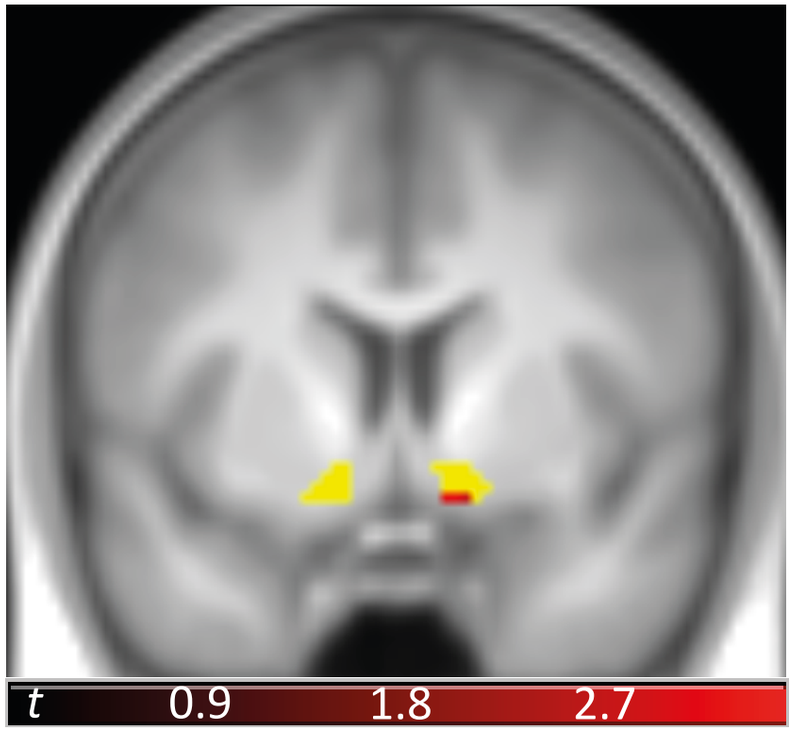

Schad, …, Huys (2017) in prep

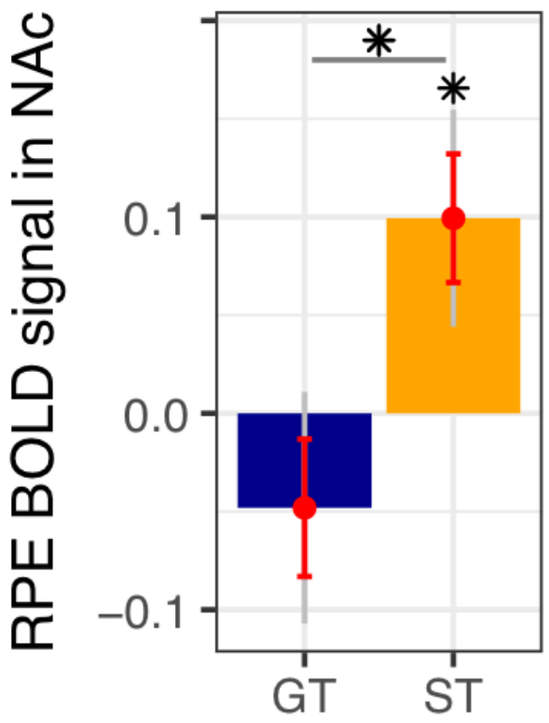
# STs only show BOLD RPE




Schad, …, Huys (2017) in prep

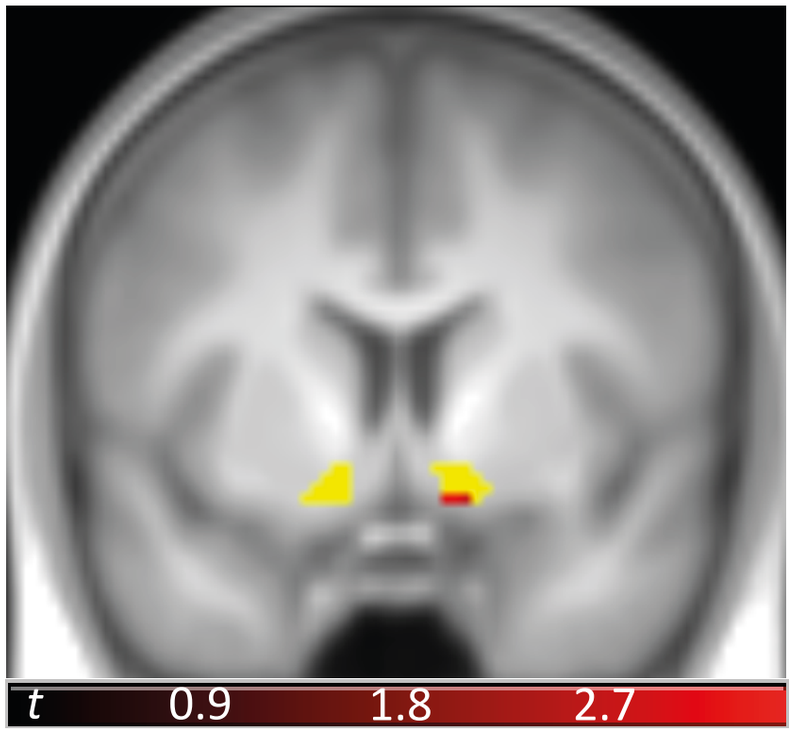
# STs only show BOLD RPE

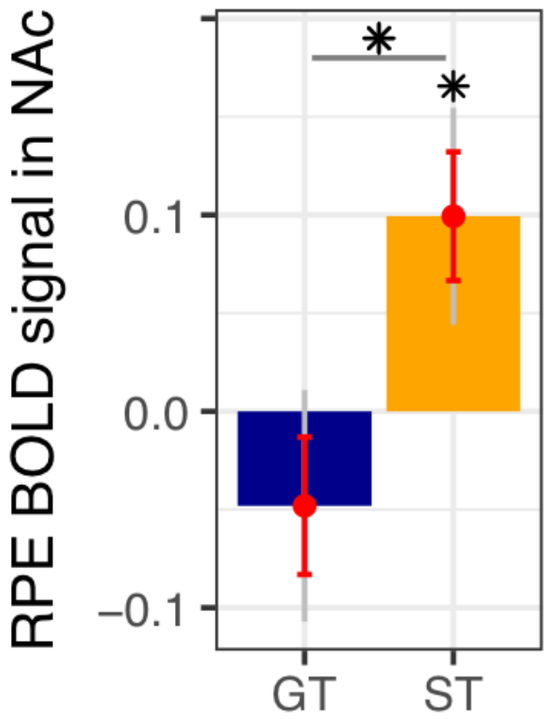


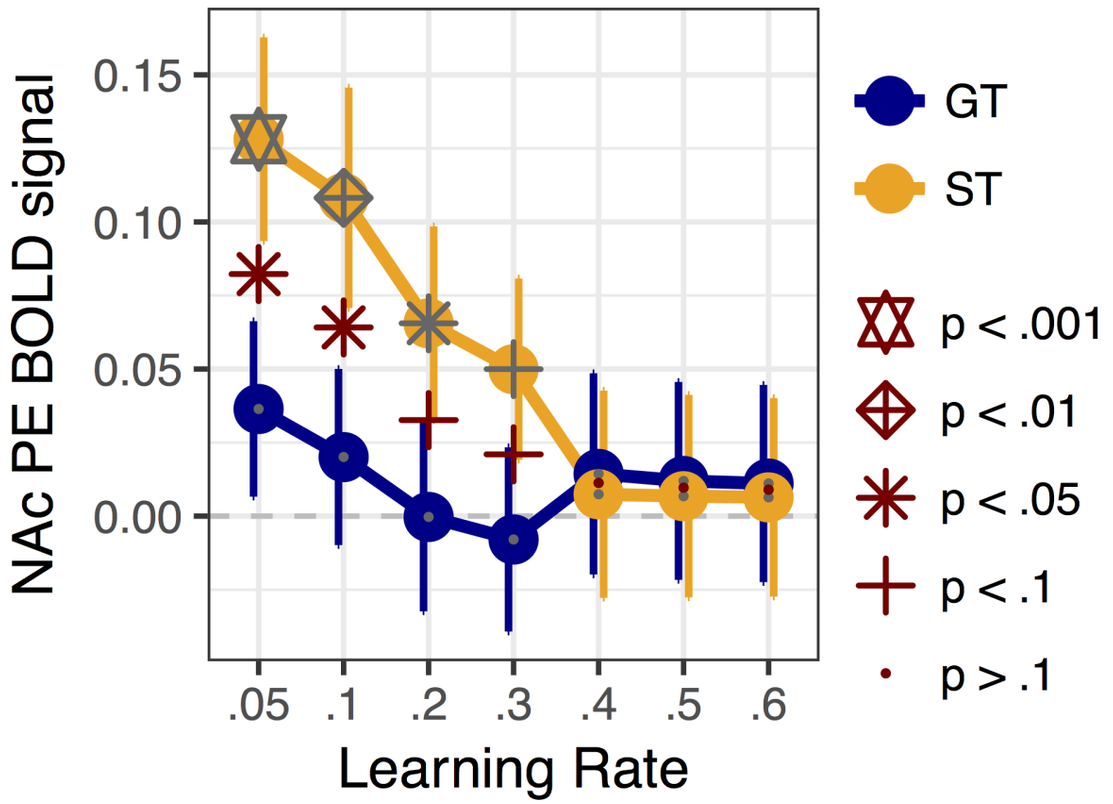




Schad, …, Huys (2017) in prep

# STs only show BOLD RPE

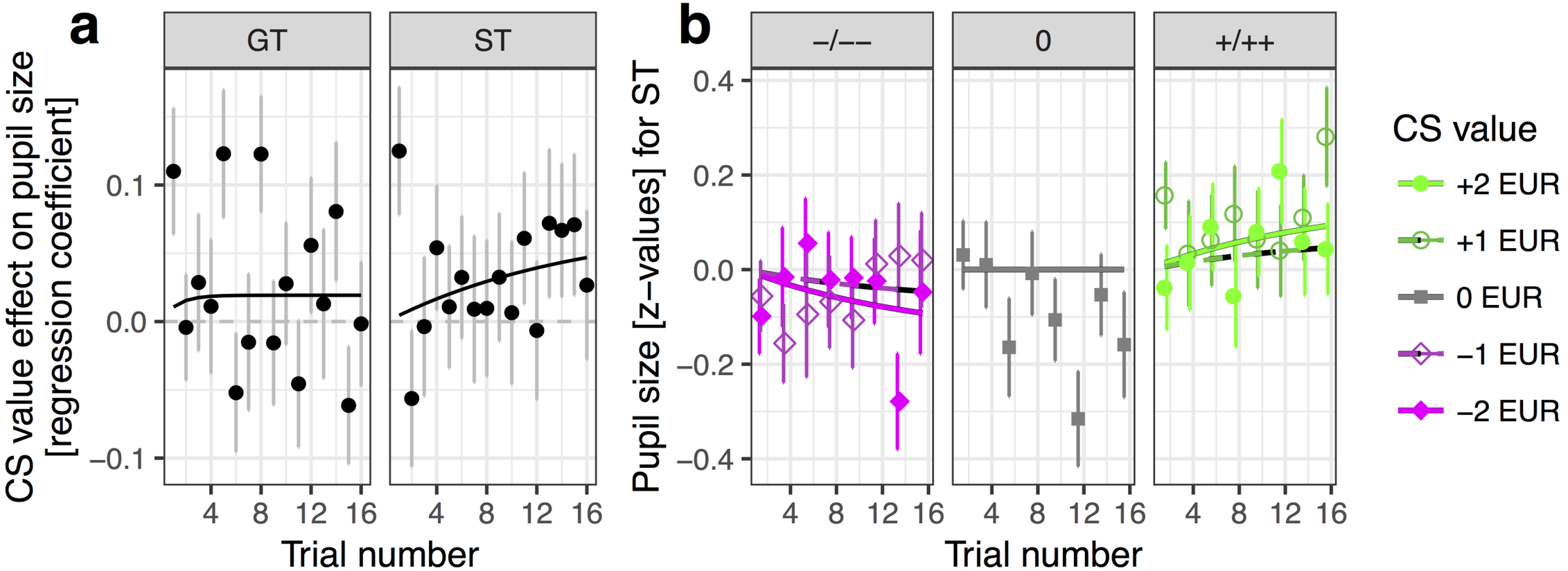


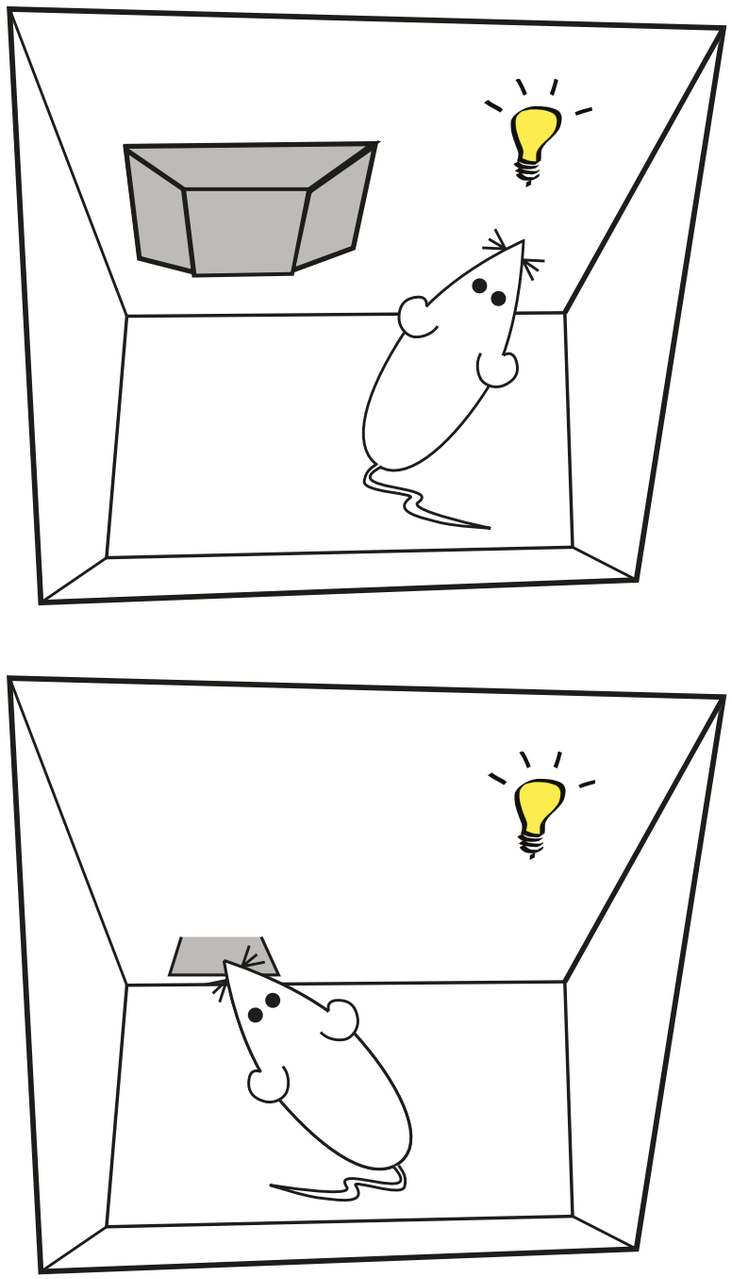

Schad, …, Huys (2017) in prep

# Pupil size accommodates in STs only



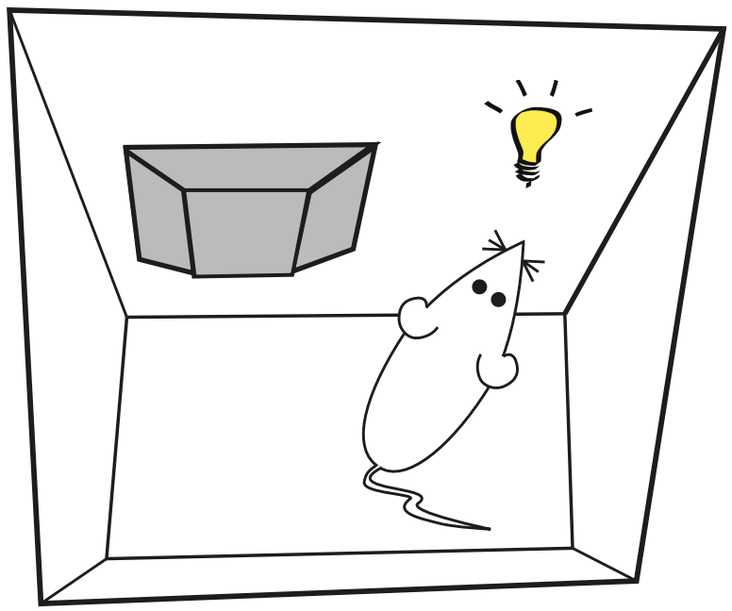

Schad, …, Huys (2017) in prep

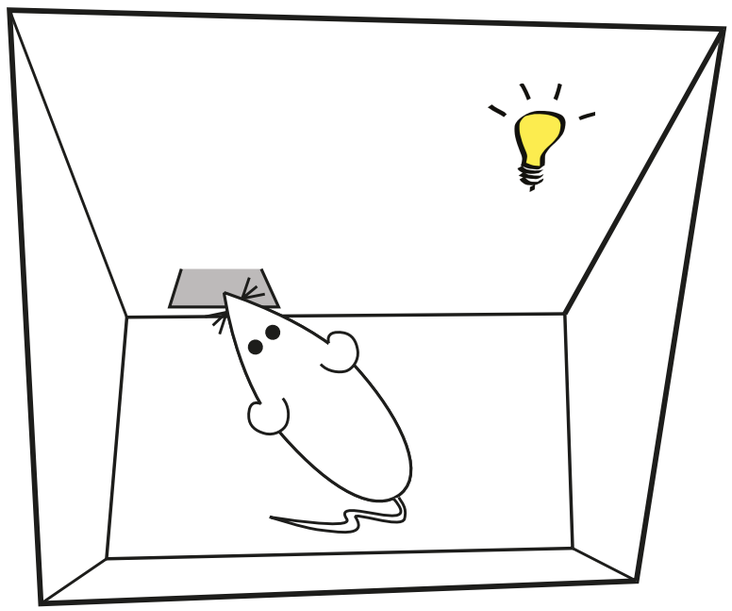
# Pavlovian-Instrumental Transfer



Schad, …, Huys (2017) in prep

# Pavlovian-Instrumental Transfer

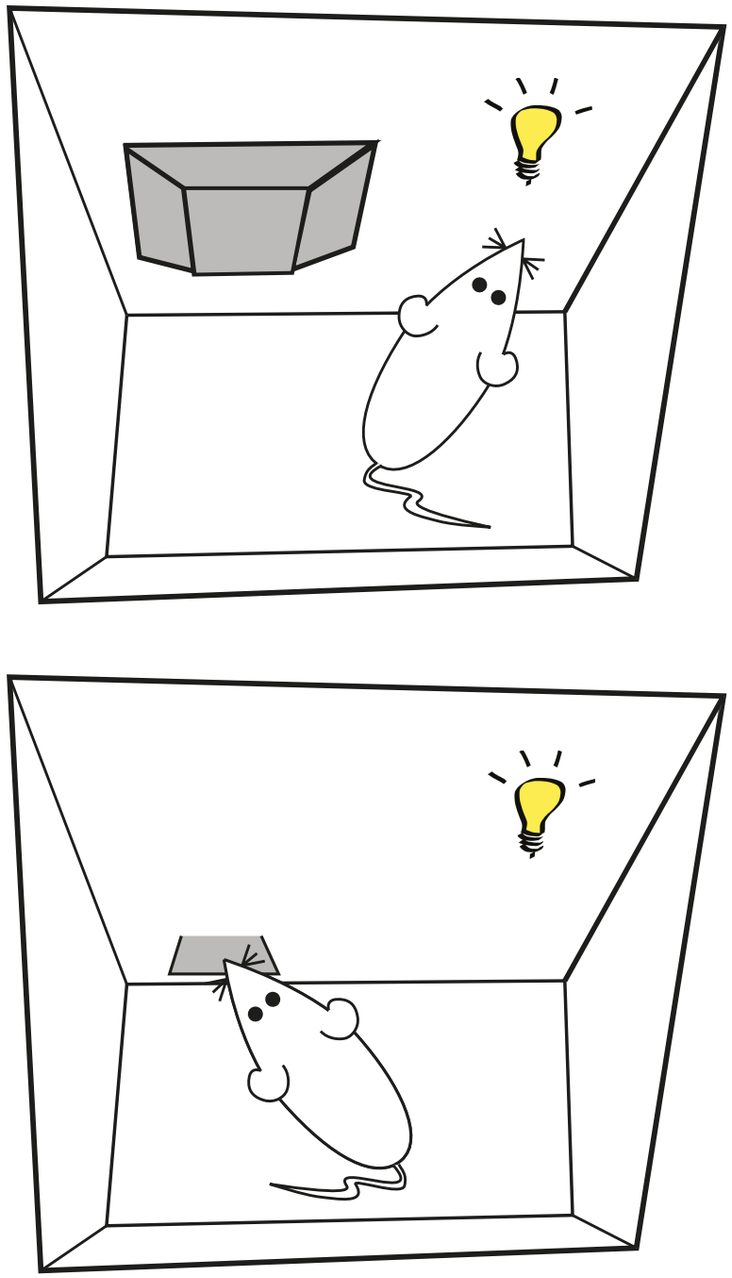




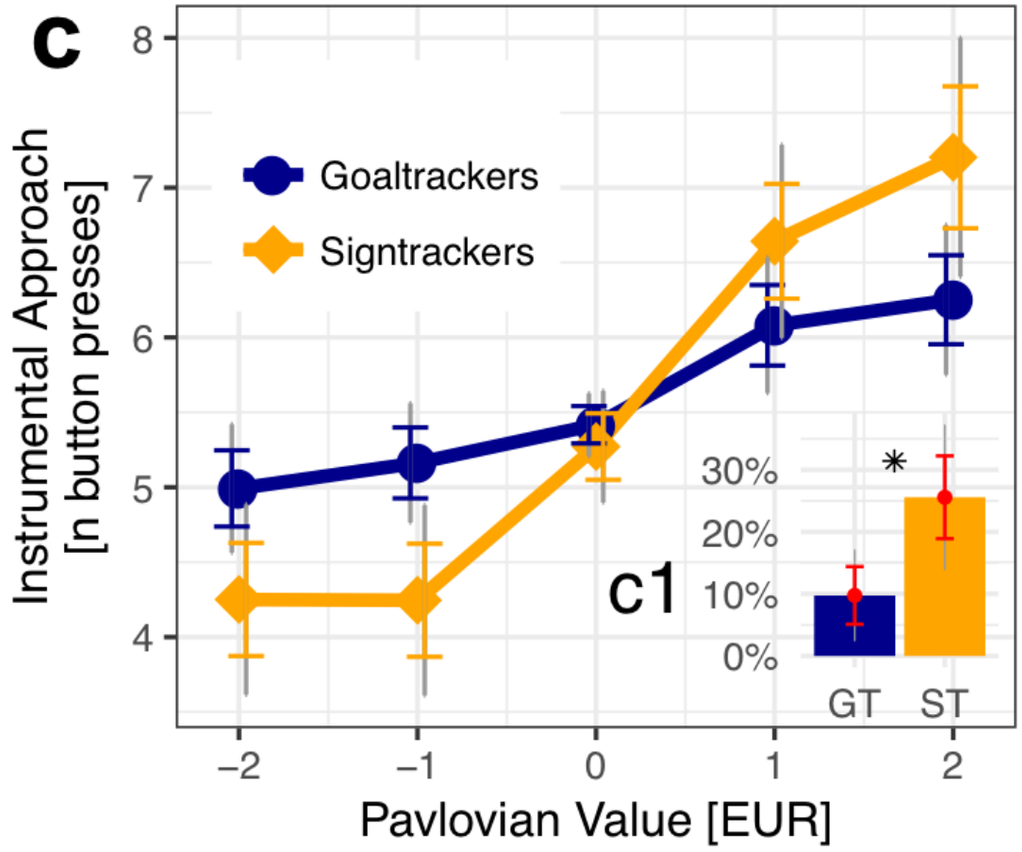
Stimulus control

Schad, …, Huys (2017) in prep

# Pavlovian-Instrumental Transfer

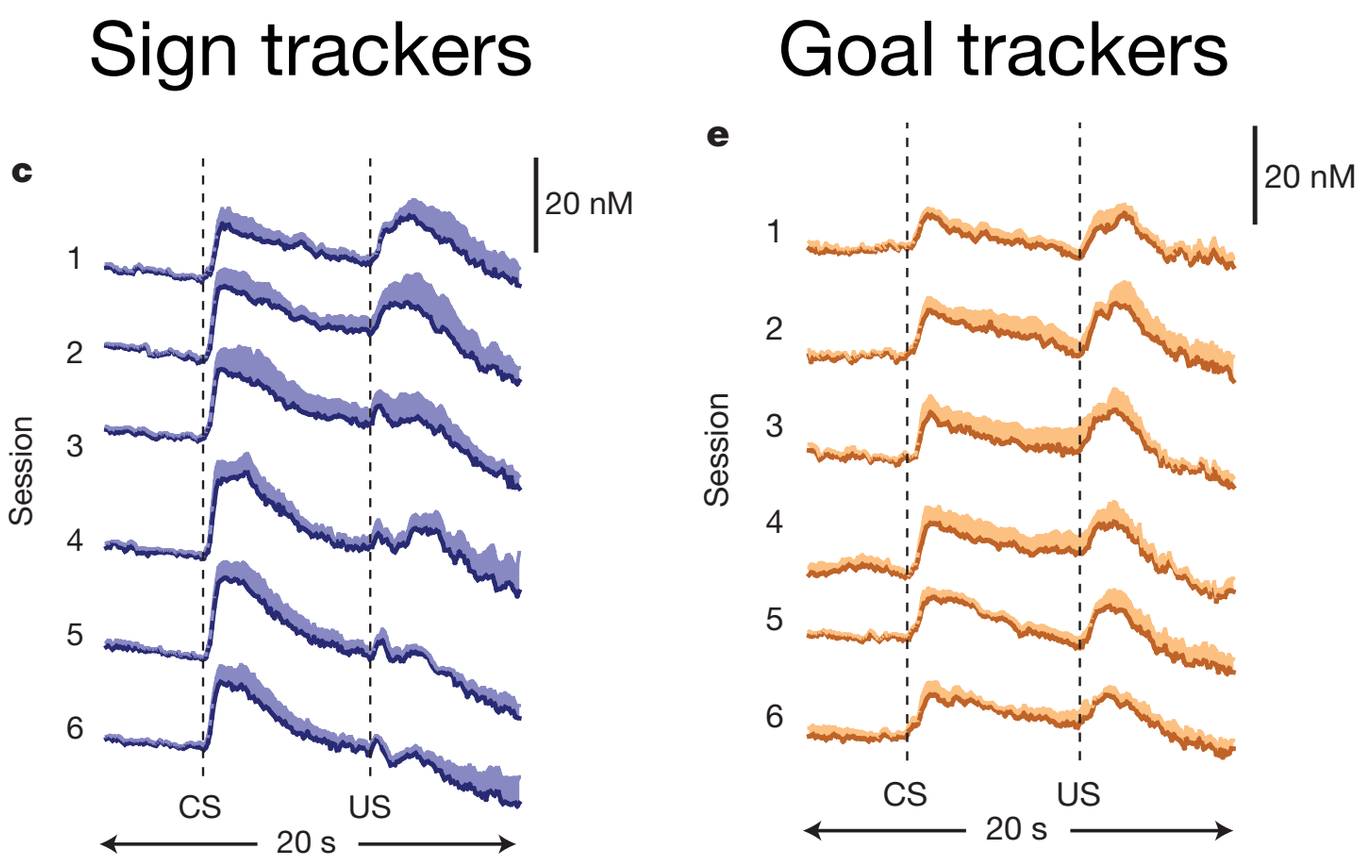


## Stimulus control




Schad, …, Huys (2017) in prep

# Absent model?

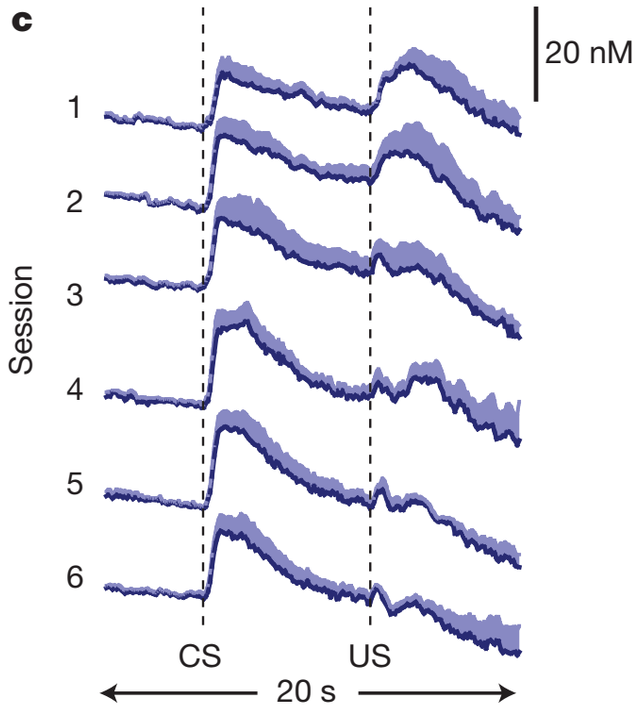



$$\delta = r - Q$$

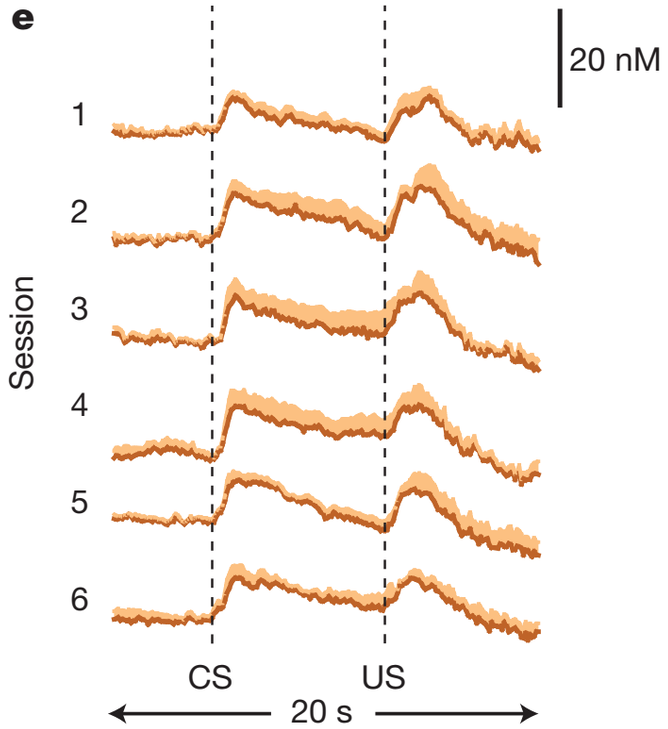
Flagel et al., 2011 Nature

# Absent model?

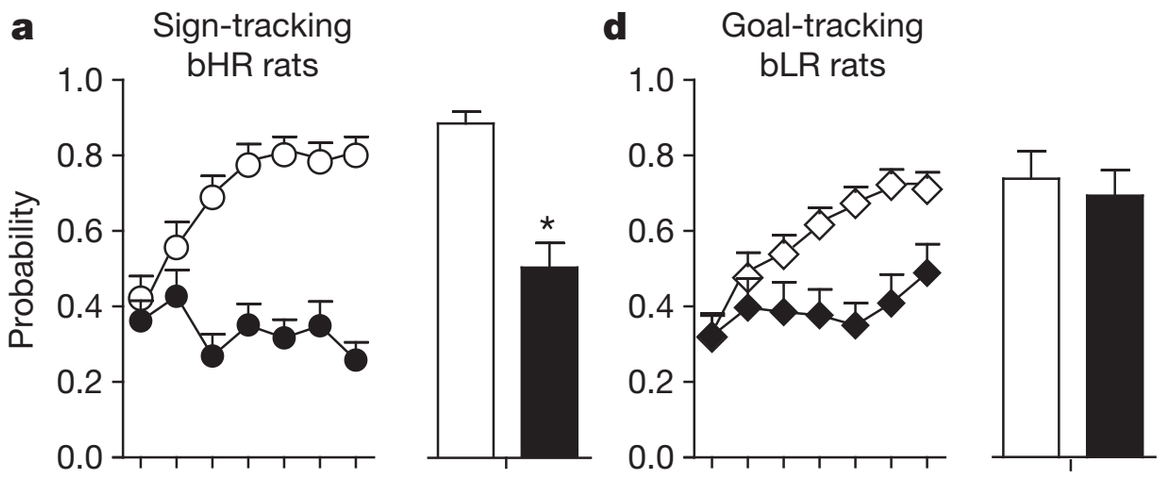
## Sign trackers




## Goal trackers

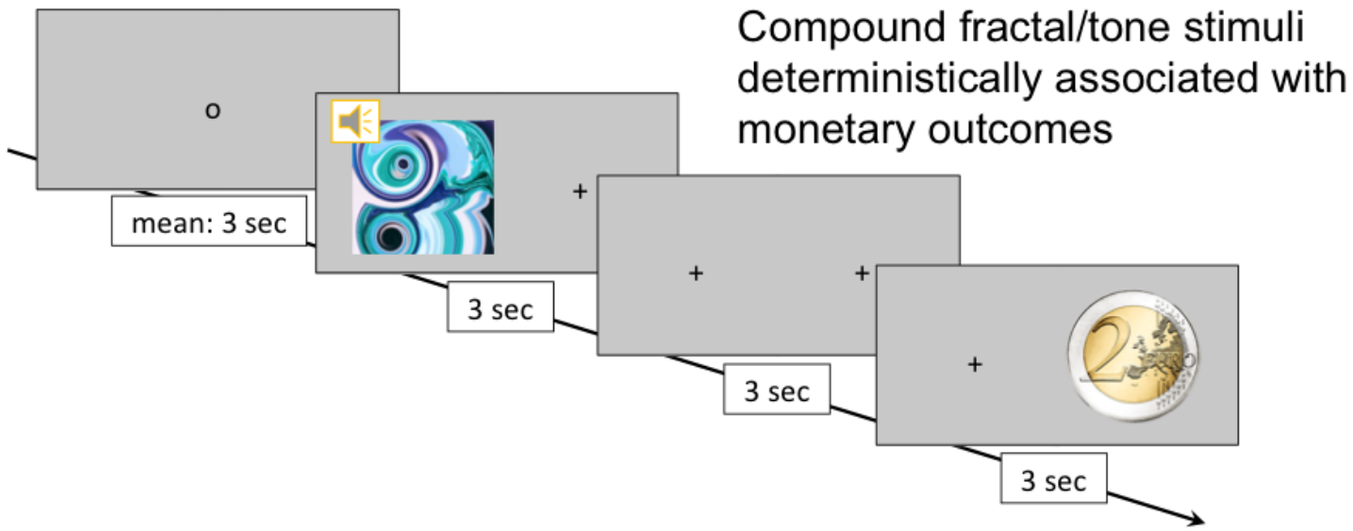



$$\delta = r - Q$$




Flagel et al., 2011 Nature

# Goal-tracking in humans?




Compound fractal/tone stimuli deterministically associated with monetary outcomes

ST: learn expected value V
GT: learn mappings T from CS to US identity

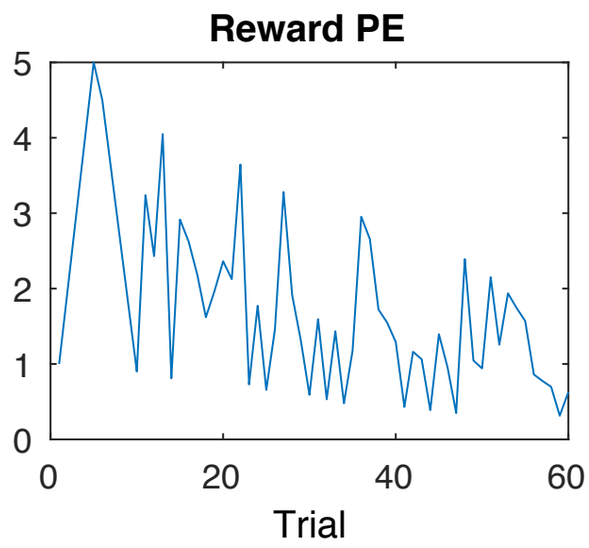
$$\mathcal{V}(s) = \sum_a \pi(a;s) \sum_{s'} \mathcal{T}(s'|s,a)[\mathcal{R}(s',a,s) + \mathcal{V}(s')]$$

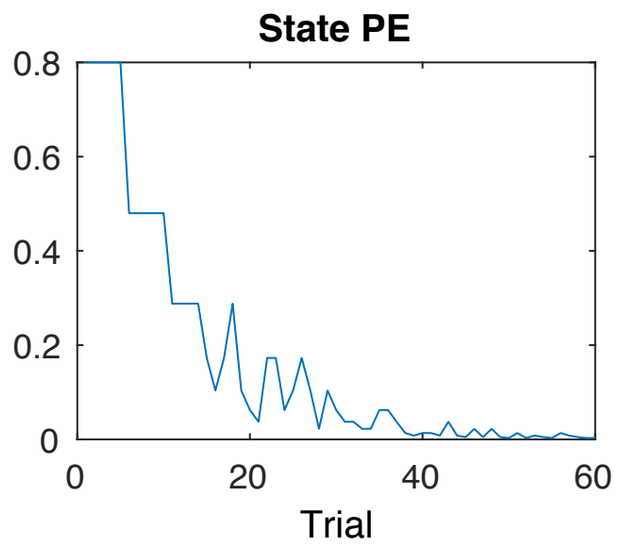
Schad et al., in prep

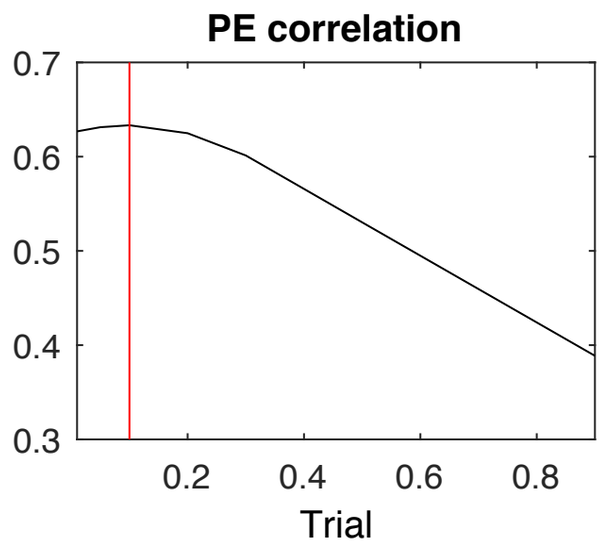
# Pavlovian learning in ST vs GT

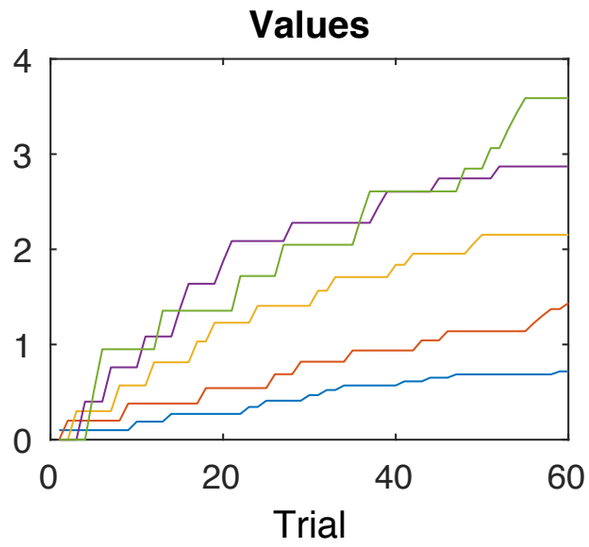
$$\mathcal{V}_t(s) = \mathcal{V}_{t-1}(s) + \alpha^r \, \delta_t^r \qquad \mathcal{T}_t(cs, us) = \mathcal{T}_{t-1}(cs, us) + \alpha^s \, \delta_t^s$$

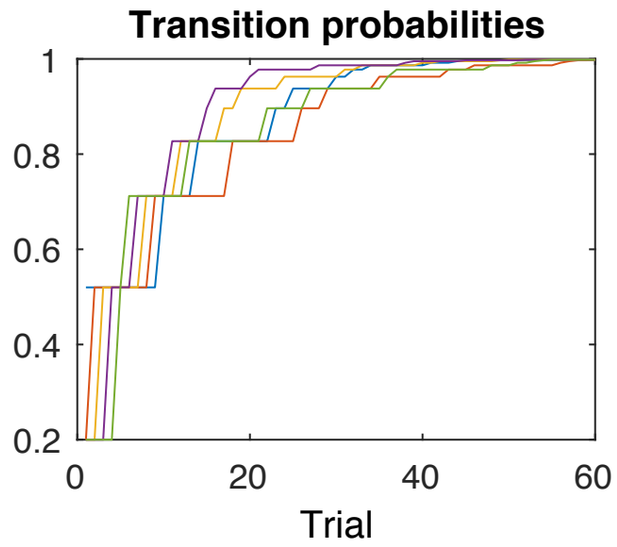
$$\delta_t^r = r_t - \mathcal{V}_{t-1}(s) \qquad \delta_t^s = 1 - \mathcal{T}_{t-1}(cs, us)$$

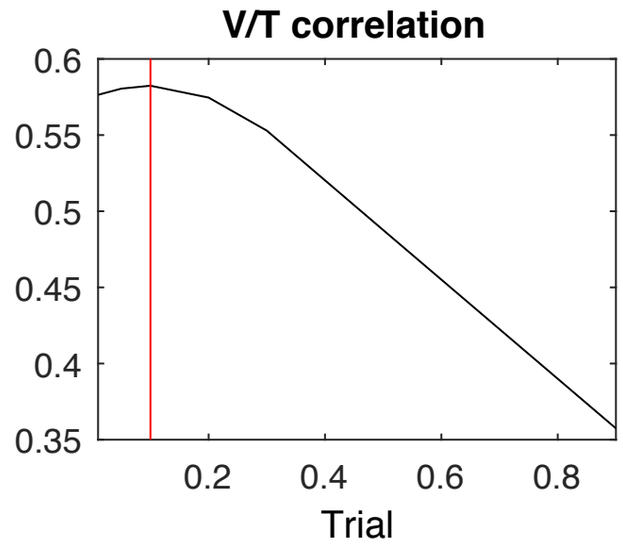


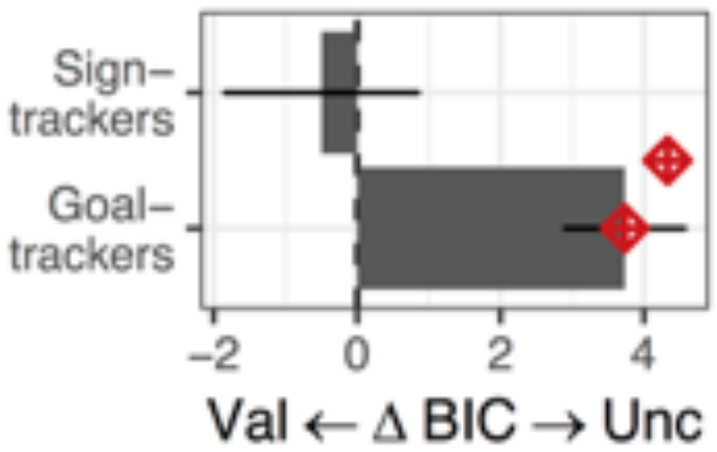



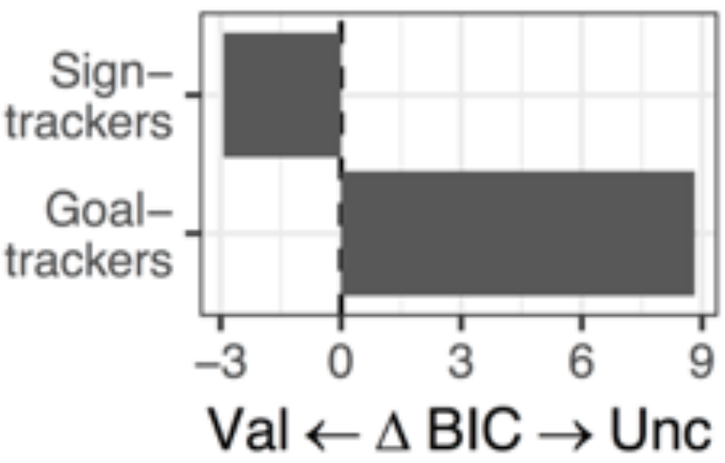



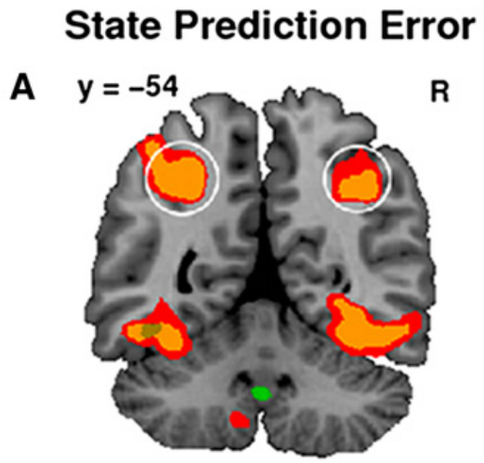
# Goal-tracking signatures

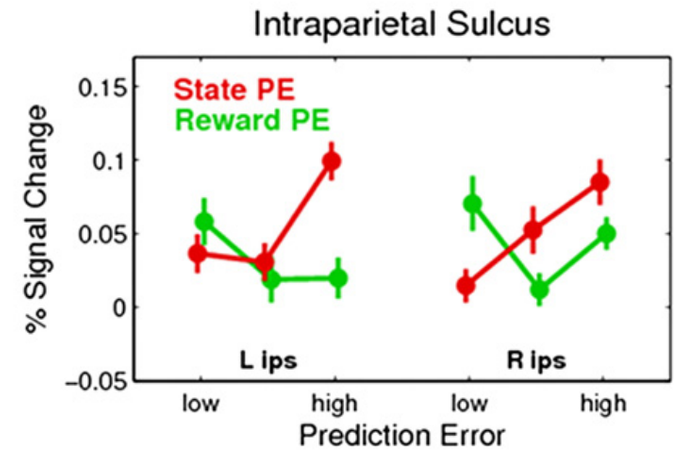
## Gaze

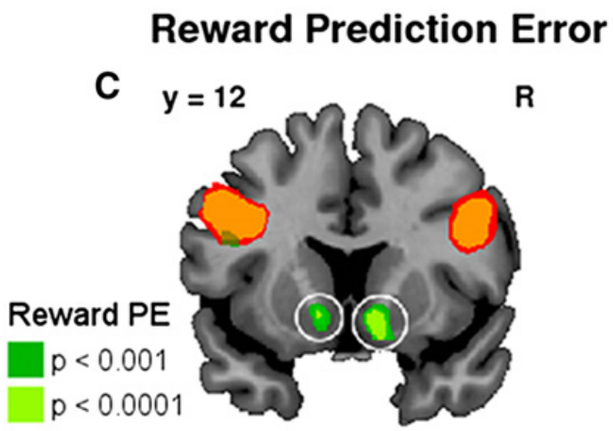


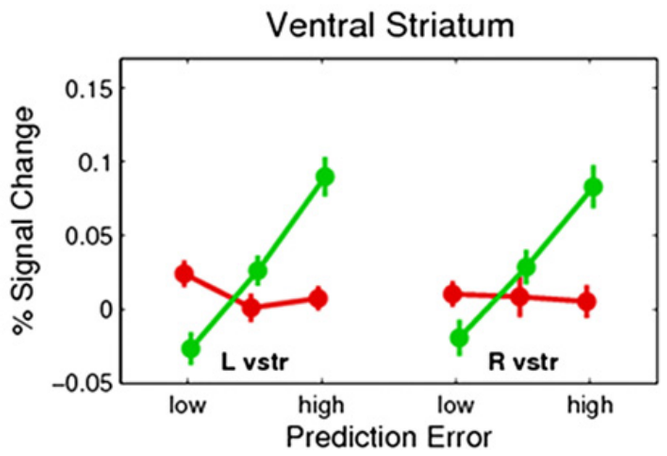

## Pupil



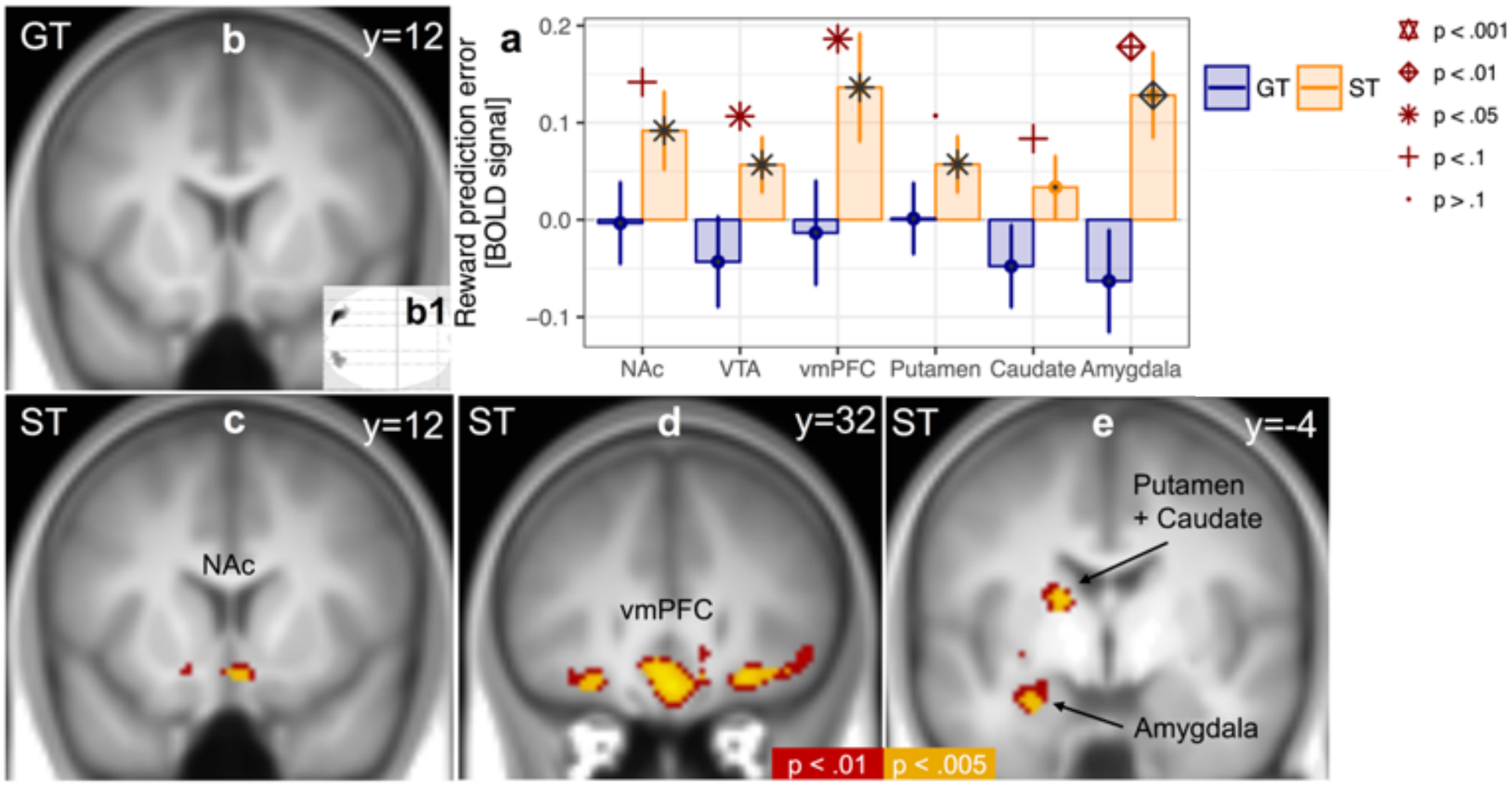



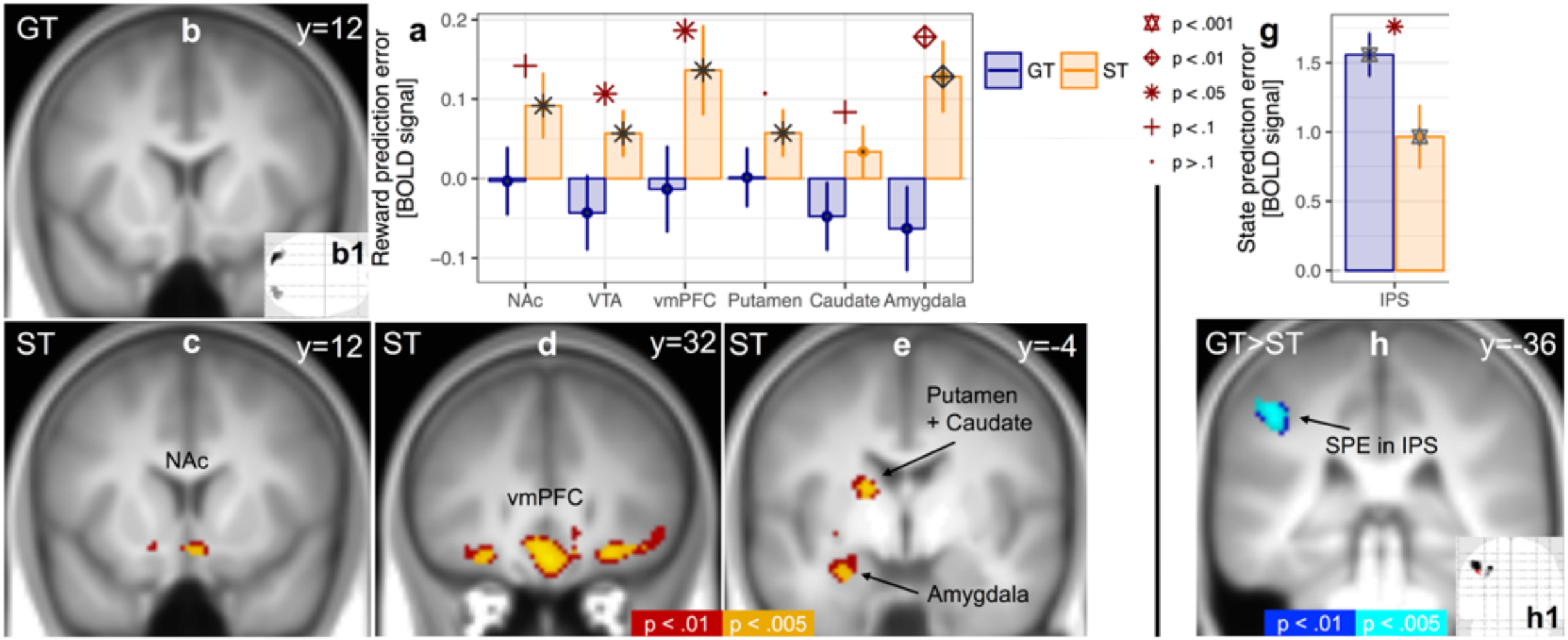

Schad et al., in prep, Gläscher et al. 2010 Neuron

# Double dissociation between ST and GT




Schad et al., in prep

# Double dissociation between ST and GT




Schad et al., in prep

# Innate behaviours

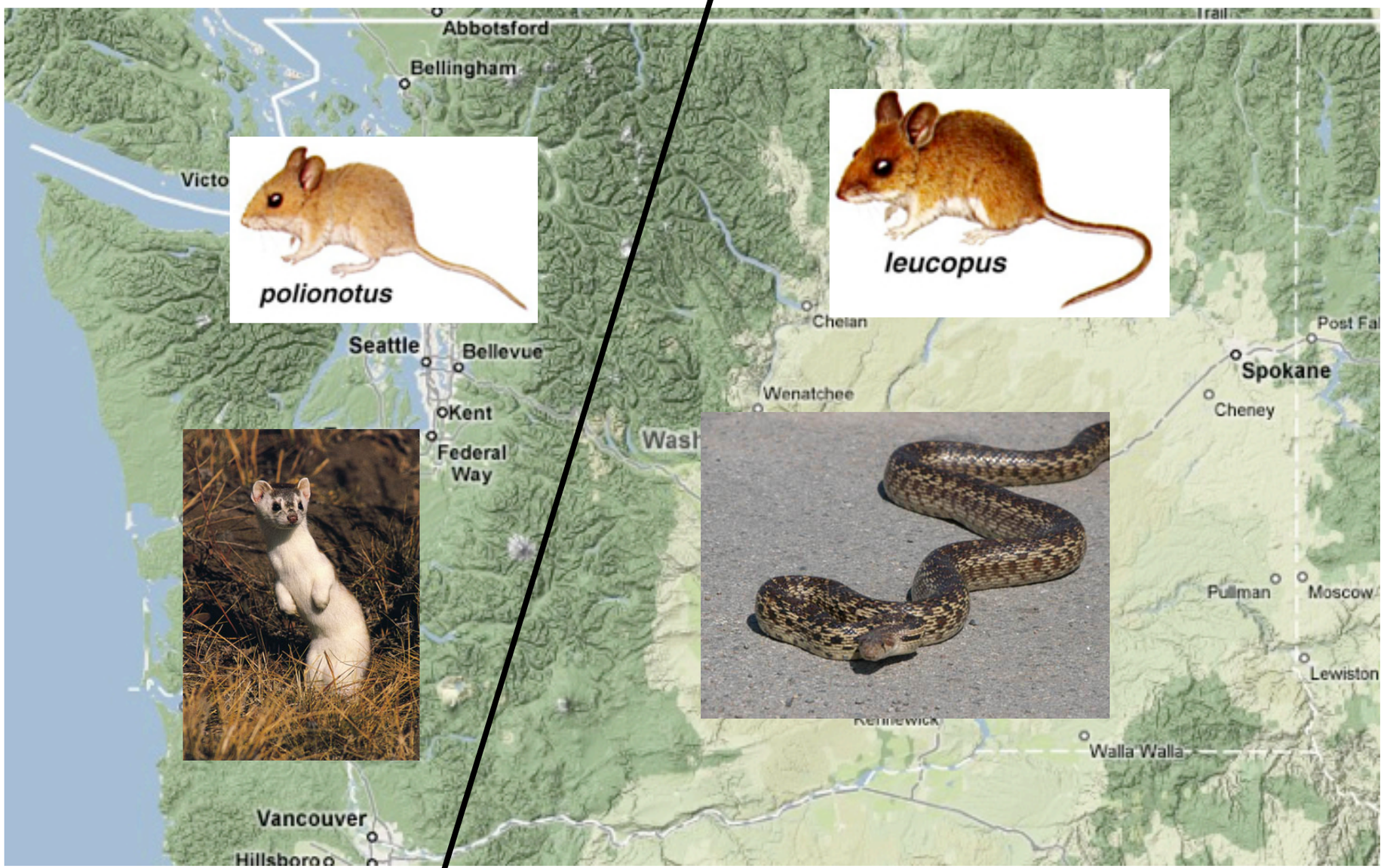
- Strong value-dependent responding exists in humans
- These can be “overcome”
- They relate to addiction
- Individual variation relates to differences in learning processes

- Are these emotions?

# Outline

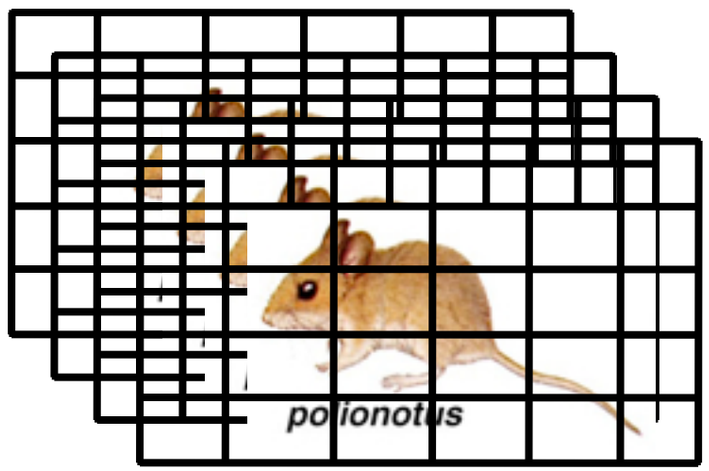
- Innate behaviours in humans
- Are emotions Pavlovian responses?
  - Theories of emotions
- Disorders of emotion

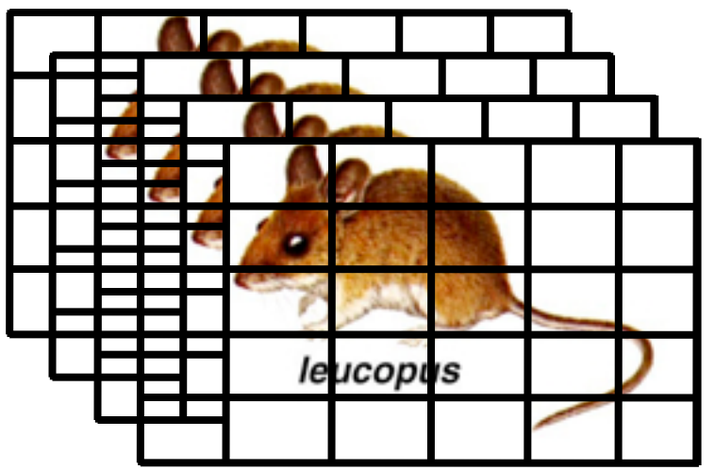
# Innate evolutionary strategies




Hirsch & Bolles 1980

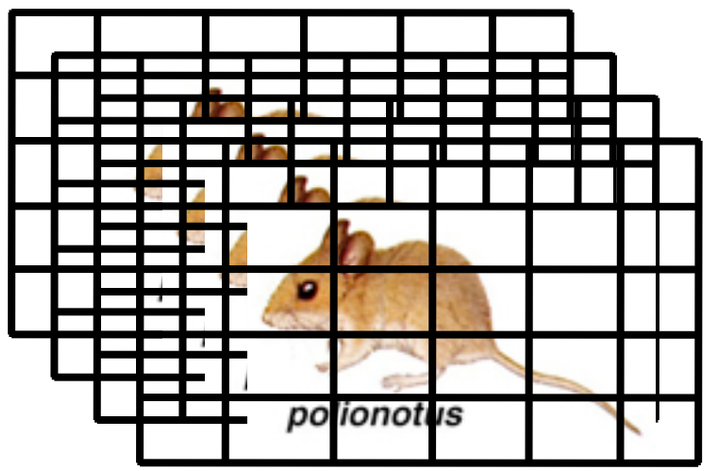
# Innate evolutionary strategies

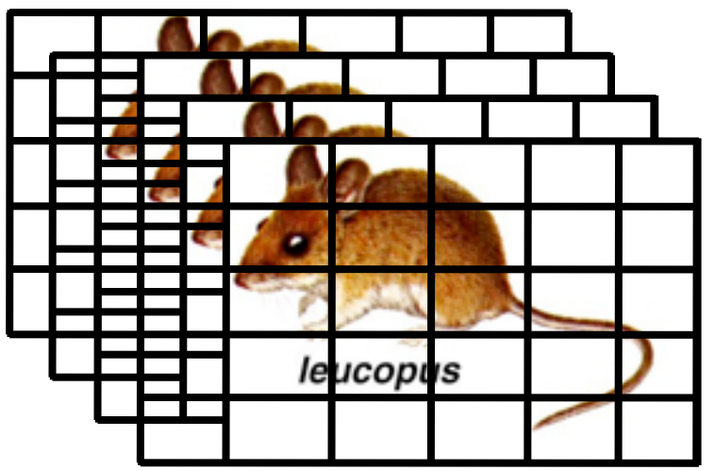



Hirsch & Bolles 1980

# Innate evolutionary strategies



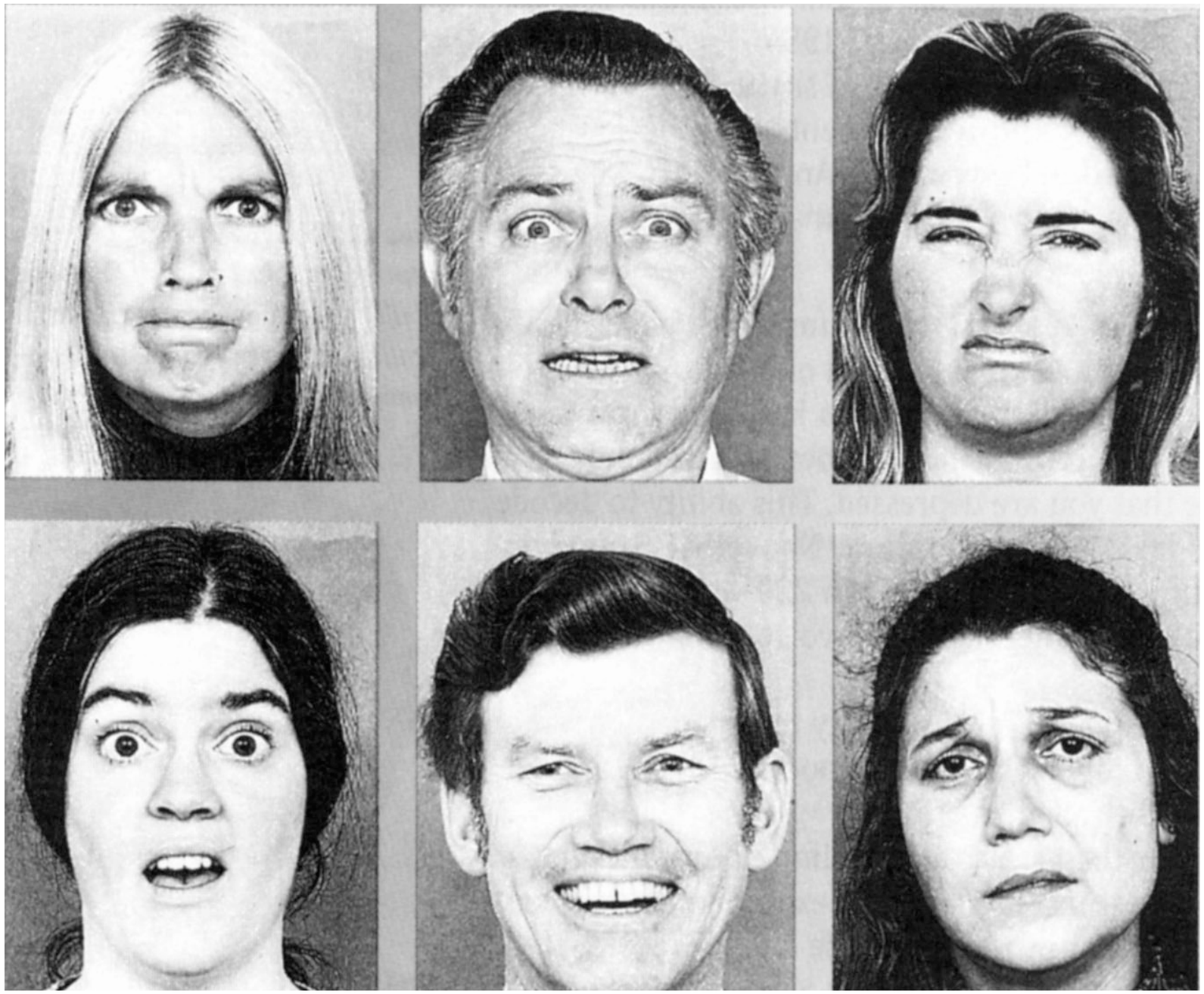

more survive

fewer survive

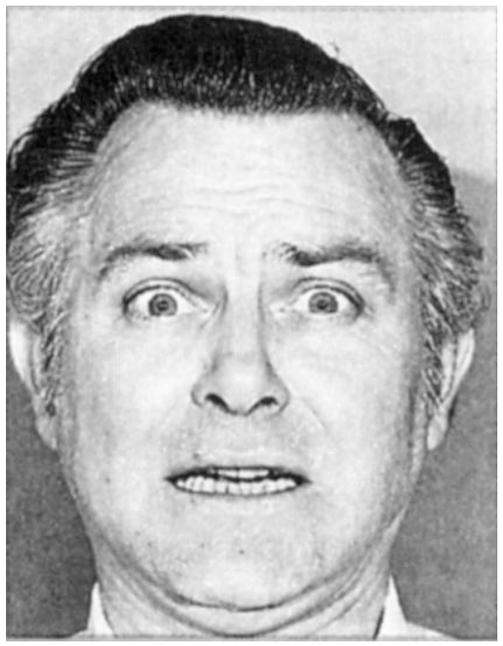
more survive

Hirsch & Bolles 1980

# Facial expressions



# Facial expressions



Happiness

Sadness

Surprise

Fear

Anger

Disgust

Table 1
*Single-Emotion Judgment Task: Percentage of Subjects Within Each Culture Who Chose the Predicted Emotion*

| Nation | Happiness | Surprise | Sadness | Fear | Disgust | Anger |
|---|---|---|---|---|---|---|
| Estonia | 90 | 94 | 86 | 91 | 71 | 67 |
| Germany | 93 | 87 | 83 | 86 | 61 | 71 |
| Greece | 93 | 91 | 80 | 74 | 77 | 77 |
| Hong Kong | 92 | 91 | 91 | 84 | 65 | 73 |
| Italy | 97 | 92 | 81 | 82 | 89 | 72 |
| Japan | 90 | 94 | 87 | 65 | 60 | 67 |
| Scotland | 98 | 88 | 86 | 86 | 79 | 84 |
| Sumatra | 69 | 78 | 91 | 70 | 70 | 70 |
| Turkey | 87 | 90 | 76 | 76 | 74 | 79 |
| United States | 95 | 92 | 92 | 84 | 86 | 81 |

Table 2
*Kappa Coefficients*

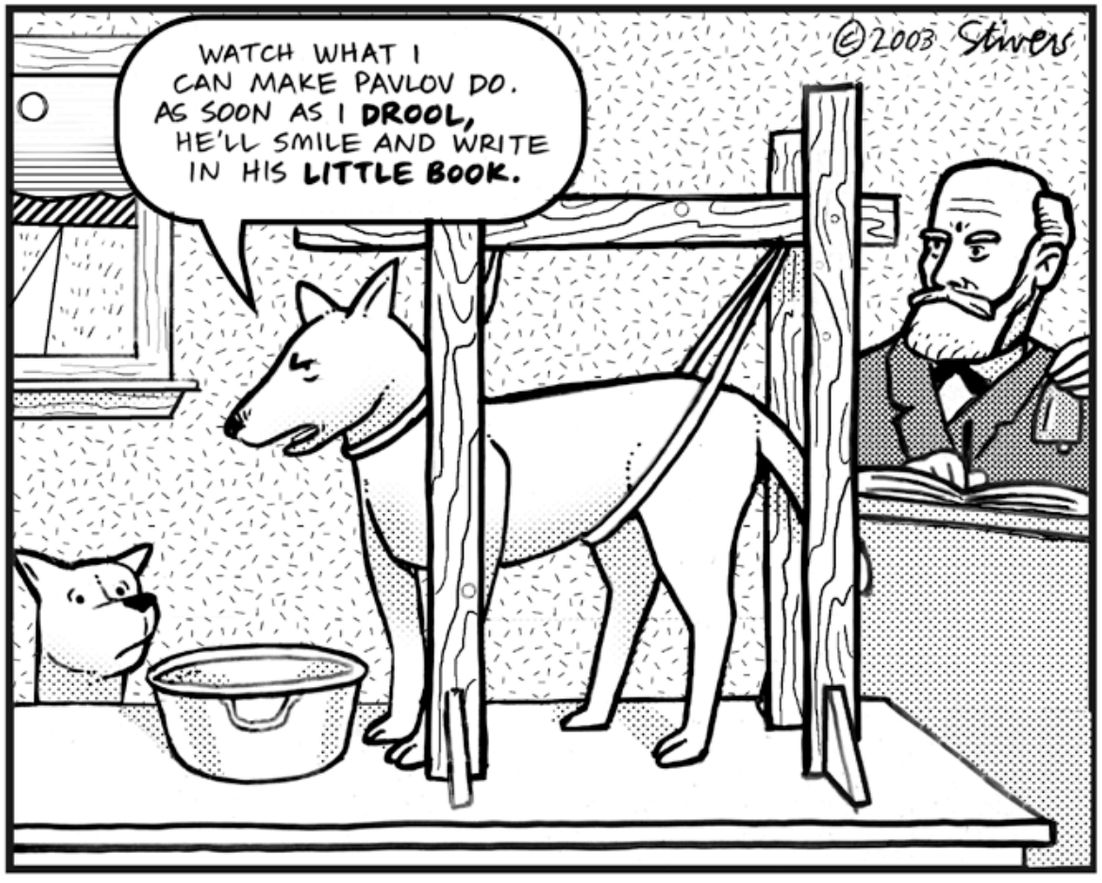
| Nation | Single judgments | Multiple judgments |
|---|---|---|
| Estonia | .790 | .744 |
| Germany | .736 | .739 |
| Greece | .762 | .789 |
| Hong Kong | .763 | .718 |
| Italy | .800 | .783 |
| Japan | .693 | .678 |
| Scotland | .815 | .809 |
| Sumatra | .657 | .541 |
| Turkey | .729 | .738 |
| United States | .835 | .607 |

*Note.* All figures are significant beyond .001.

Ekman et al., 1972 Pers. Proc. Indiv. Diff.

# Standard computational view

- Emotions as “complex actions”
  - akin to Pavlovian reflexes
  - computational models capture how expression changes with experience



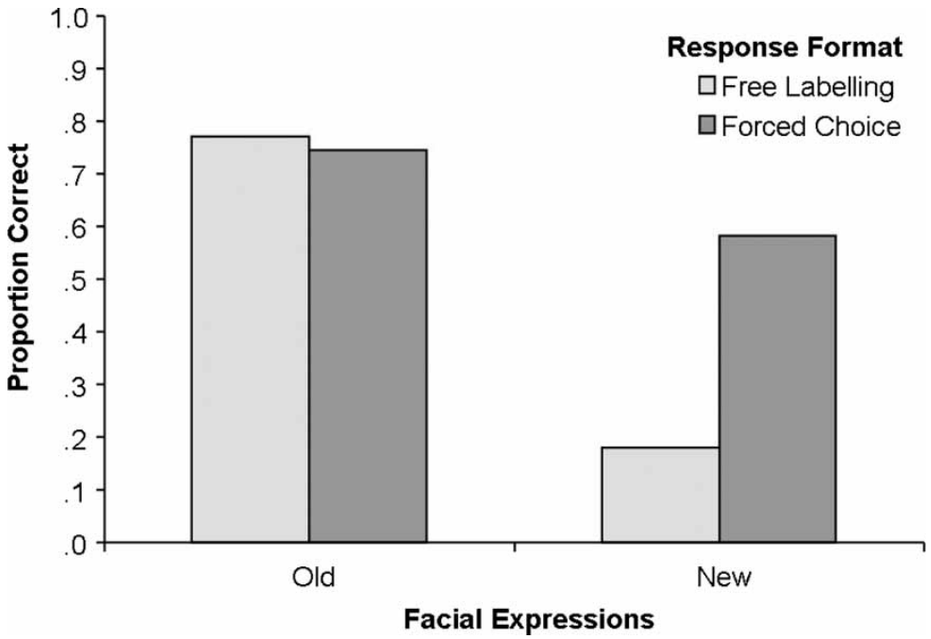
# Computational approach

- Treat as “complex actions”
  - Basic emotion view
  - Action tendencies are important
  - Most prominent approach
  - Inflexibility -> Pavlovian account

$$p(a;s) \propto \mathcal{Q}(a,s)$$

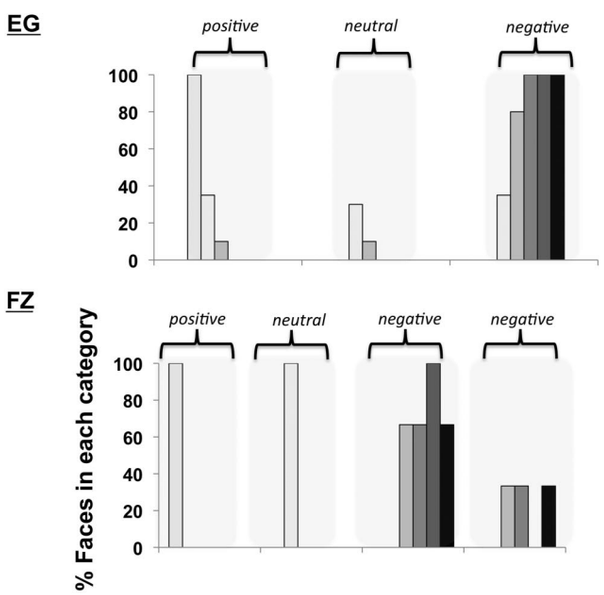
$$p(a(c(s))) \propto \mathcal{V}(s)$$

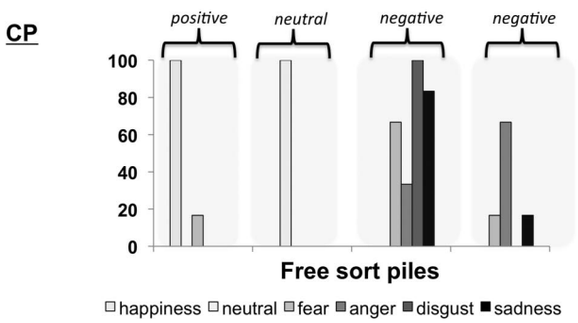
# Facial expressions

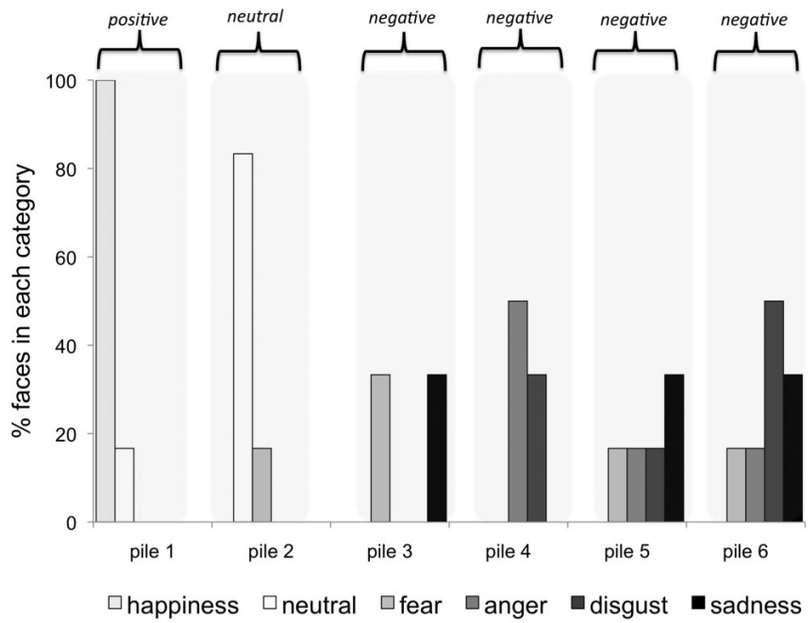






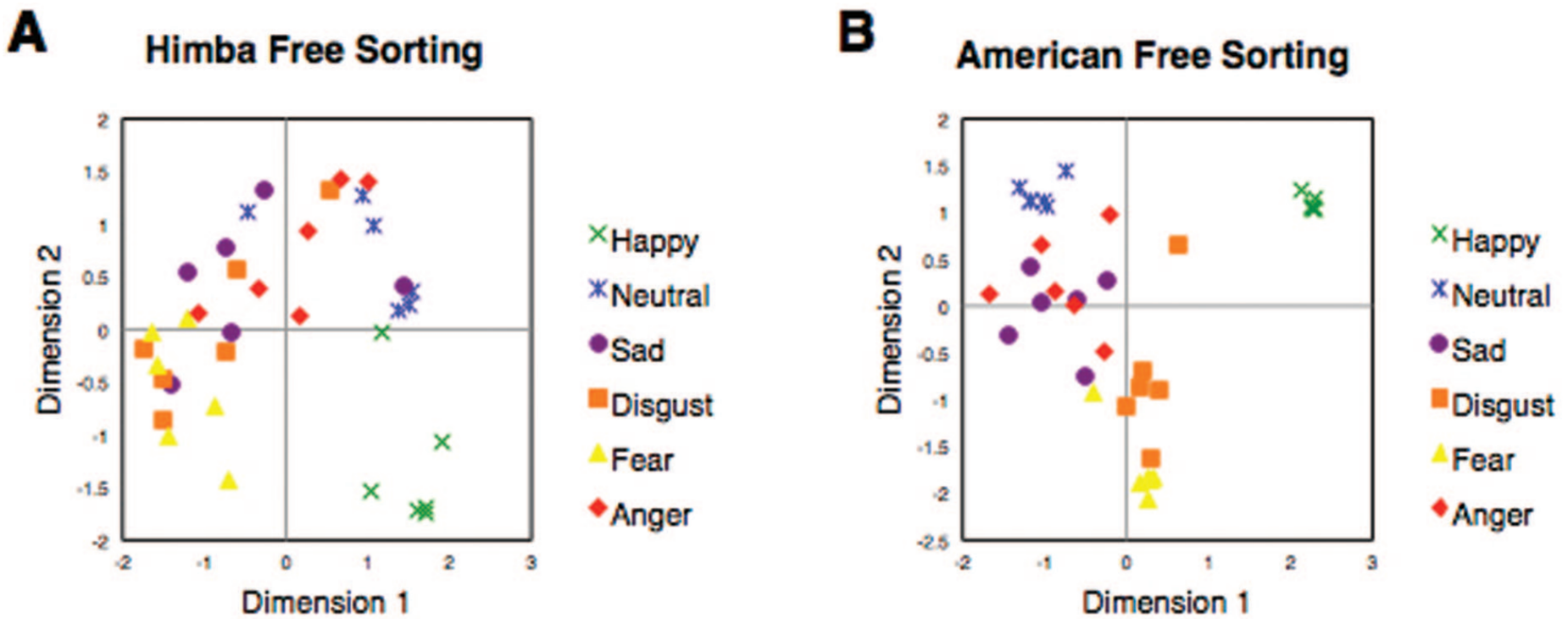


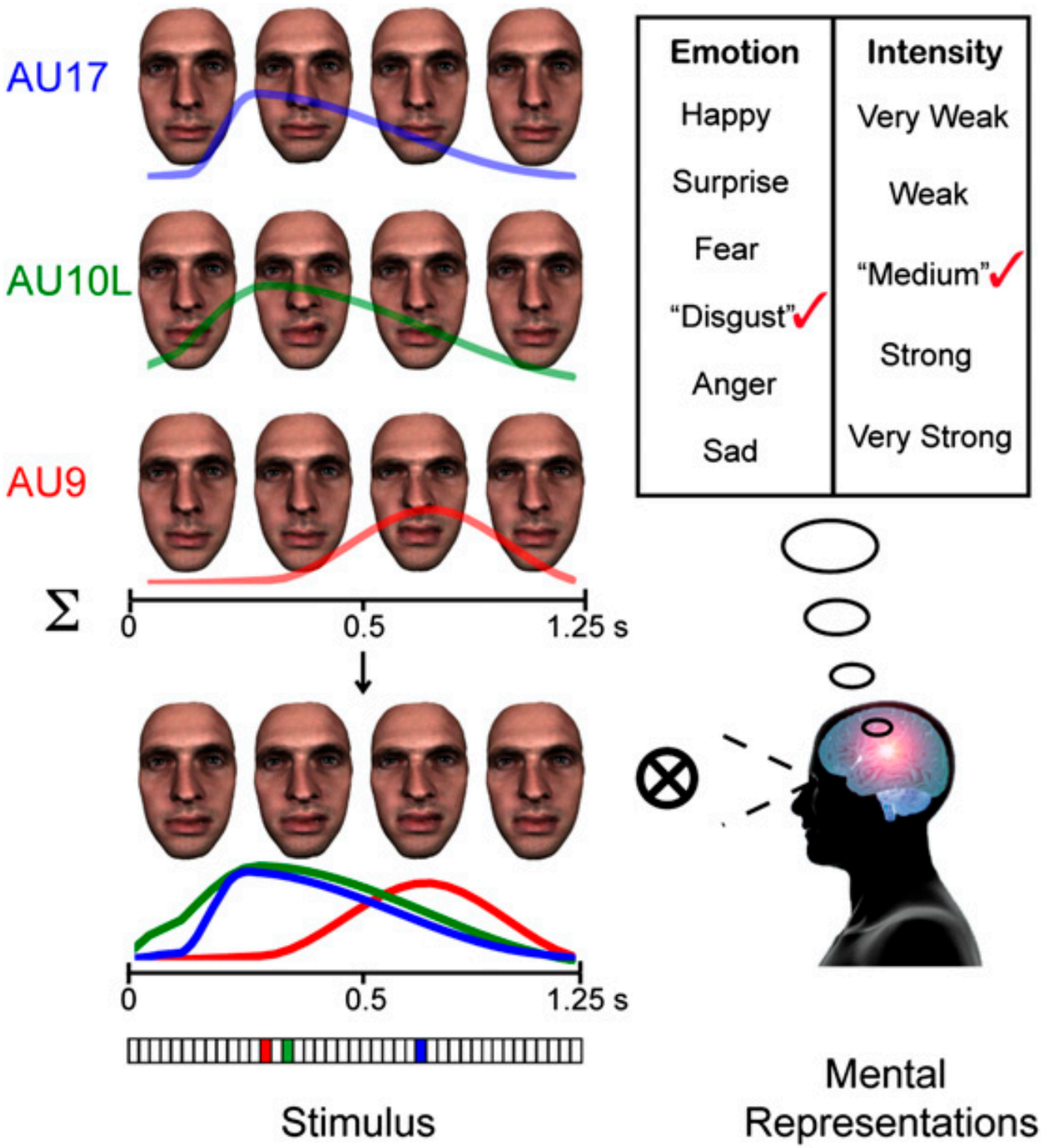

Widen et al., 2010, Lindquist et al., 2006 2014

# Free sorting in remote cultures



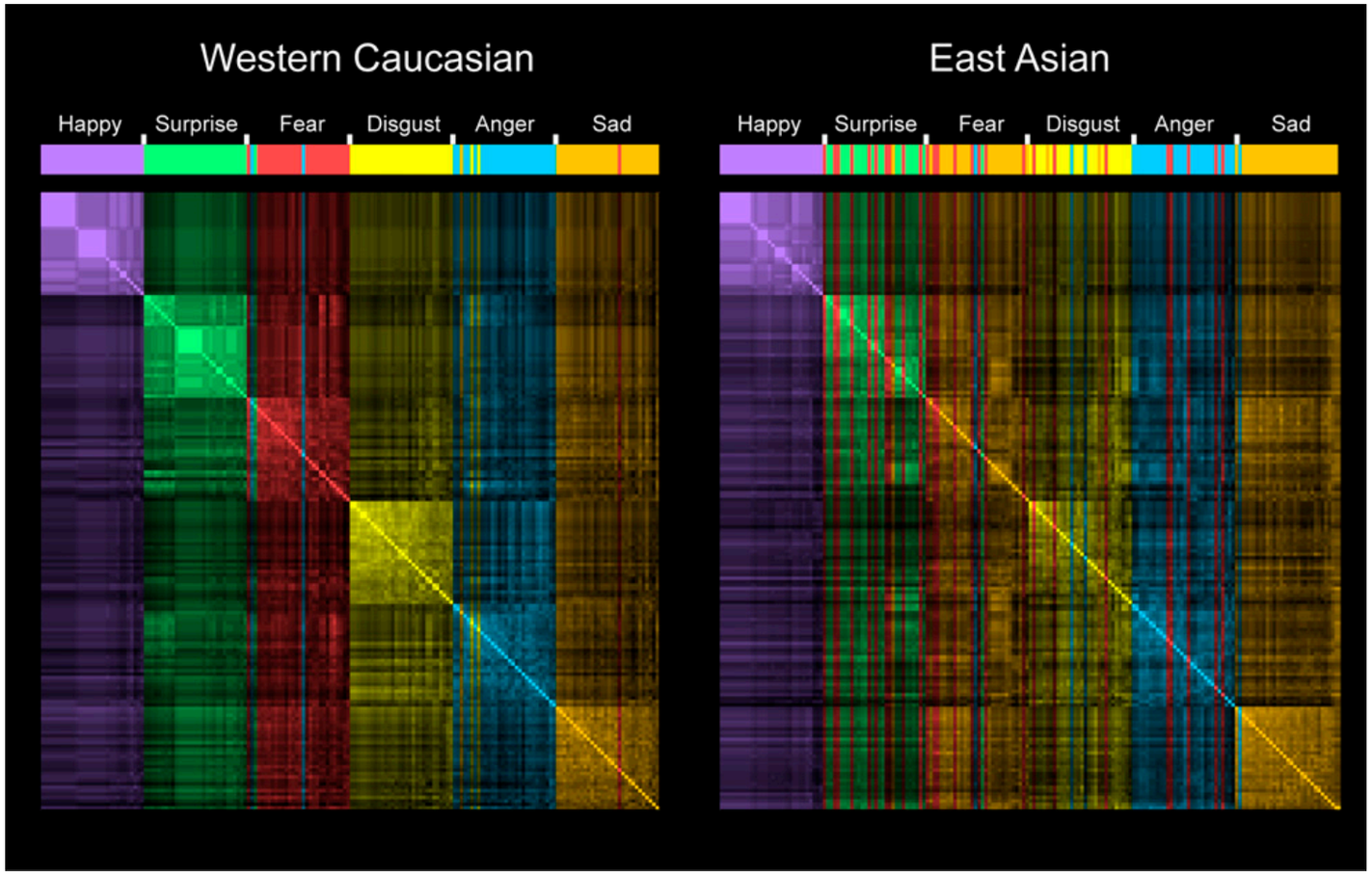

Gendron et al., 2014

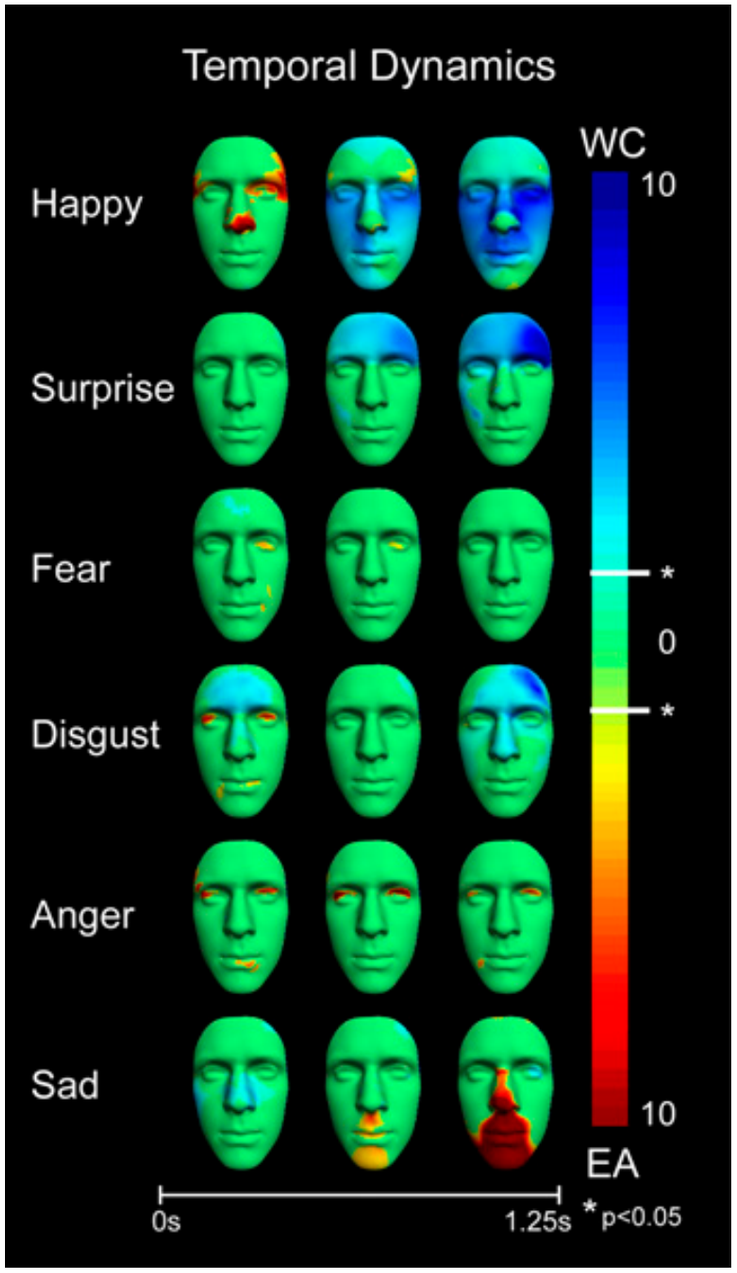
# Facial emotion recognition




Jack et al., 2012 PNAS

# Facial emotion recognition




Jack et al., 2012 PNAS

# Physiological correlates?

- Weak correlations between experience, facial expression & physiology

Mauss et al., 2005; Cacioppo et al., 2010

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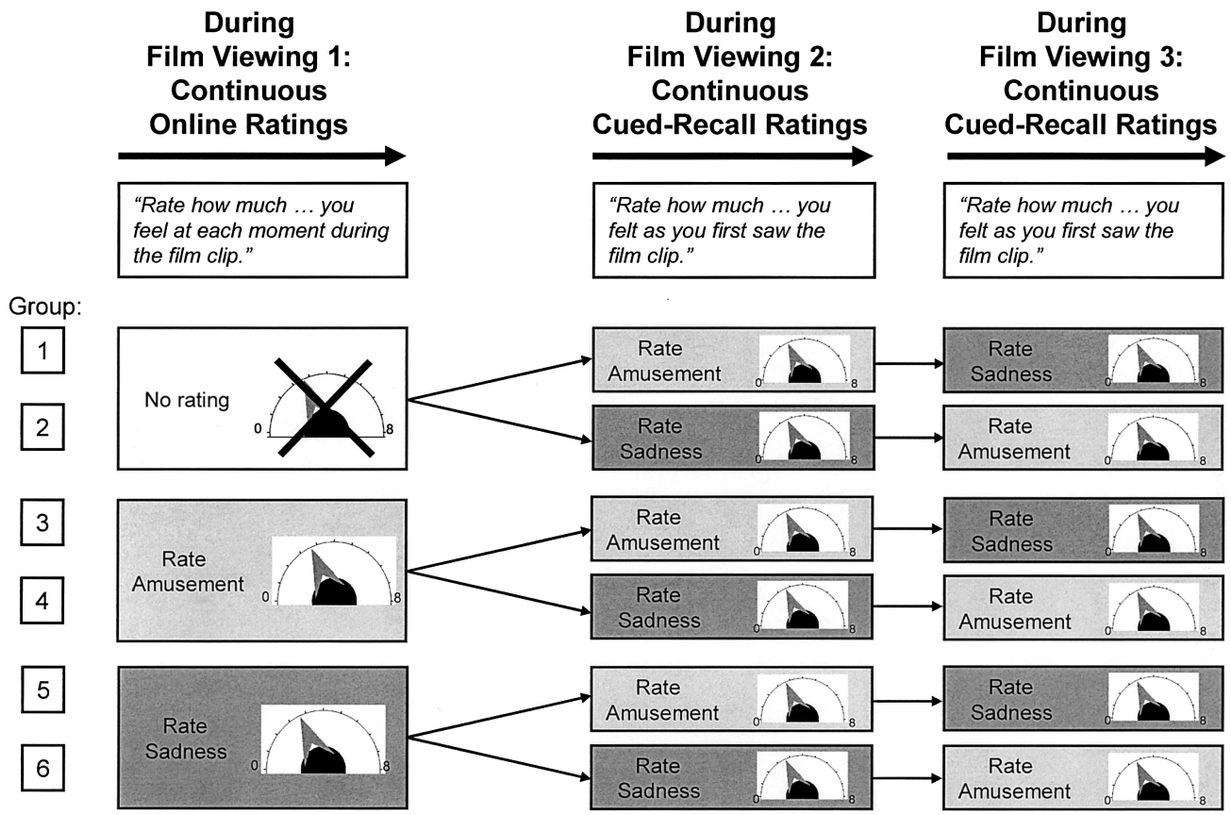


Mauss et al., 2005; Cacioppo et al., 2010

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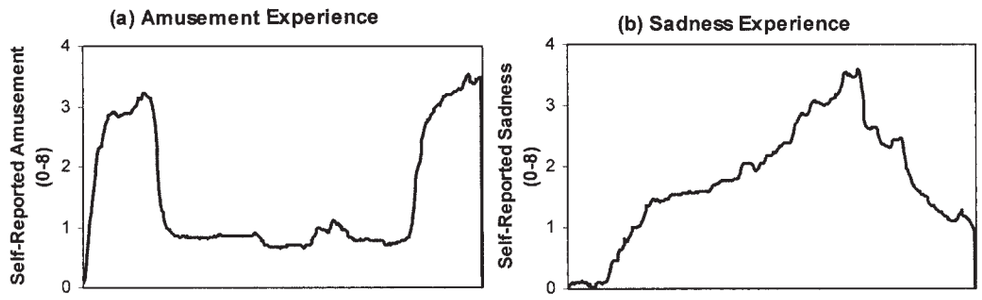


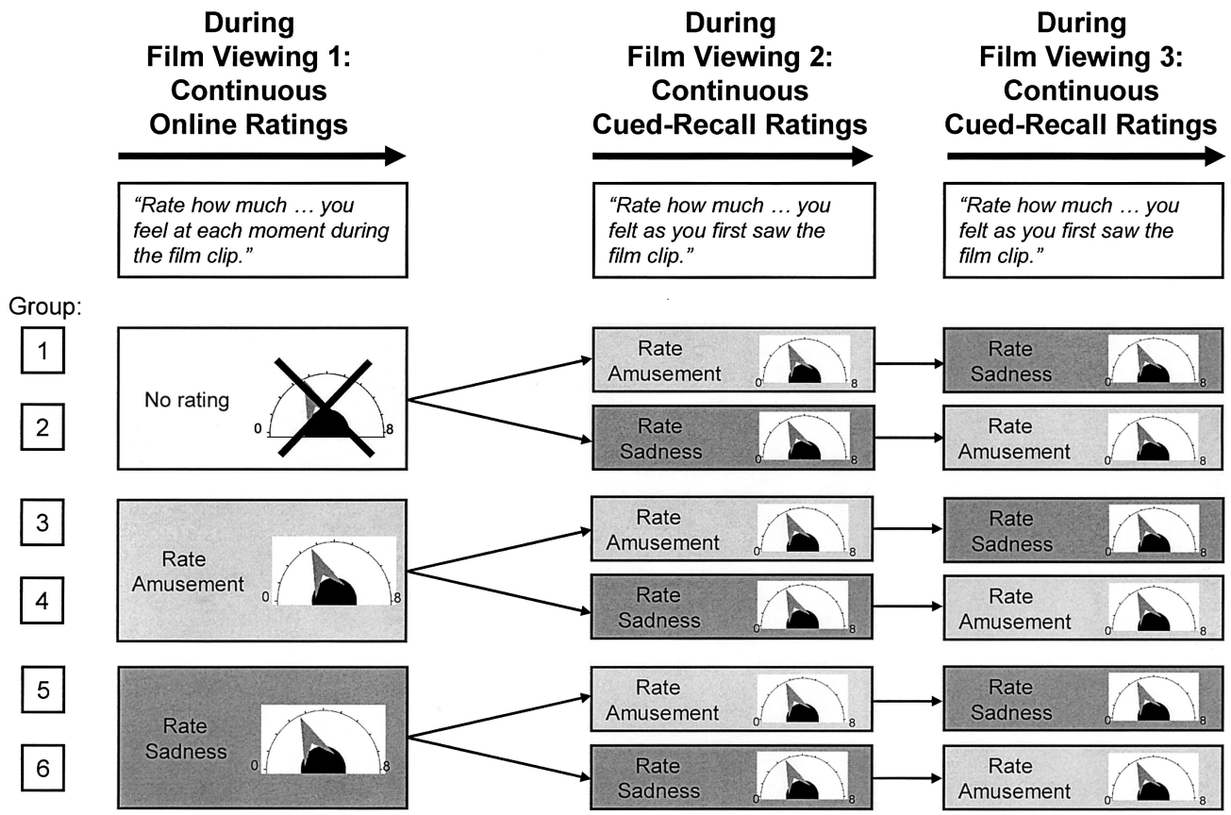


Mauss et al., 2005; Cacioppo et al., 2010

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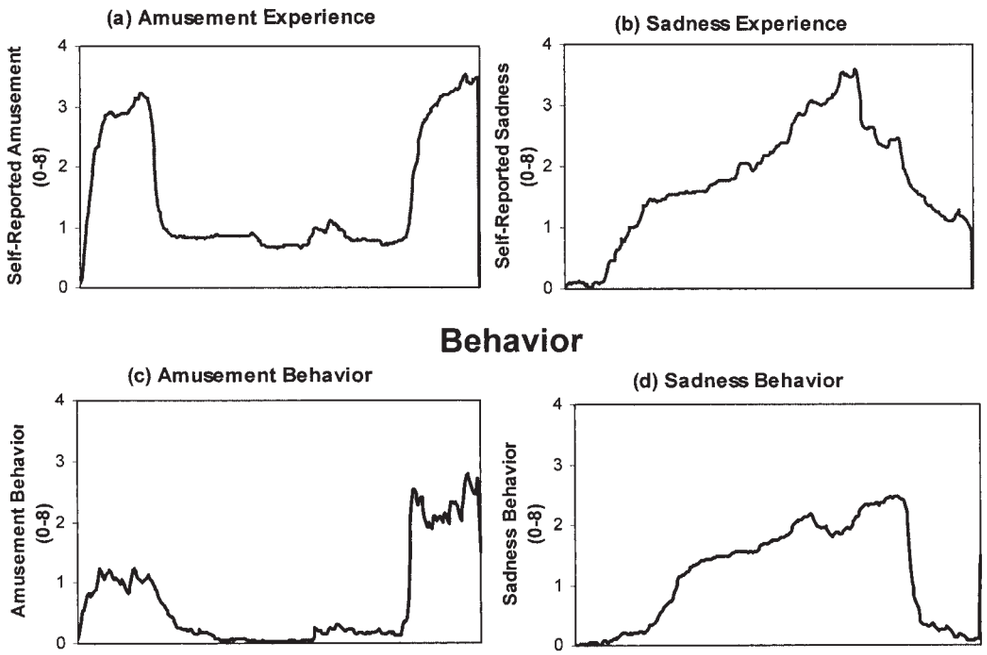


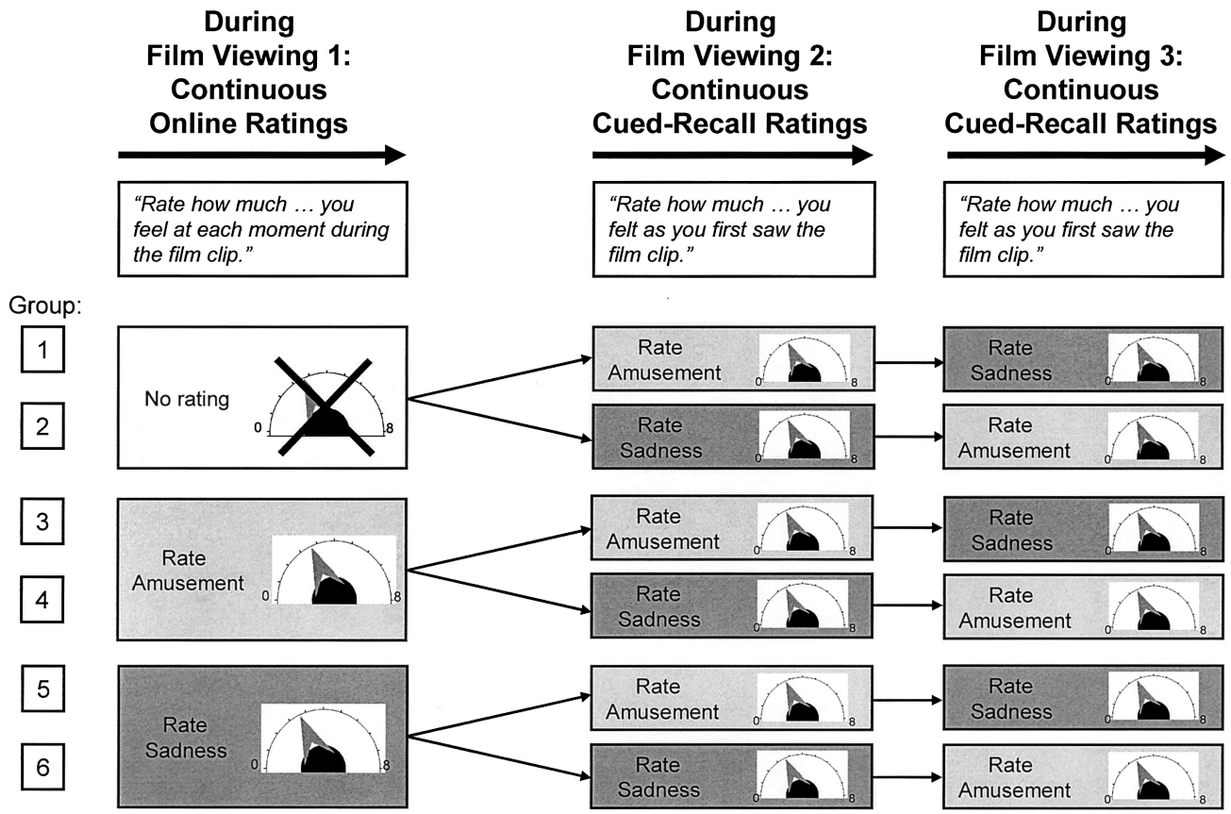


Mauss et al., 2005; Cacioppo et al., 2010

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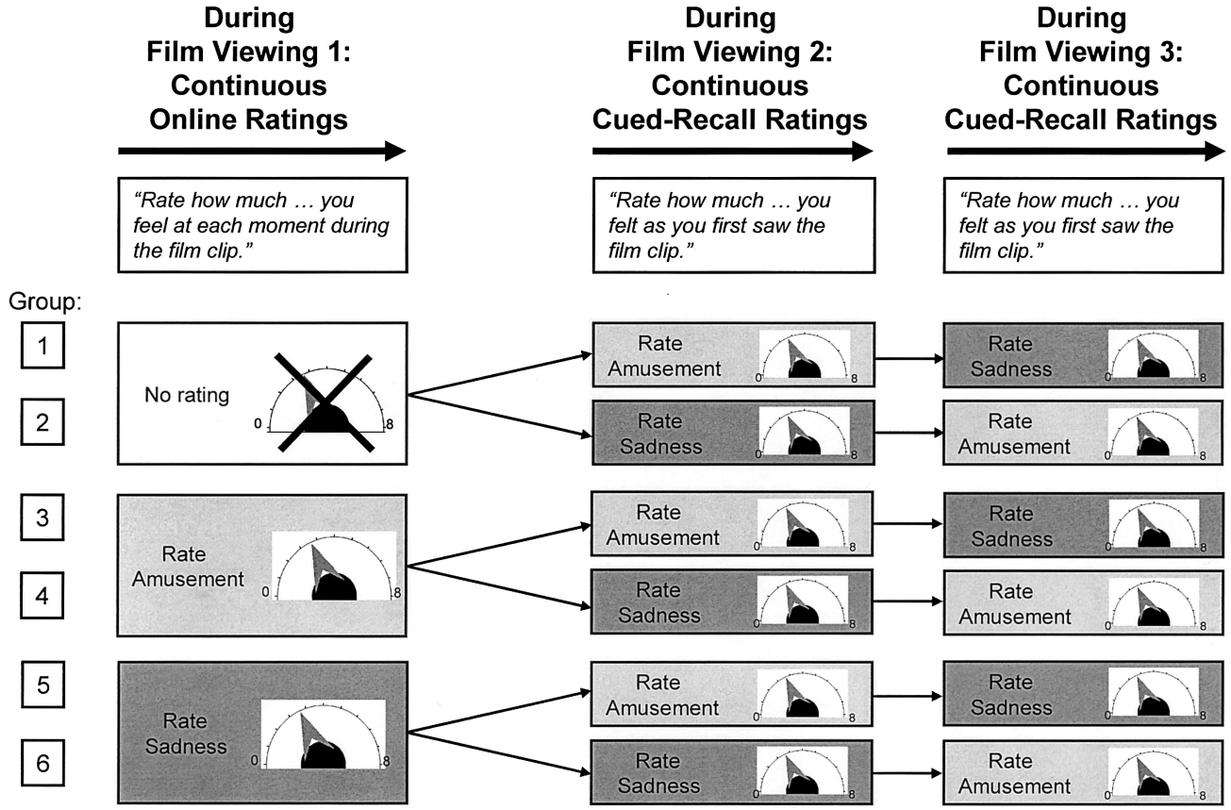
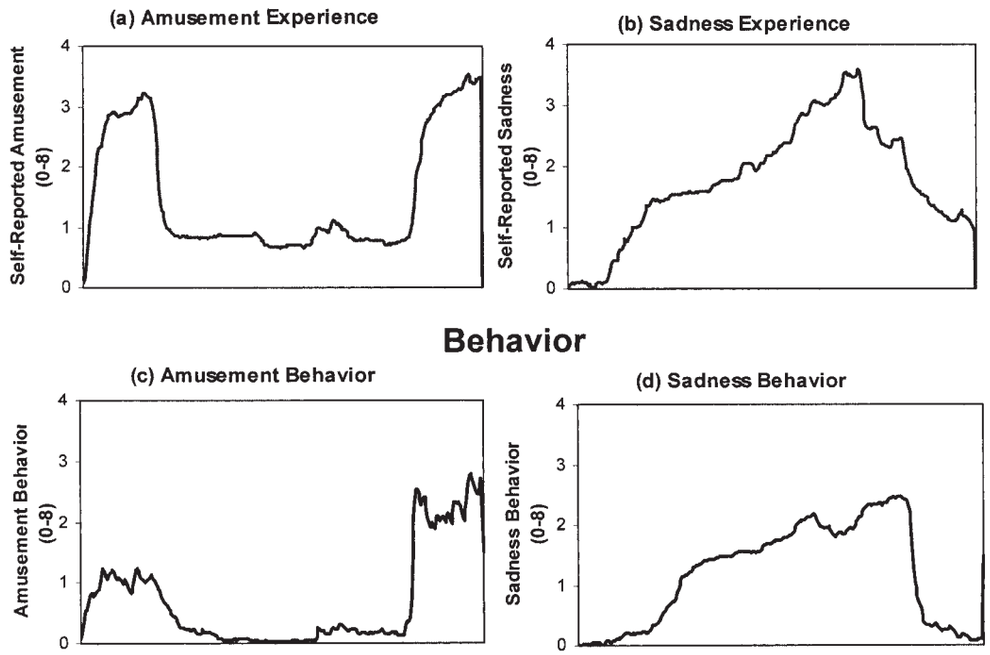
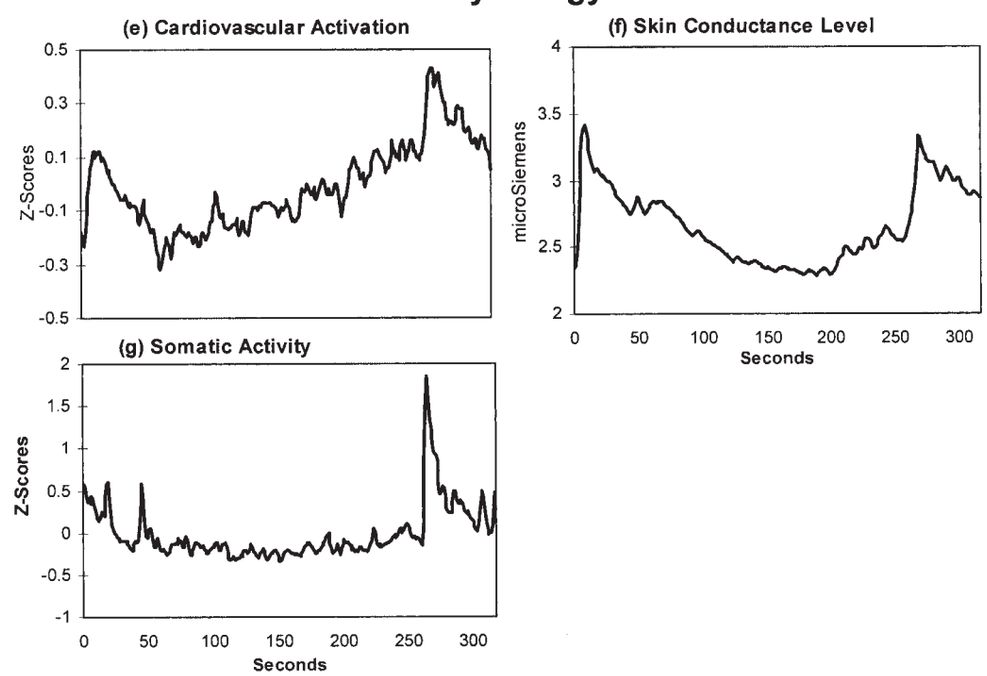
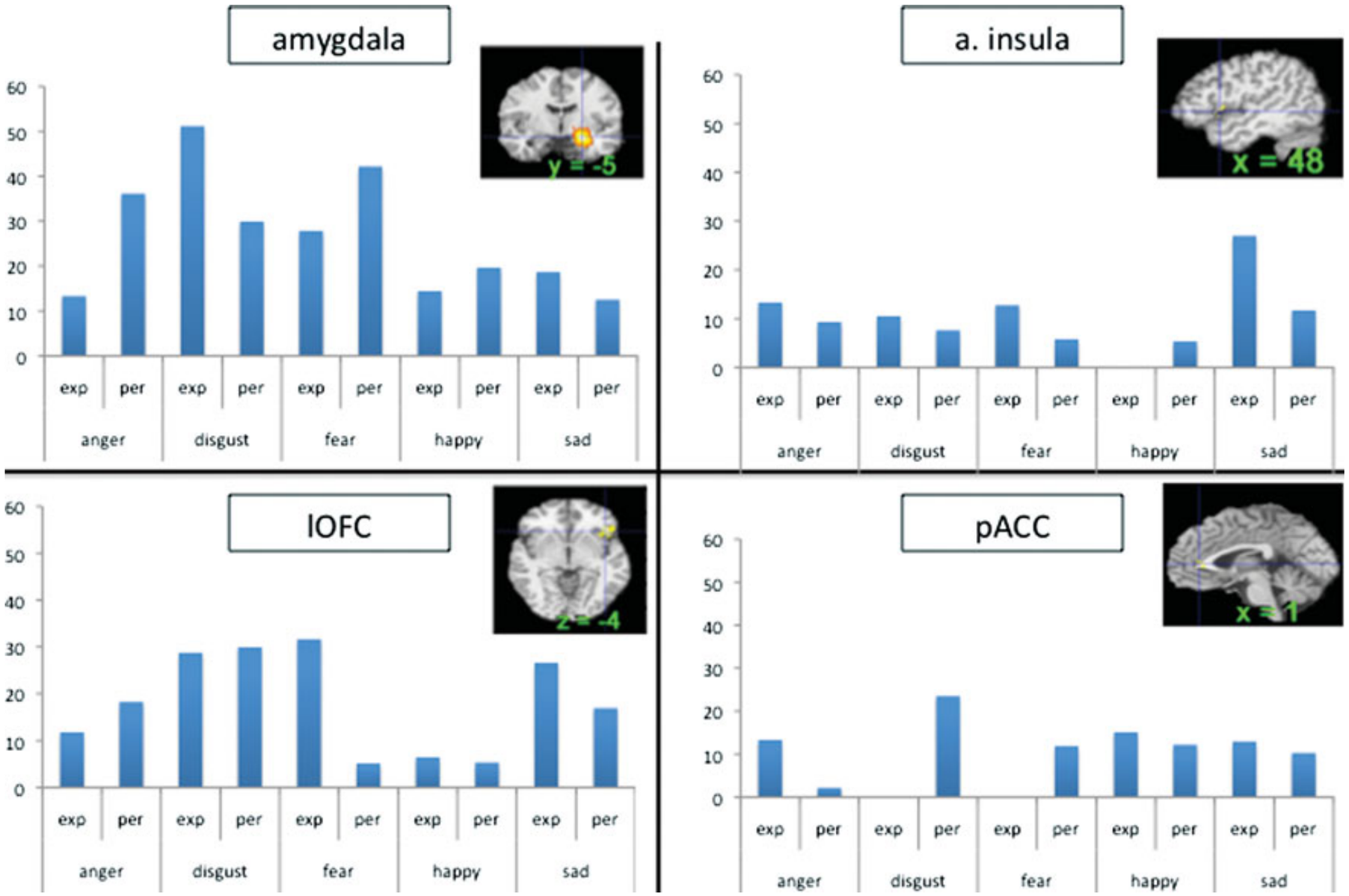


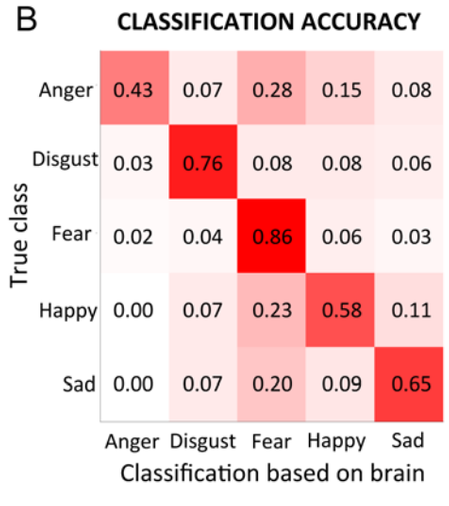

Mauss et al., 2005; Cacioppo et al., 2010

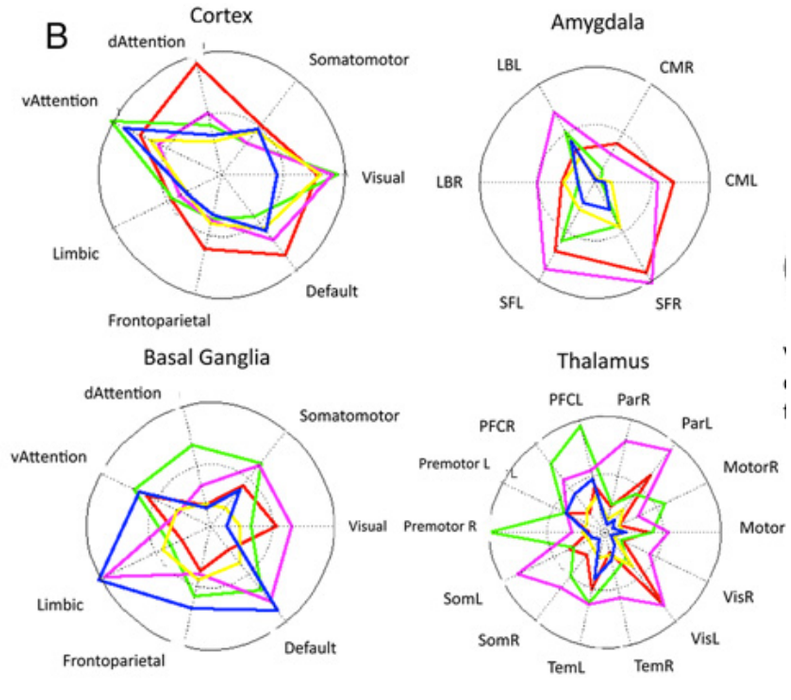
# Are there specific neural circuits for

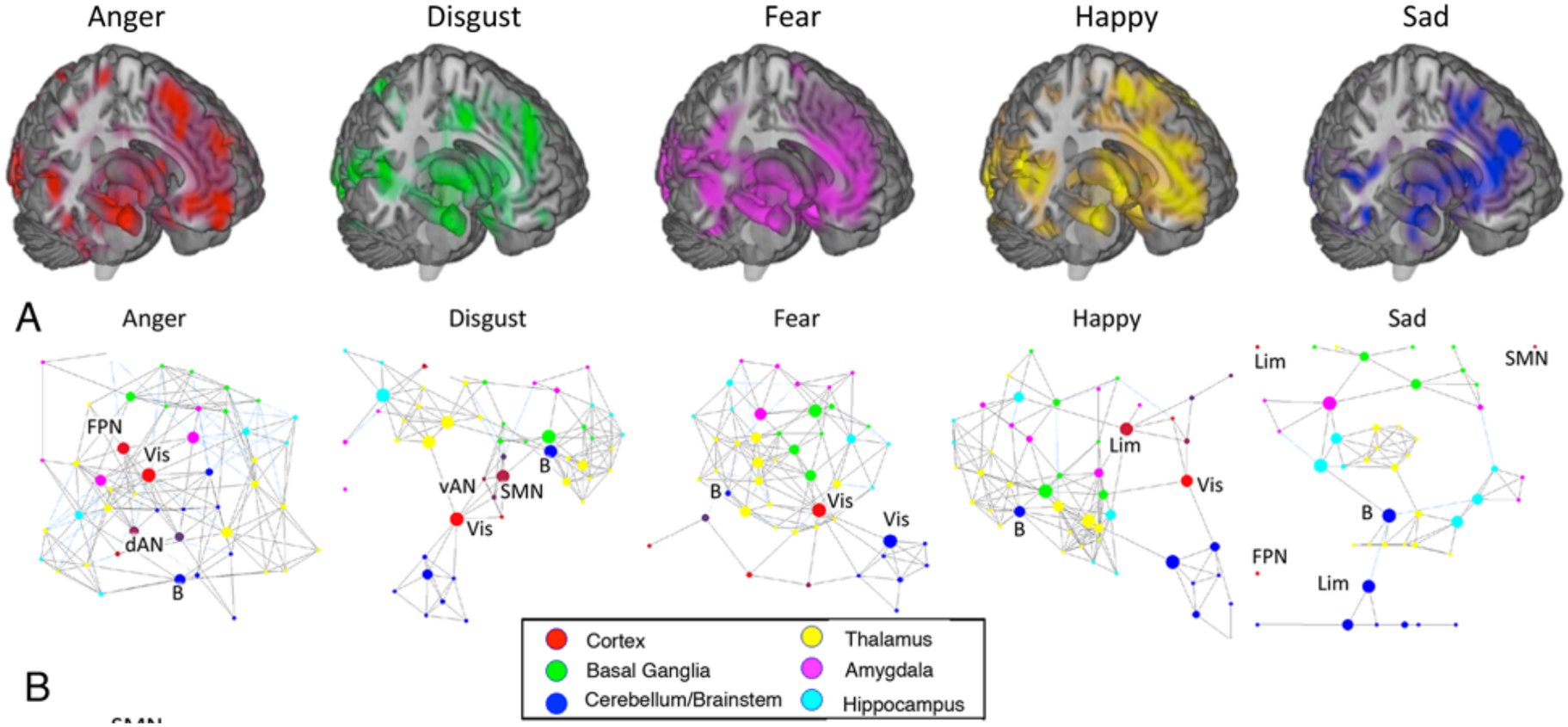



Linquist et al., 2012 Behavioral and Brain Sciences

# Can specific emotions be decoded?

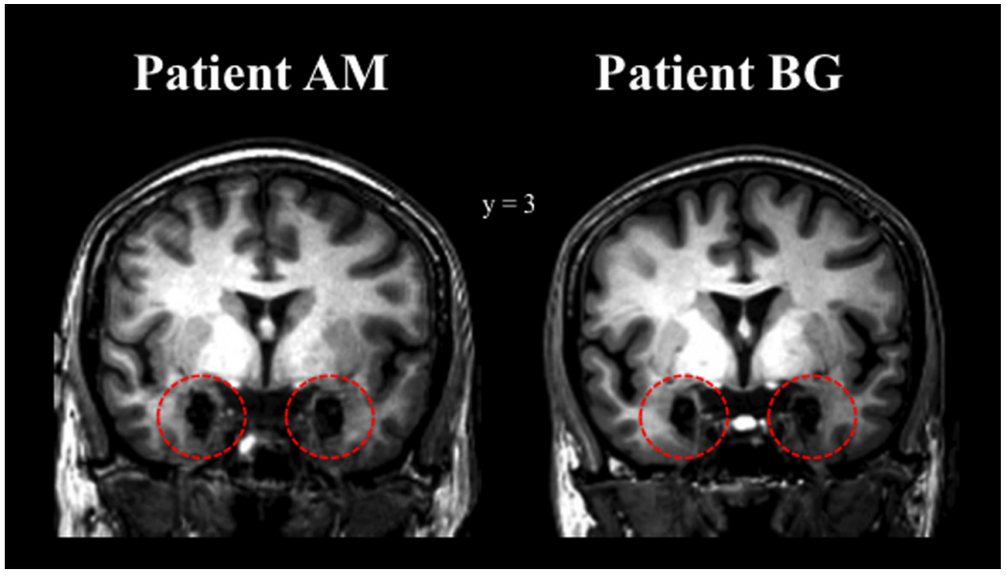


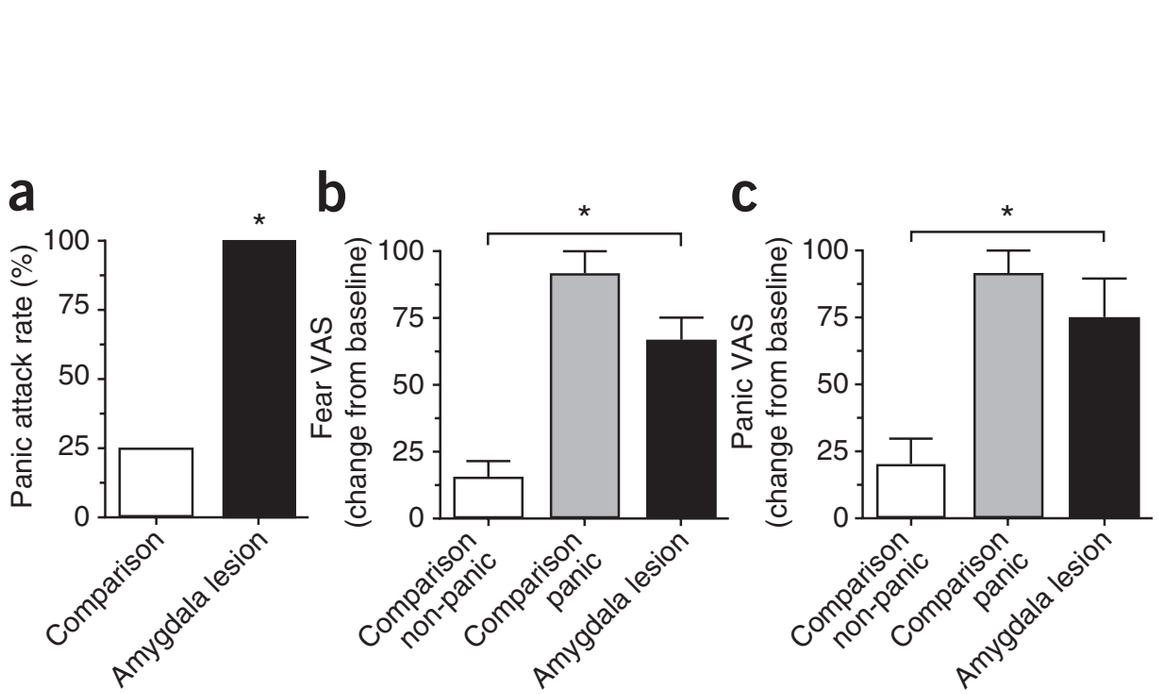



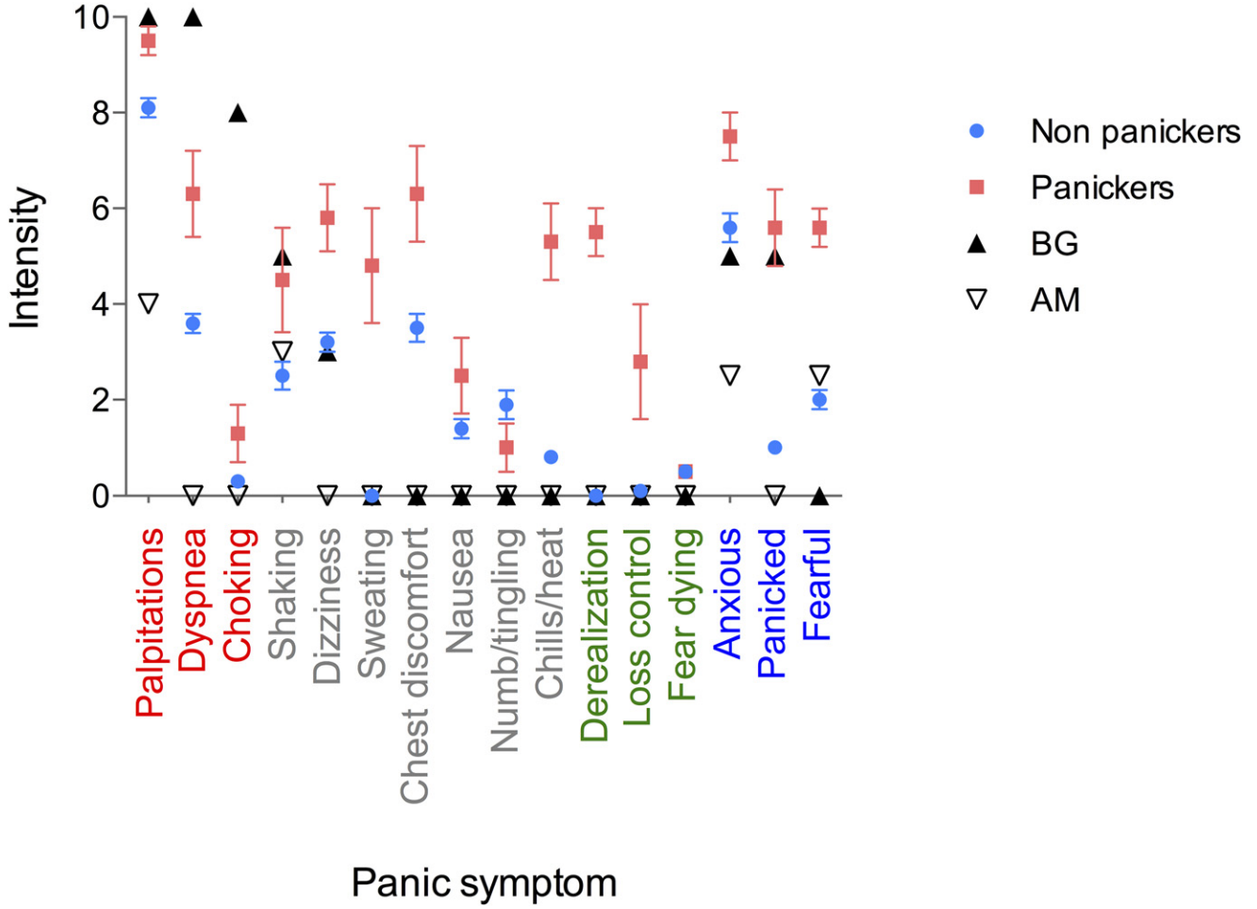




Wager et al., 2015 PLoS Comp Biol

# Is the amygdala necessary for fear?



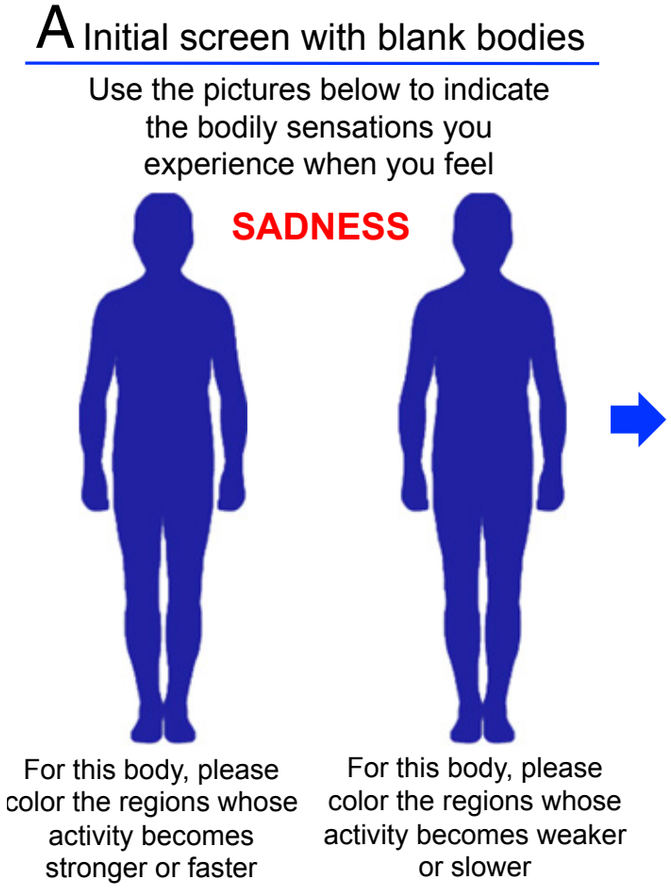



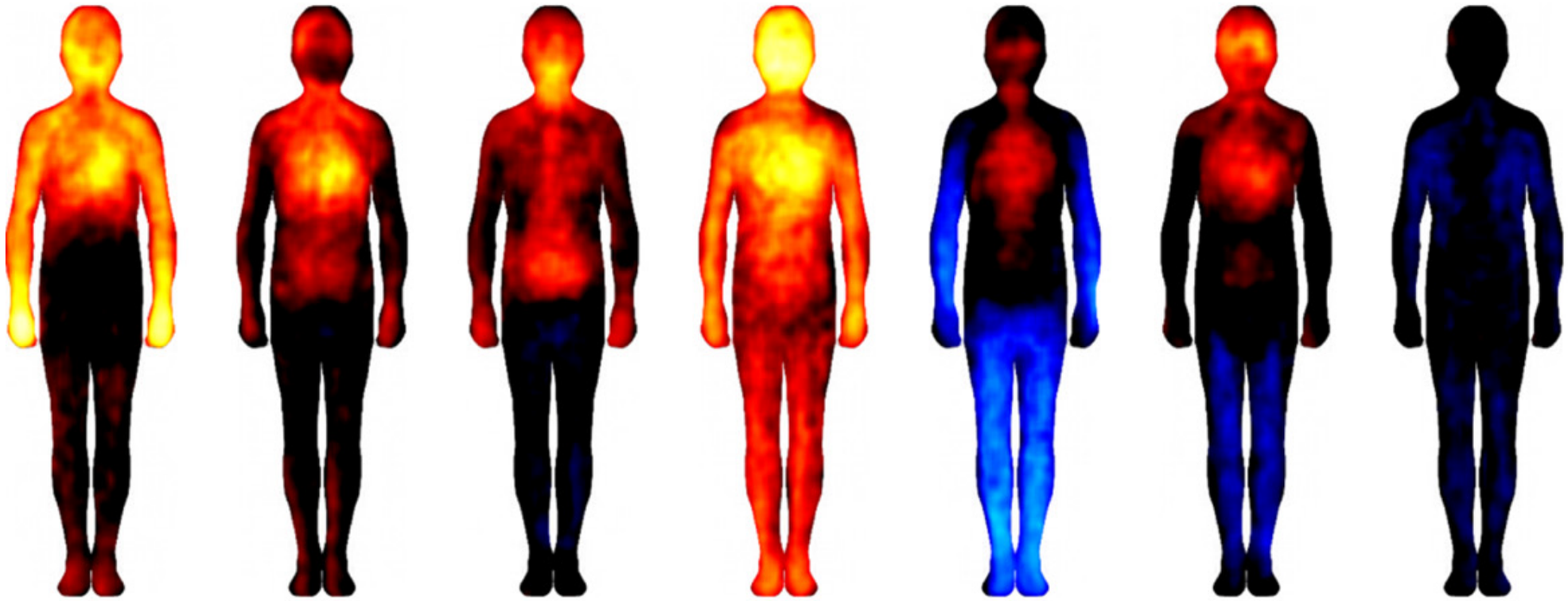

Feinstein et al., 2012 Nat. Neurosci.; Khalsa et al., 2016 J. Neurosci.

# Interoceptive categories

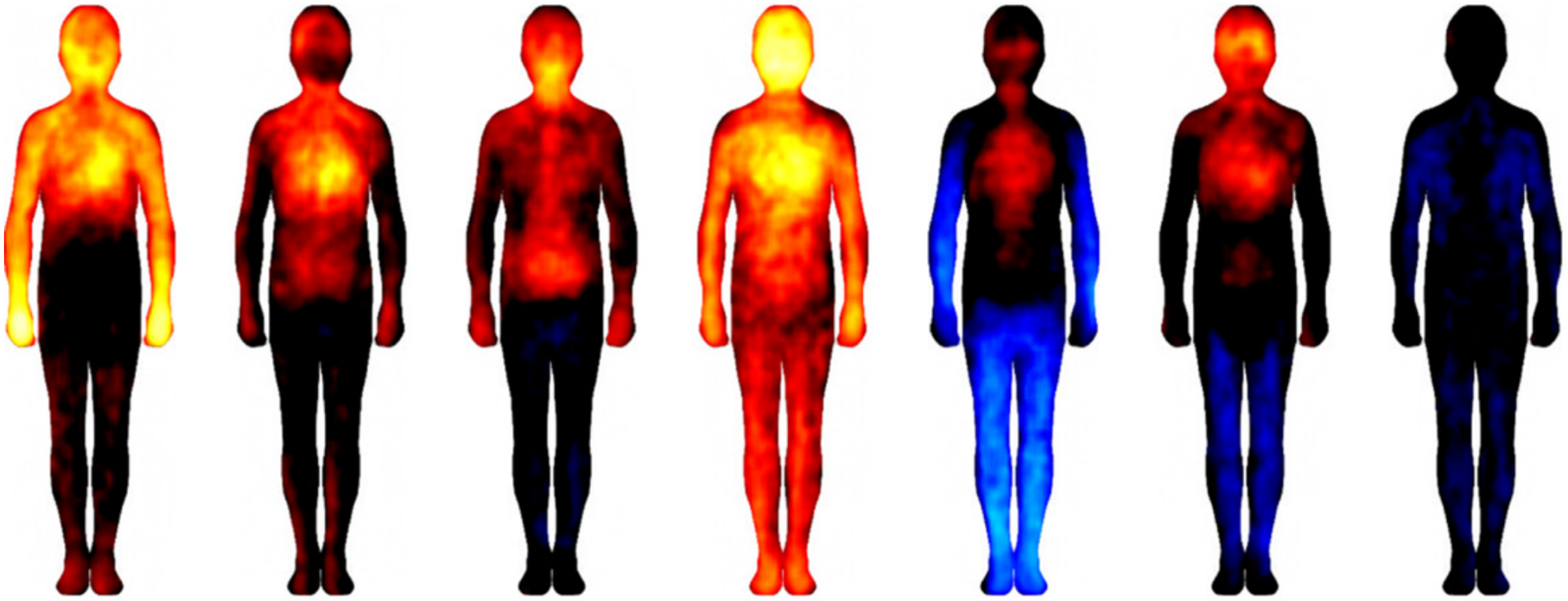
- Discrete emotions as categorisations of internal states




Nummenmaa et al., 2015 PNAS



1 2 3 4 5 6 7

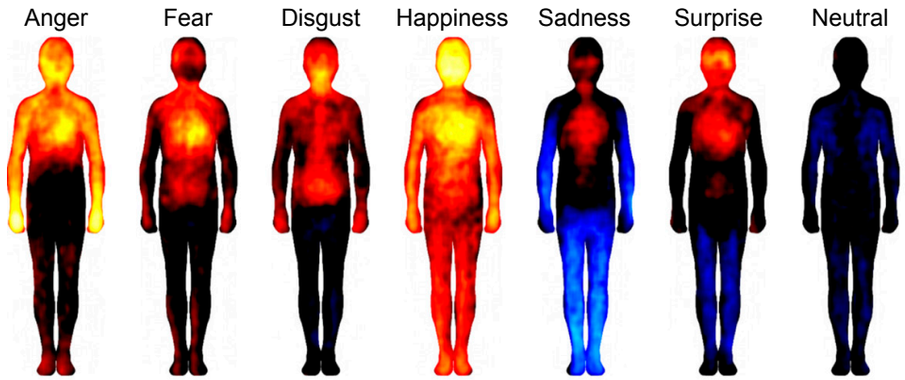


1 2 3 4 5 6 7

Anger
Disgust
Fear
Happiness
Neutral
Sadness
Surprise

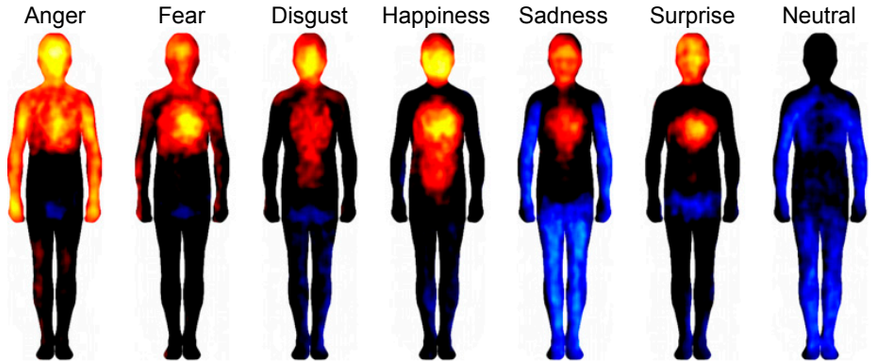
# Interoceptive classes?

words

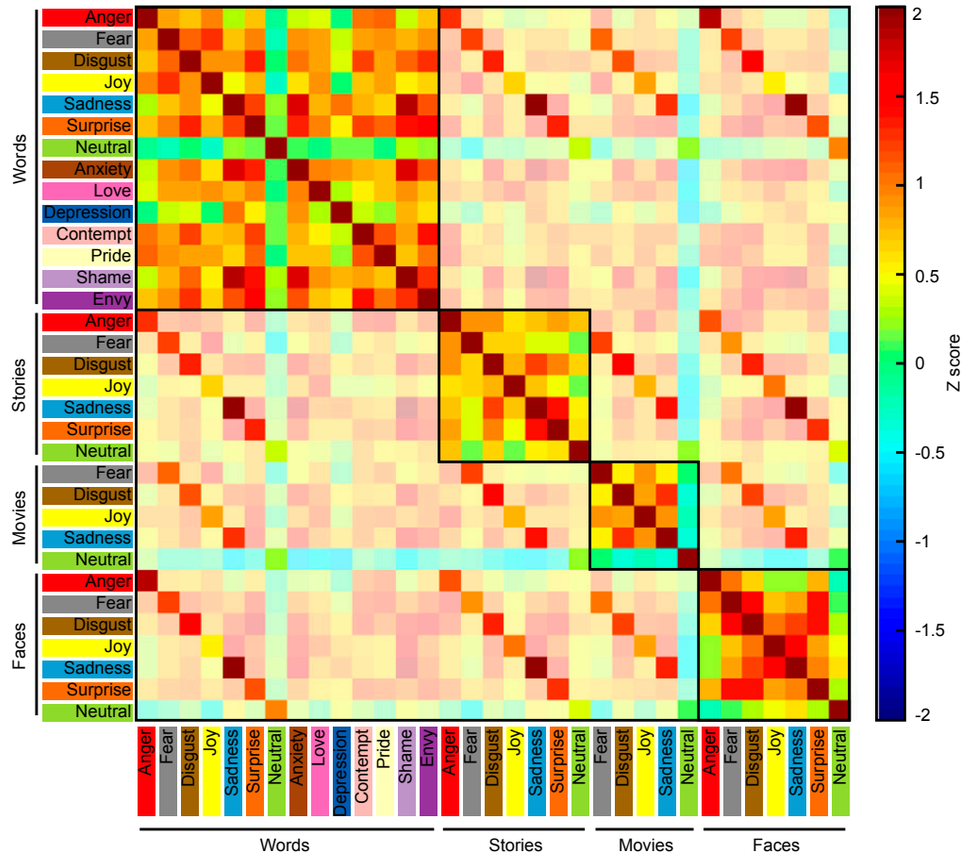



stories


faces

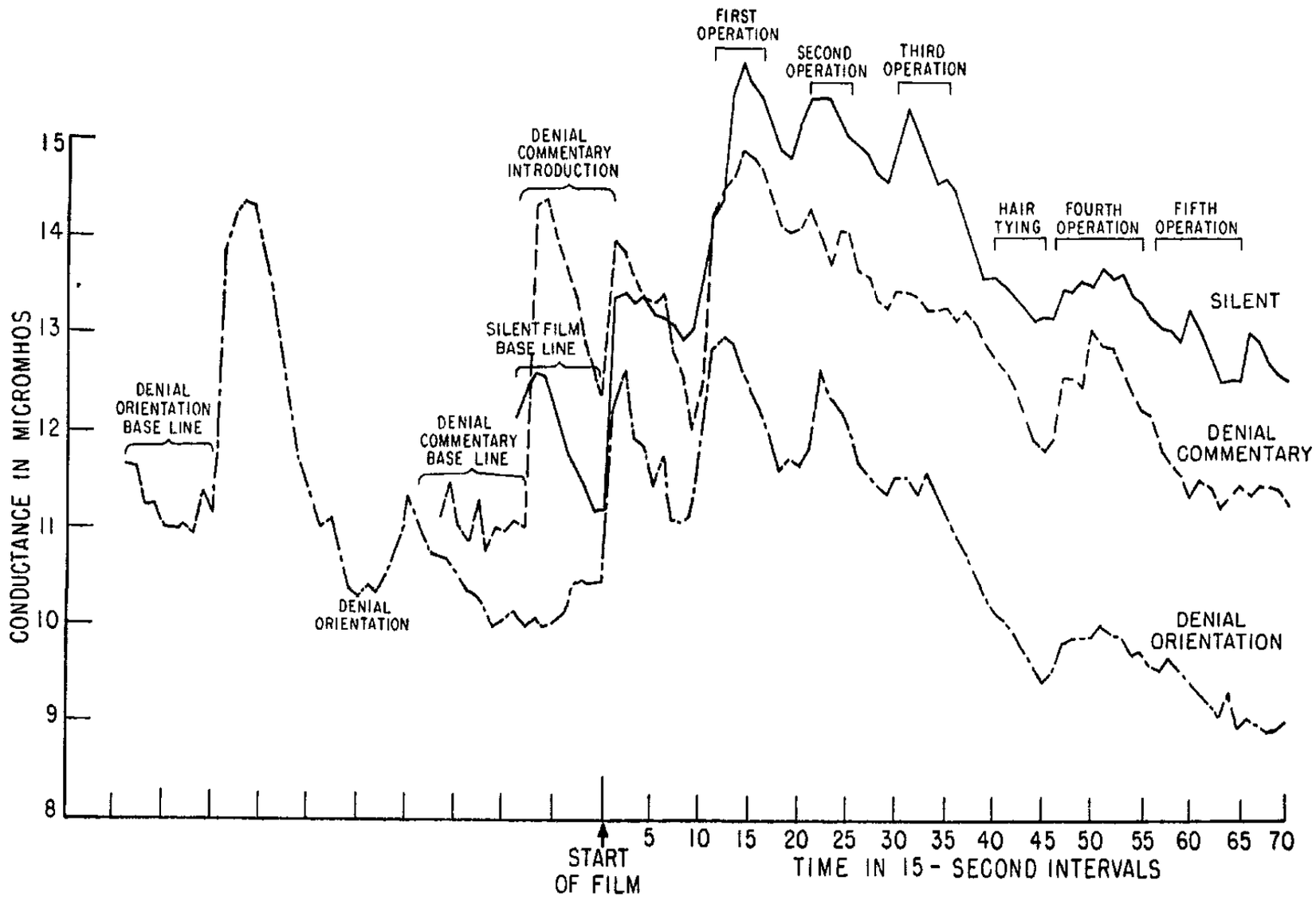



movies


Nummenmaa et al., 2015 PNAS

# Appraisal effect




Emotions also strongly affect our thoughts

Lazarus & Alfert 1964

# Appraisal theories

Motivational relevance

Motivational congruence

Coping: problem

Agency - other

Coping: emotion

Agency - self

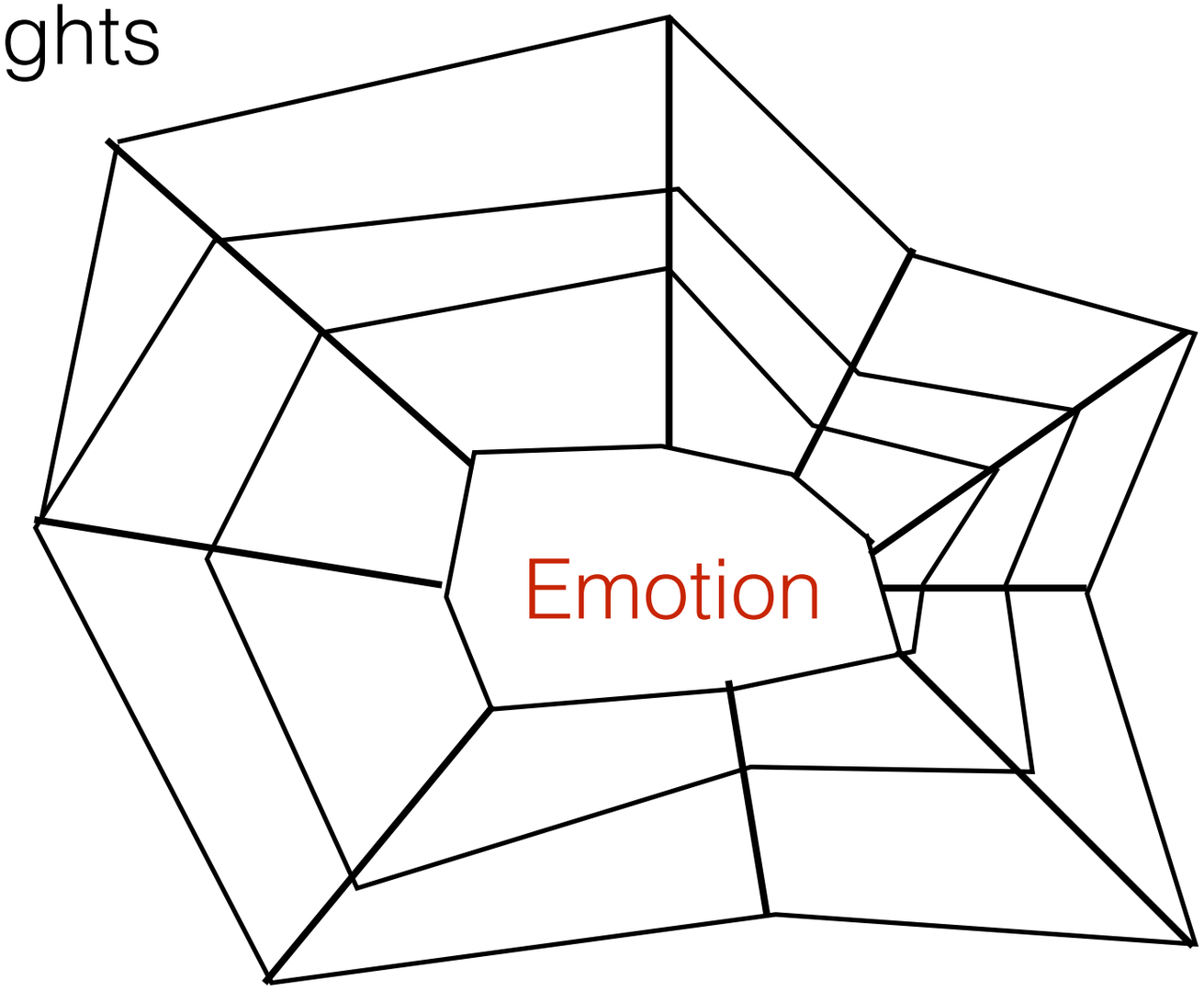
Future expectancy

Lazarus, 1991

# Features of emotions - the "emotion net"

Physiological responses

Thoughts

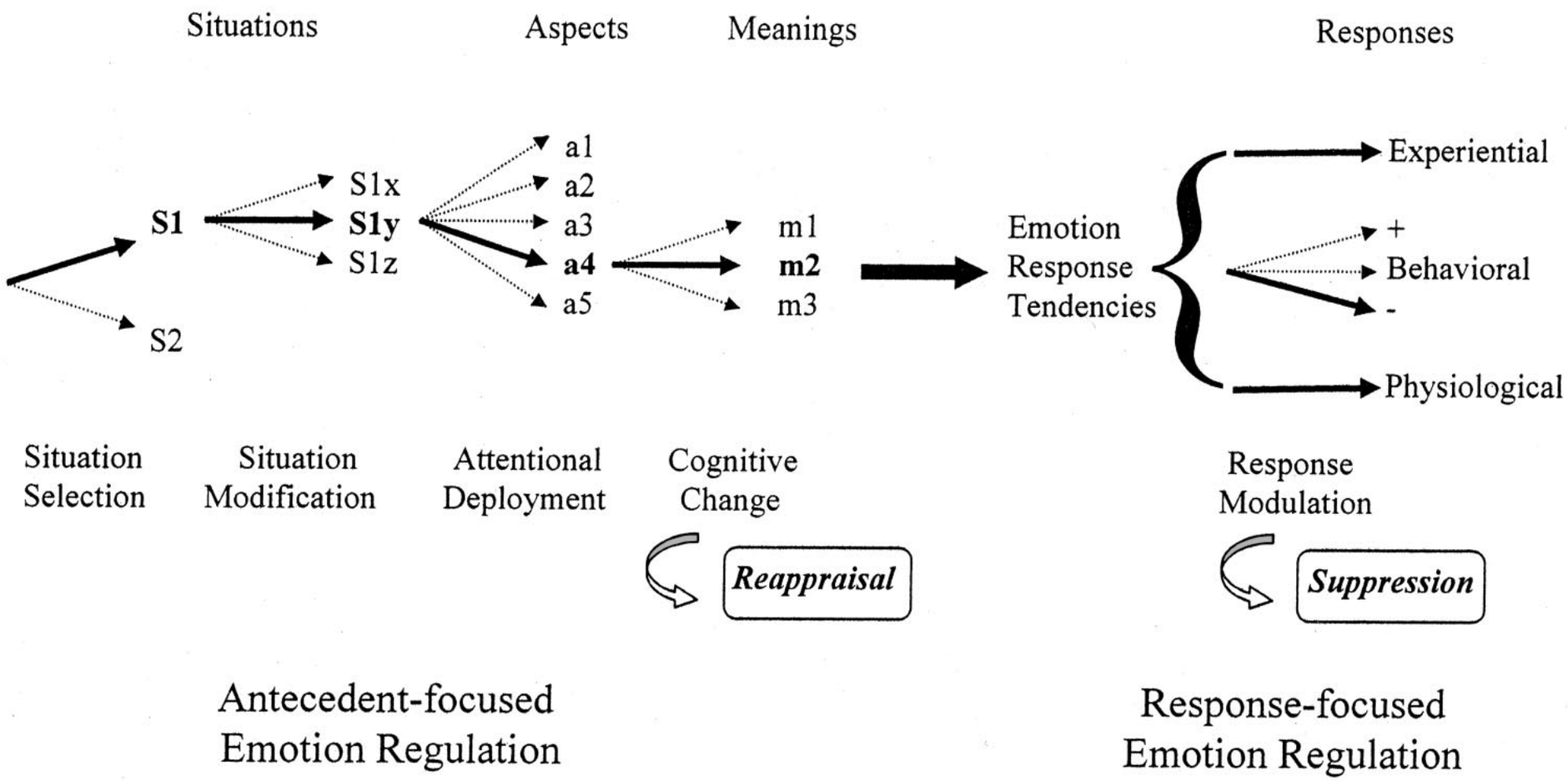



Postural adaptation

Perception

Action tendency

# Emotion regulation




Gross & John 2003 J Pers. Soc. Psychol.

# Emotion regulation habits

1. I control my emotions by changing the way I think about the situation I'm in.
2. When I want to feel less negative emotion, I change the way I'm thinking about the situation.
3. When I want to feel more positive emotion, I change the way I'm thinking about the situation.
4. When I want to feel more positive emotion (such as joy or amusement), I change what I'm thinking about.
5. When I want to feel less negative emotion (such as sadness or anger), I change what I'm thinking about.
6. When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm.
7. I control my emotions by not expressing them.
8. When I am feeling negative emotions, I make sure not to express them.
9. I keep my emotions to myself.
10. When I am feeling positive emotions, I am careful not to express them.

Gross & John 2003 J Pers. Soc. Psychol.

# Emotion regulation habits

Reappraisal

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*Longer Term Implications of Reappraisal and Suppression for Well-Being (Study 5)*

| | Emotion regulation strategy | |
|---|---|---|
| | Reappraisal | Suppressior |
| Depression[F] | | |
| BDI | −.23* | .25* |
| CES-D | −.25* | .23* |
| Zung | −.29* | .27* |
| Life satisfaction[E] | .30* | −.34* |
| Self-esteem[E] | .30* | −.39* |
| Optimism[C] | .25* | −.25* |
| Well-being[F] | | |
| Environmental mastery | .41* | −.23* |
| Autonomy | .29* | −.22* |
| Personal growth | .27* | −.28* |
| Purpose in life | .25* | −.34* |
| Self-acceptance | .35* | −.38* |
| Positive relations with others | .23* | −.46* |

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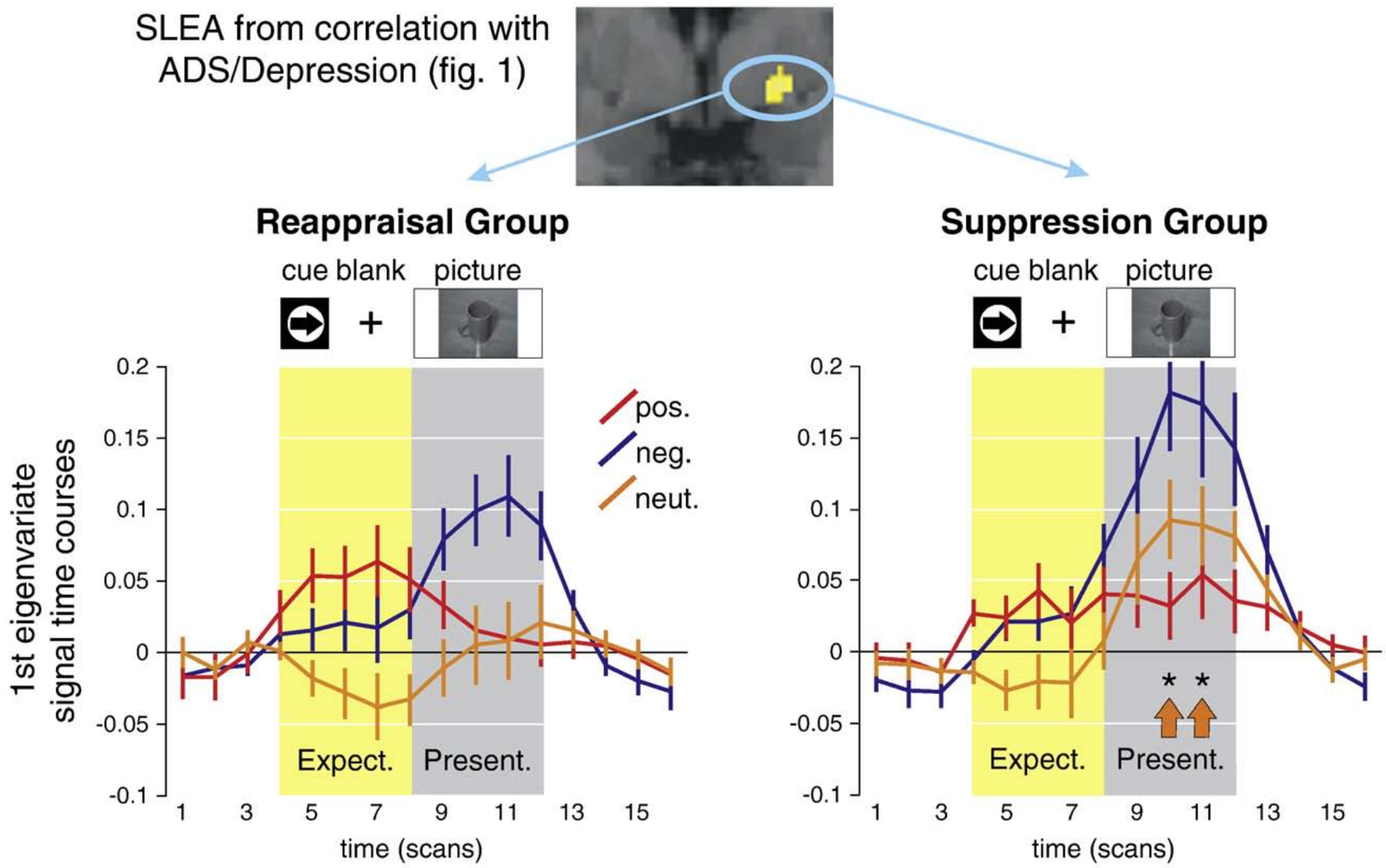
| Big Five personality dimensions[A] | | |
| Neuroticism | −.20* | .03 |
| Extraversion | .11* | −.41* |
| Openness | .15* | −.18* |
| Agreeableness | .14* | −.11* |
| Conscientiousness | .13* | −.14* |

Gross & John 2003 J Pers. Soc. Psychol.

# Habitual ER strategy

- Habitual suppression vs reappraisal - alters amygdala reactivity to aversive IAPS images




Abler et al., 2010

# Watch your thoughts

Watch your thoughts, for they become words.
Watch your words, for they become actions.
Watch your actions, for they become habits.
Watch your habits, for they become your character.
Watch your character, for it becomes your destiny.

# Computational approach

- Treat as “complex actions”
  - Basic emotion view
  - Action tendencies are important
  - Most prominent approach
  - Inflexibility -> Pavlovian account

$$p(a;s) \propto \mathcal{Q}(a,s)$$

$$p(a(c(s))) \propto \mathcal{V}(s)$$

# Computational approach

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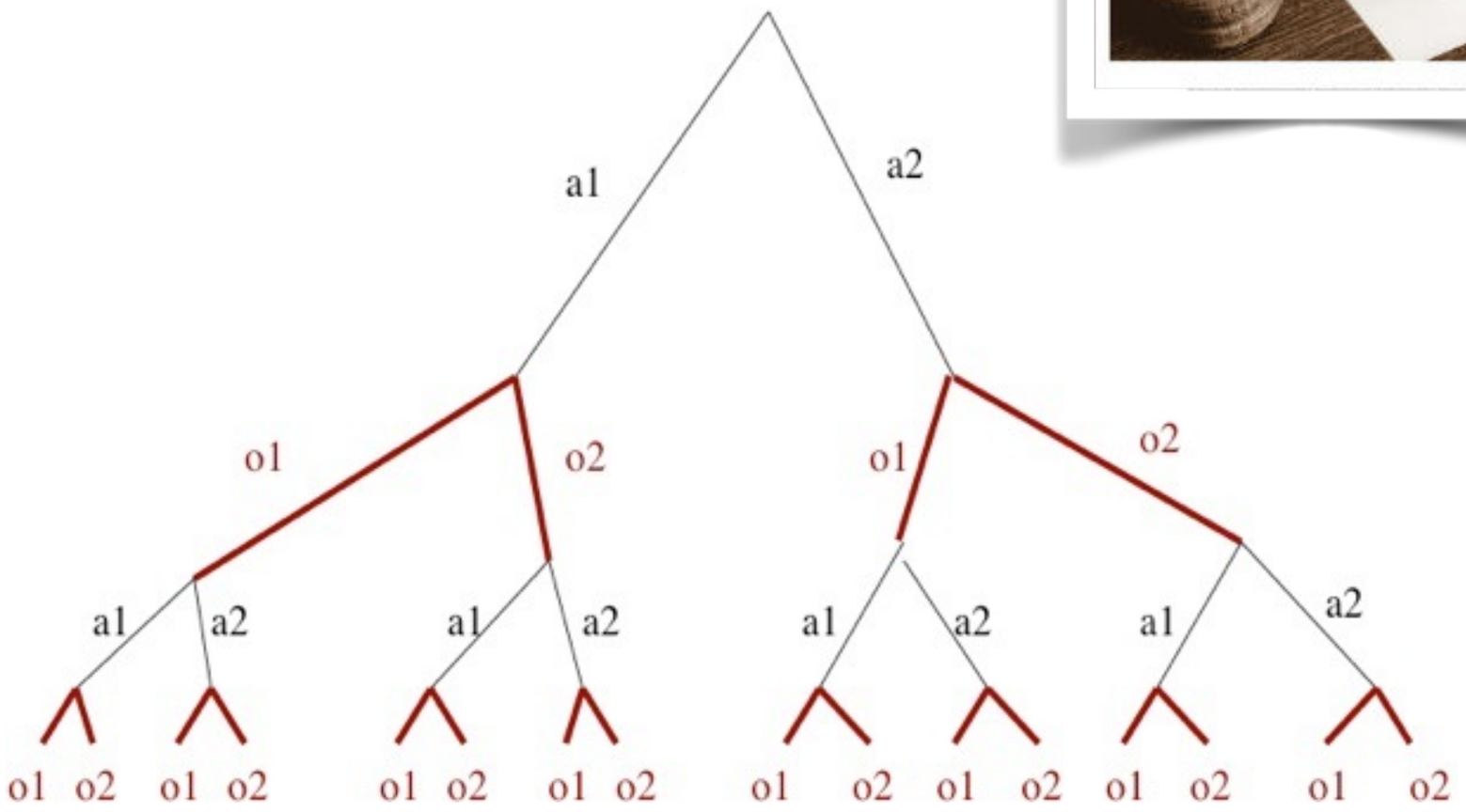
  - Most prominent appro
  - Inflexibility -> R

$$p(a; s)$$

$$p(a(c(s)))$$

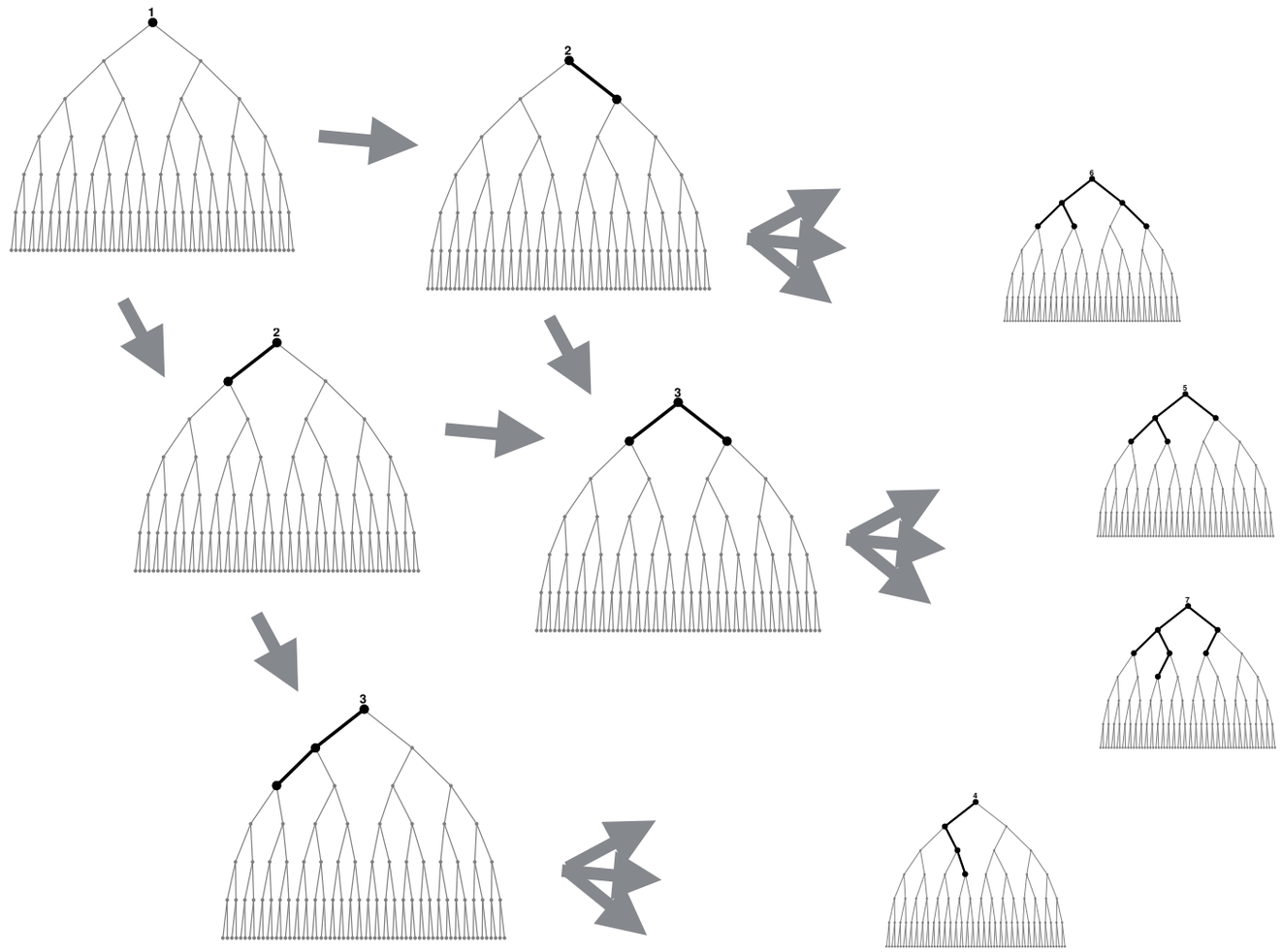

# Goal-directed decision making

- Each move: 30 odd options
- $30^{40}$?
- Legal boards ~$10^{123}$
- Can't just do full tree search.



# Metareasoning

- Resource constraints induce further problem
- Optimally deploying resources




Huys and Renz, 2017 Biol. Psych.

# Metareasoning

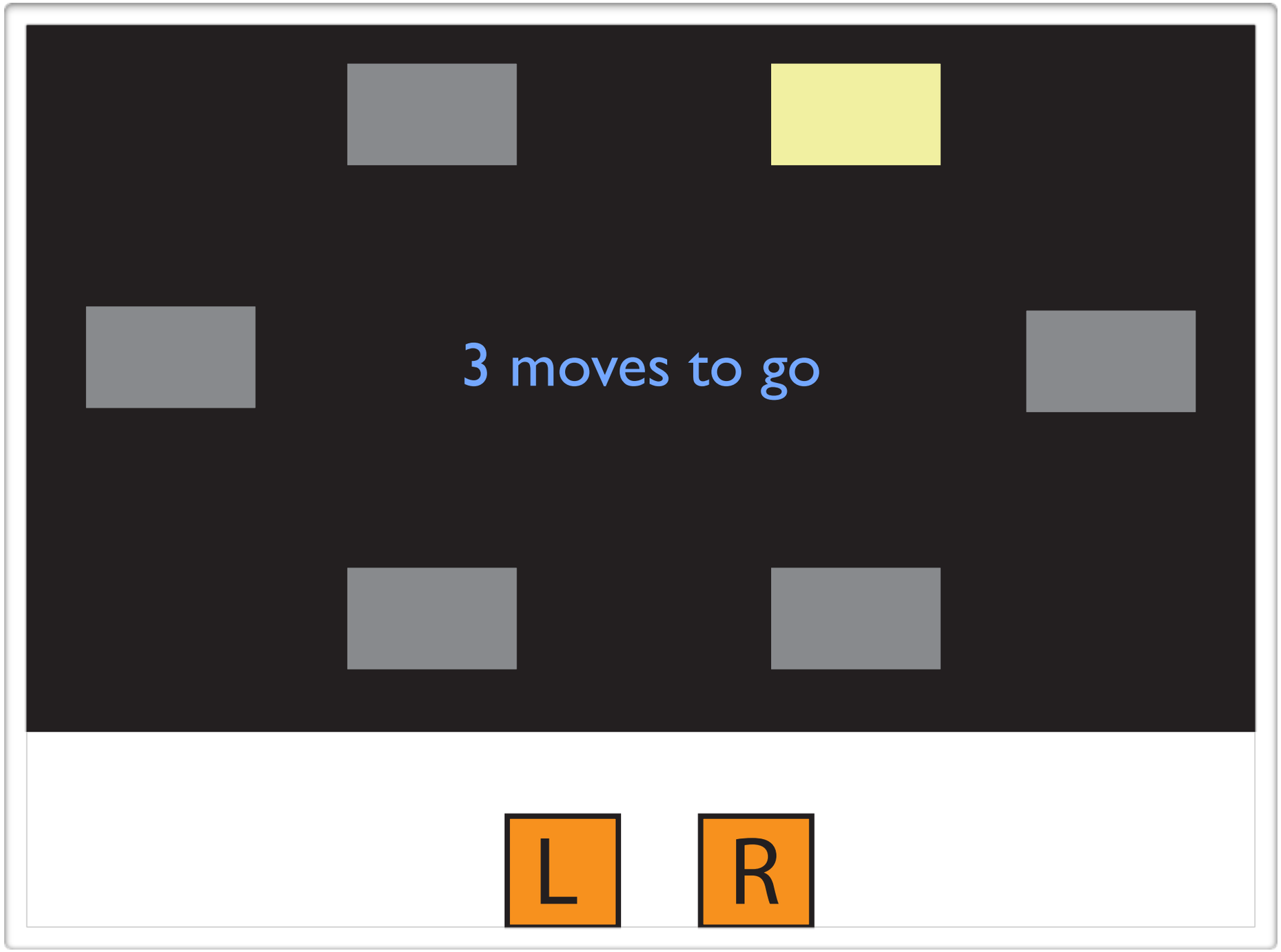
- Resource constraints induce further problem
- Optimally deploying resources

$$\mathcal{Q}(s,a) = \sum_{s'} \mathcal{T}(s'|s,a)[\mathcal{R}(s',a,s) + \mathcal{V}(s')]$$
$$= b_{s,a}$$

$$\mathcal{Q}(b,c) = \sum_{b'} \mathcal{T}(b'|b,c)[\mathcal{R}(b',c,b) + \mathcal{V}(b')]$$

- Entirely intractable
- Approximations are **mandatory**

# Studying metareasoning



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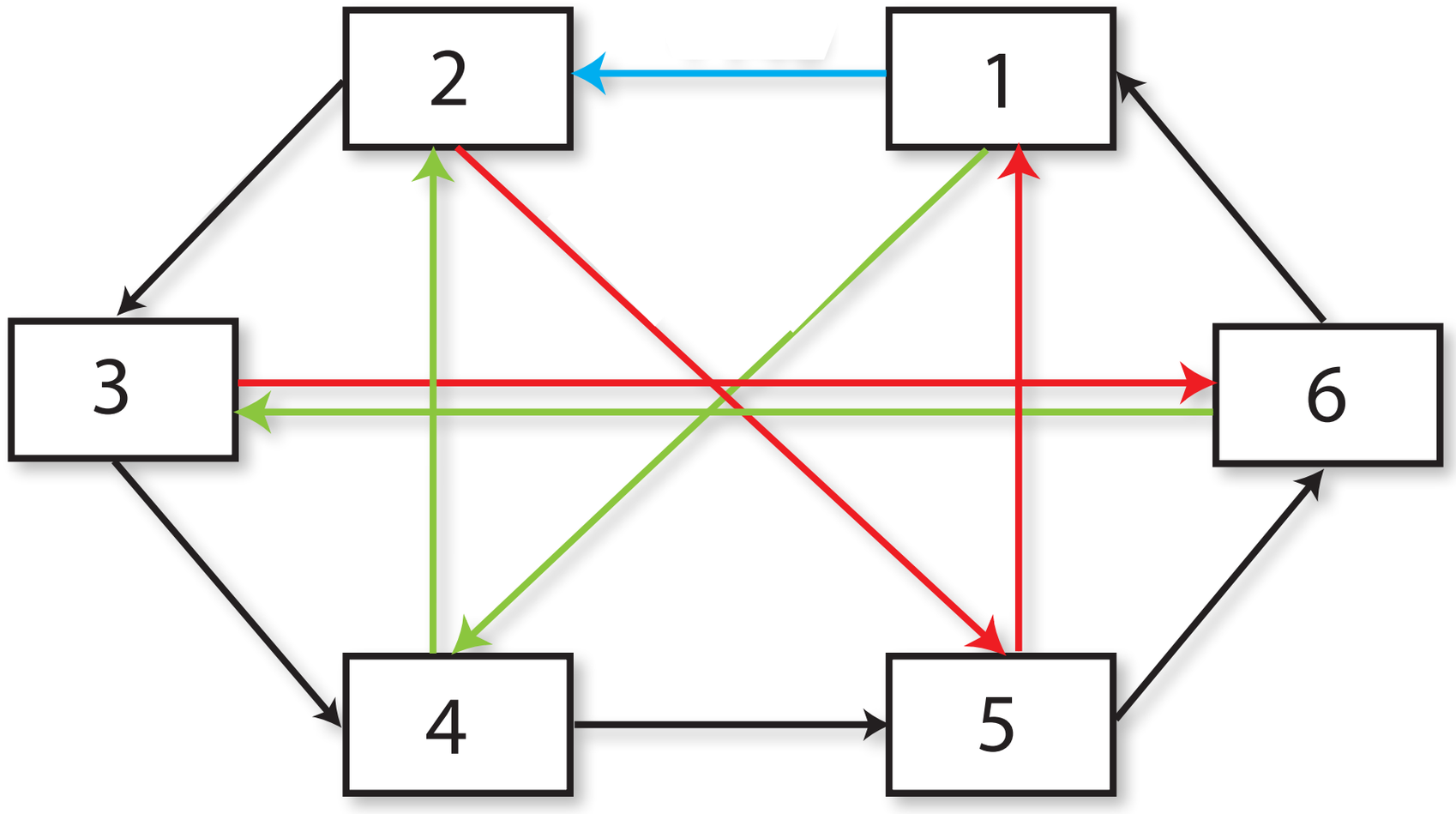
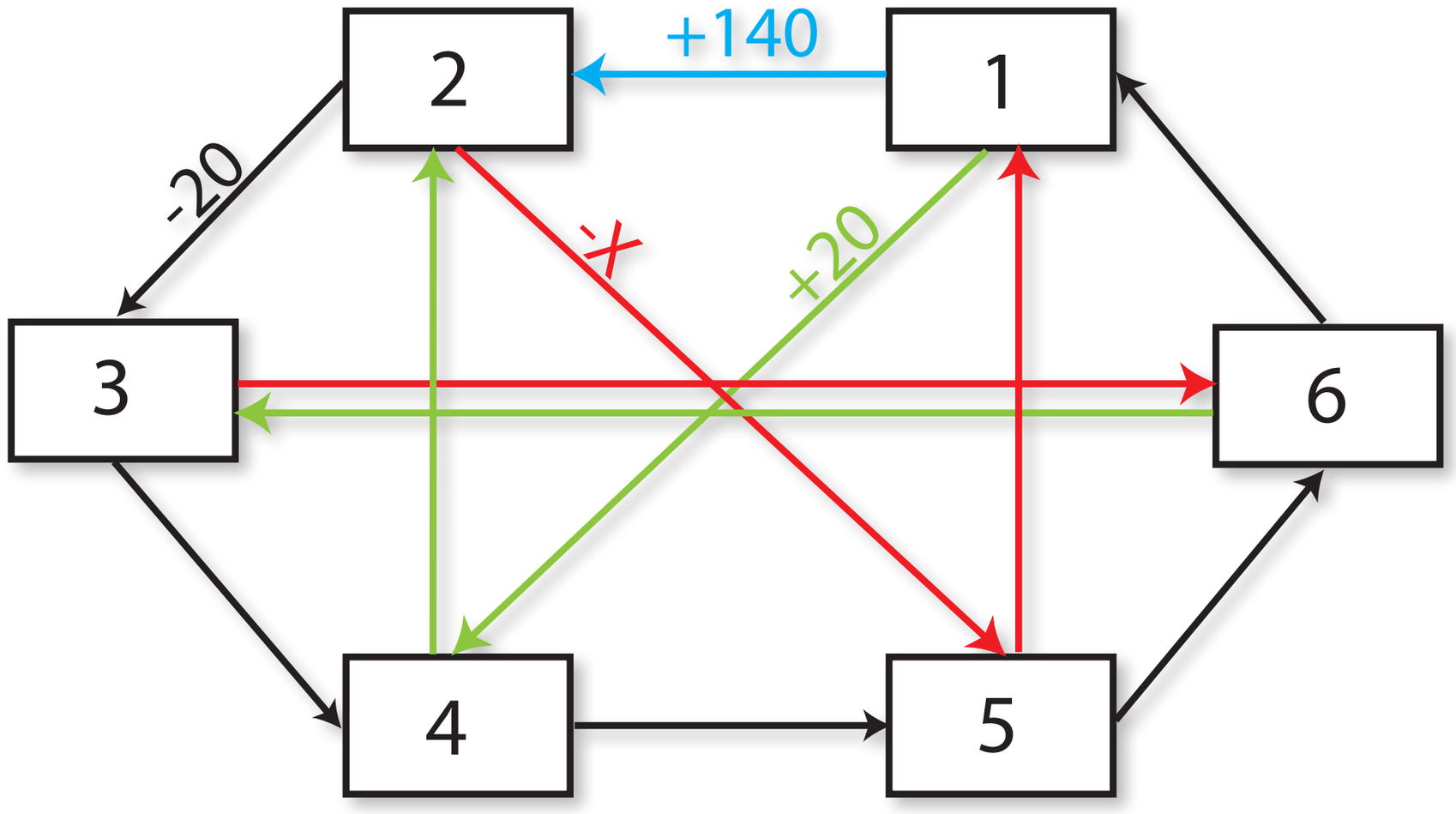



A tree search task

# Studying metareasoning

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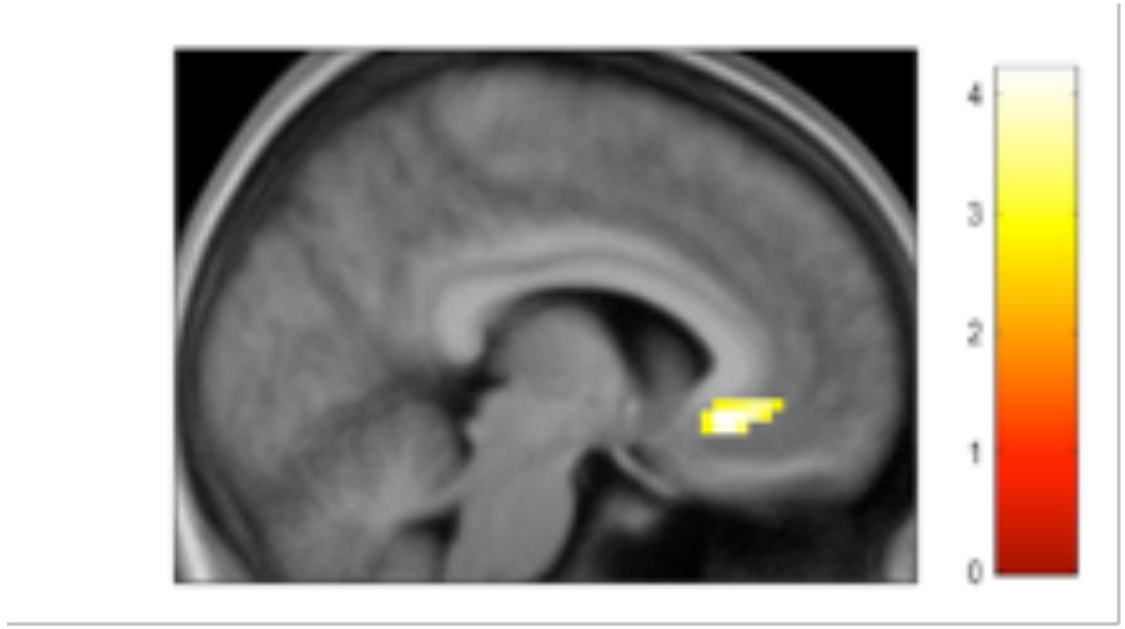


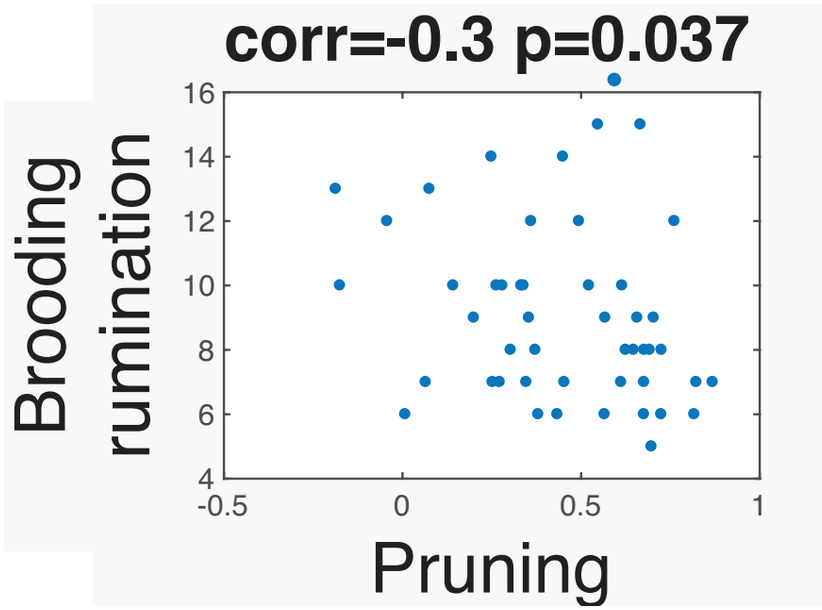


Lally et al., 2018, J. Neurosci; Huys et al., in prep.

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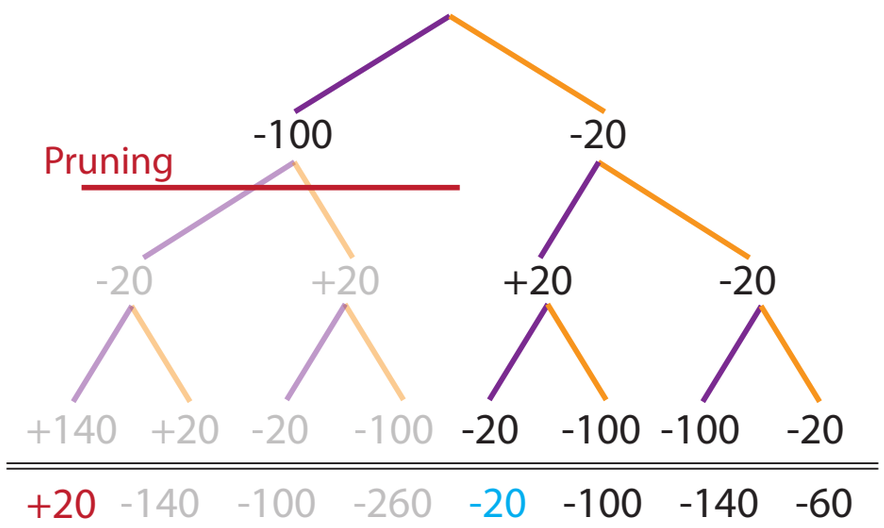


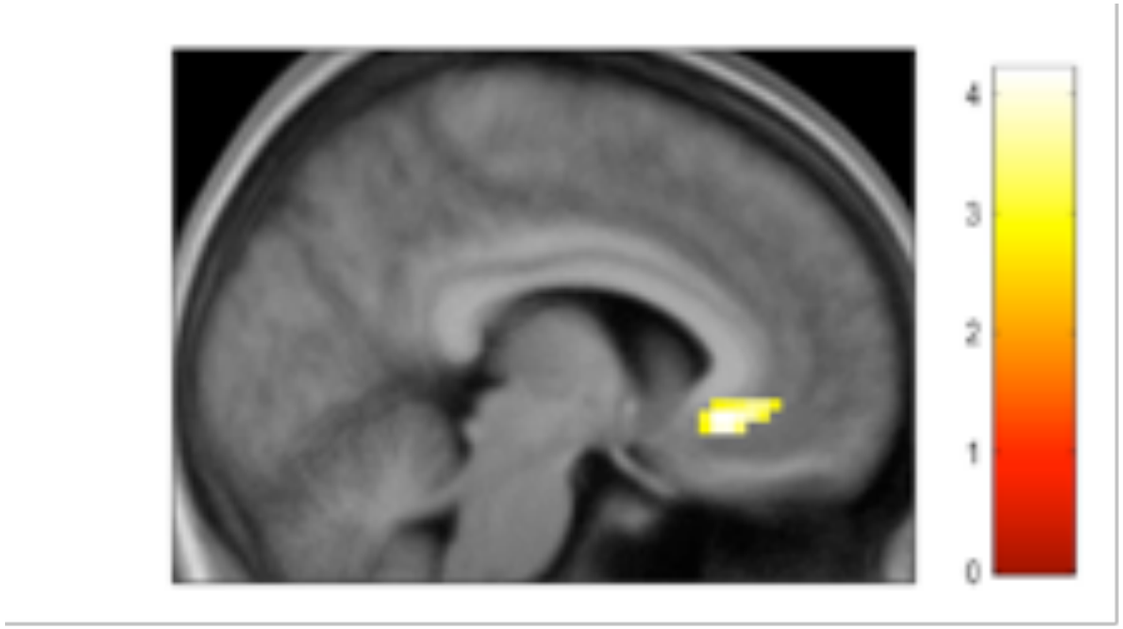


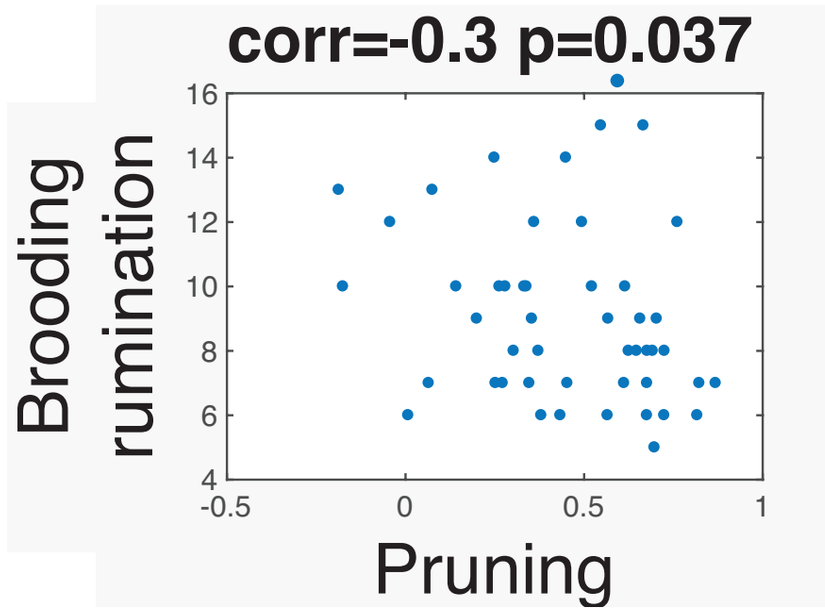


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# Emotions

- Basic emotions
  - Innate response strategies to evolutionarily important situations
  - Fail some critical tests
- Appraisal theories
  - Humans vary hugely in emotional responses
  - Depends on interpretation
  - Reappraisal, emotion regulation
  - Triggers… basic emotion
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# Outline

- Innate behaviours in humans
- Are emotions Pavlovian responses?
  - Theories of emotions
- Disorders of emotion

# DSM IV Major Depressive Disorder

- depressed mood
- anhedonia
- hypersomnia / insomnia
- weight gain / weight loss
- psychomotor retardataion
- fatigue
- guilt / worthlessness / helplessness
- indecisiveness, concentration difficulties
- suicidality

- duration & impairment

**TABLE 1.** Sensitivity, Specificity, OR, PPV and NPV of Alternative Symptom Criteria for Major Depressive Disorder ($N = 1523$)[a]

| Symptom | Sensitivity % | Specificity % | OR | PPV % | NPV % |
|---|---|---|---|---|---|
| Depressed mood | 92.9 | 82.4 | 61.2 | 86.3 | 90.6 |
| Diminished interest/pleasure | 80.6 | 87.8 | 29.7 | 88.7 | 79.1 |

McGlinchey et al., 2006

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|---|---|---|---|---|---|
| Depressed mood | 92.9 | 82.4 | 61.2 | 86.3 | 90.6 |
| **Loss of energy or diminished drive** | **97.6** | **55.3** | **50.1** | **72.3** | **95.0** |
| Loss of energy | 87.2 | 68.4 | 14.8 | 76.8 | 81.8 |
| **Diminished drive** | **88.2** | **69.9** | **17.3** | **77.8** | **83.2** |
| **Diminished interest/pleasure or diminished drive** | **94.2** | **66.4** | **32.2** | **77.0** | **90.6** |
| Diminished interest/pleasure | 80.6 | 87.8 | 29.7 | 88.7 | 79.1 |

McGlinchey et al., 2006

# 5 out of 9?

Table 5
Prevalences of lifetime interference, help seeking, and use of medication for minor depression and major depression

| | Interference[a] | | Saw MD[a] | | Saw other[a] | | Took medication[a] | | Any of the four | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | (S.E.) | % | (S.E.) | % | (S.E.) | % | (S.E.) | % | (S.E.) | (*n*) |
| Minor depression | 18.1 | (1.1) | 24.5 | (1.3) | 12.1 | (1.0) | 10.0 | (0.9) | 42.0 | (1.5) | (810) |
| Major depression 5–6 | 29.7[b] | (1.4) | 27.8 | (1.4) | 18.0[b] | (1.2) | 15.8[b] | (1.1) | 49.7[b] | (1.5) | (664) |
| Major depression 7–9 | 52.3[b] | (1.7) | 35.3[b] | (1.6) | 21.5[b] | (1.4) | 20.3[b] | (1.4) | 68.2[b] | (1.6) | (606) |

Average (mean) number of 30-day work loss and work cutback days associated with 12-month minor depression and major depression

| | Employed | | | | | Homemakers | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Work loss days | | Work cutback days | | | Work loss days | | Work cutback days | | |
| | $\bar{x}$ | (S.E.) | $\bar{x}$ | (S.E.) | (*n*) | $\bar{x}$ | (S.E.) | $\bar{x}$ | (S.E.) | (*n*) |
| Minor depression | 0.17 | (0.11) | 0.79 | (0.23) | (242) | 0.10 | (0.10) | 1.15 | (0.78) | (40) |
| Major depression 5–6 | 0.17 | (0.04) | 0.99 | (0.20) | (227) | 0.36 | (0.35) | 1.20 | (0.46) | (30) |
| Major depression 7–9 | 0.48[a] | (0.13) | 2.75[a] | (0.34) | (222) | 1.70[a] | (0.59) | 4.27[a] | (1.08) | (49) |

Kessler et al., 1997

# The course of depression

**Table 5.—Adjusted and Unadjusted Attributable Risks for First-Onset Major Depression at Wave II**

| Psychiatric Disorder | Unadjusted Attributable Risk | Adjusted Attributable Risk |
|---|---|---|
| Dysthymia | 0.050 | 0.077 |
| Panic disorder | 0.039 | 0.007 |
| Somatization | 0.017 | 0.006 |
| Alcohol abuse | 0.057 | 0.020 |
| Other drug abuse | 0.030 | 0.000 |
| Obsessive-compulsive disorder | 0.049 | 0.011 |
| Schizophrenia | 0.040 | 0.013 |
| Depressive symptoms | 0.581 | 0.553 |

Horwath et al., 1992 - ECA

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Table 3
*Frequency of Symptom Presentation in the Prodromal and Residual Phases (N = 331 Episodes)*

| Symptom | Prodromal frequency | Residual frequency |
|---|---|---|
| Depressed mood | 95 | 79 |
| Decreased appetite | 42 | 40 |
| Weight loss | 13 | 12 |
| Increased appetite | 10 | 12 |
| Weight gain | 20 | 17 |
| Initial insomnia | 29 | 30 |
| Middle insomnia | 13 | 10 |
| Early waking | 11 | 14 |
| Hypersomnia | 23 | 22 |
| Decreased energy | 38 | 35 |
| Decreased interest or pleasure | 82 | 75 |
| Self-blame | 51 | 55 |
| Decreased concentration | 78 | 75 |
| Indecision | 6 | 8 |
| Suicidality | 6 | 5 |
| Psychomotor agitation | 6 | 5 |
| Psychomotor retardation | 10 | 7 |
| Crying more frequently | 34 | 31 |
| Inability to cry | 4 | 2 |
| Hopelessness | 195 | 201 |
| Worrying/Brooding | 104 | 118 |
| Decreased self-esteem | 195 | 199 |
| Irritability | 85 | 72 |
| Dependency | 45 | 46 |
| Self-pity | 24 | 28 |
| Somatic complaints | 5 | 4 |
| Decreased effectiveness | 38 | 37 |
| Helplessness | 35 | 28 |
| Decreased initiation of voluntary responses | 19 | 23 |

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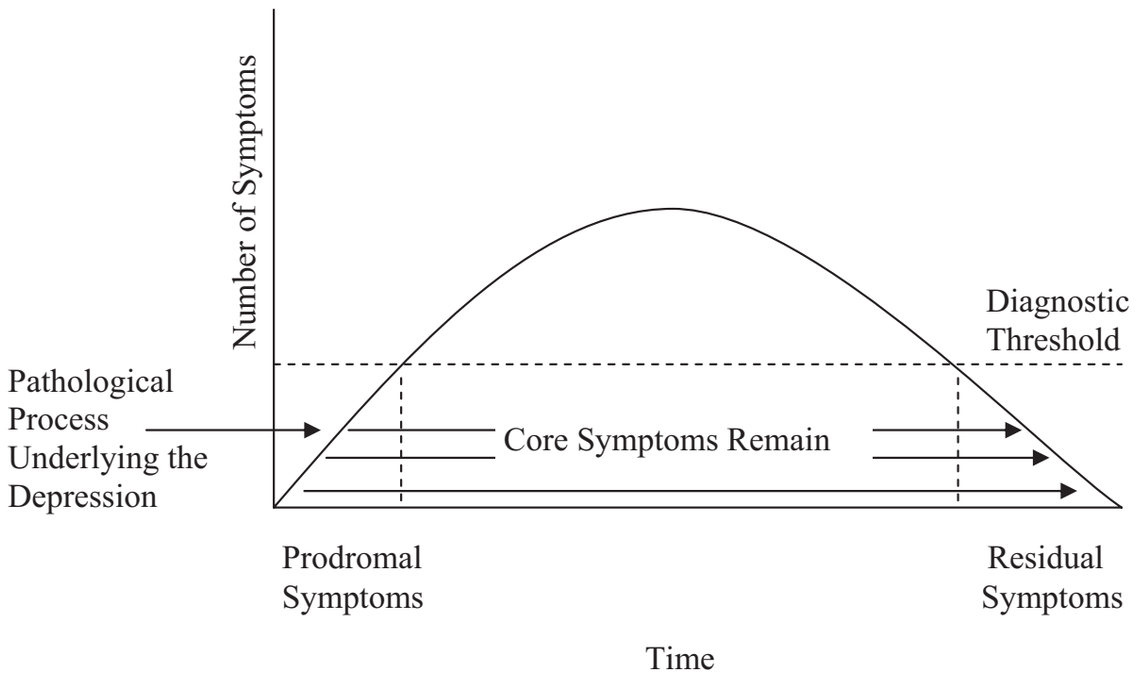


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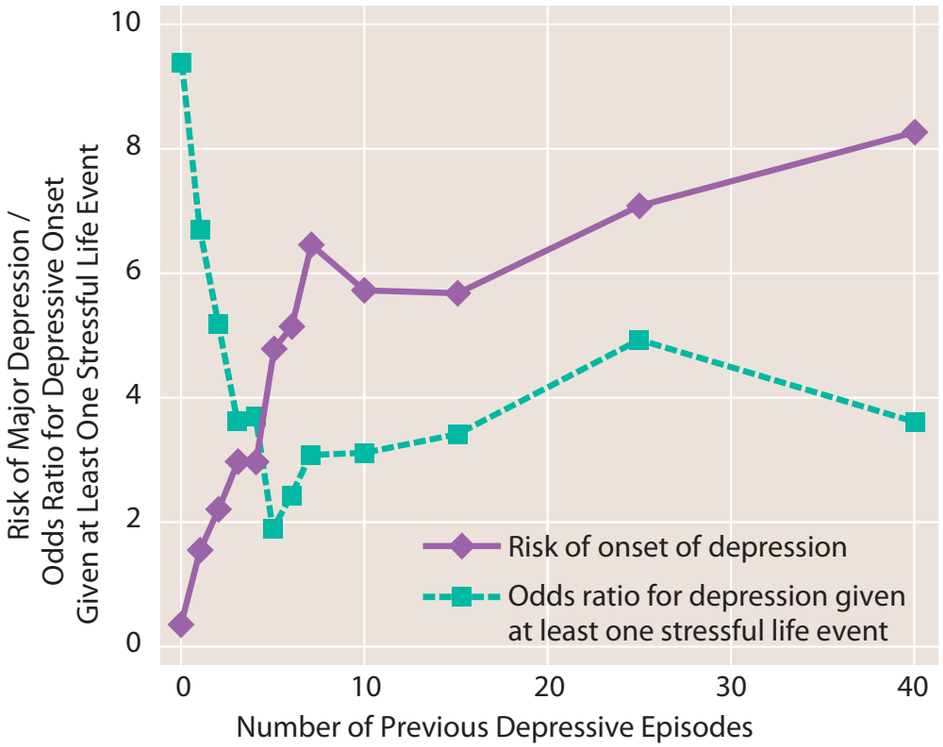
Iacoviello et al., 2010

# External causes

- Loss events
- Severe stress
- Chronic stress
- Social defeat

- Maternal depression

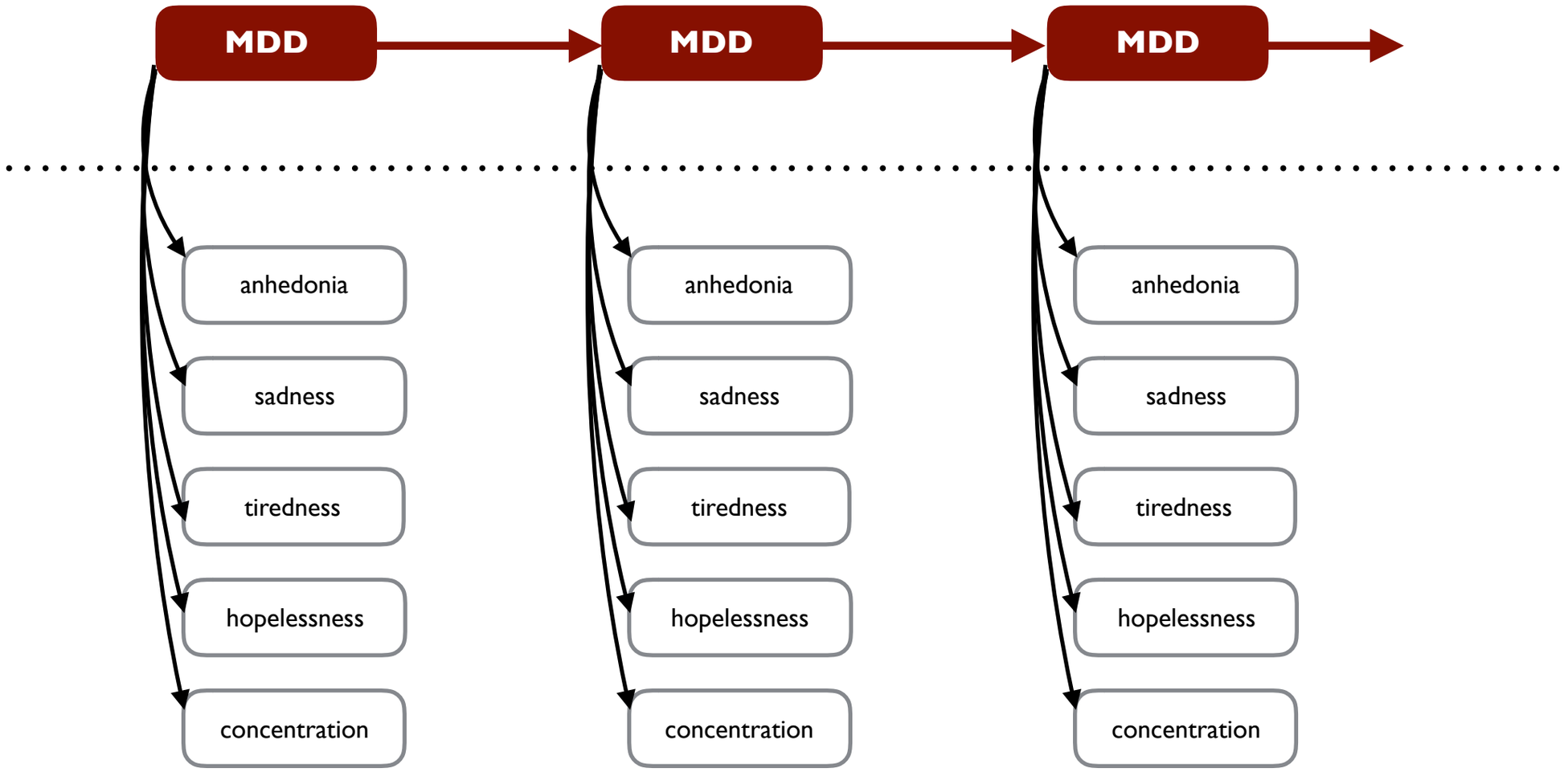
- But: 30% acausal




Kendler et al., 2000

Kendler et al., 1999,2000, Gotlib et al., 2010

# Latent cause model



# Symptom network model

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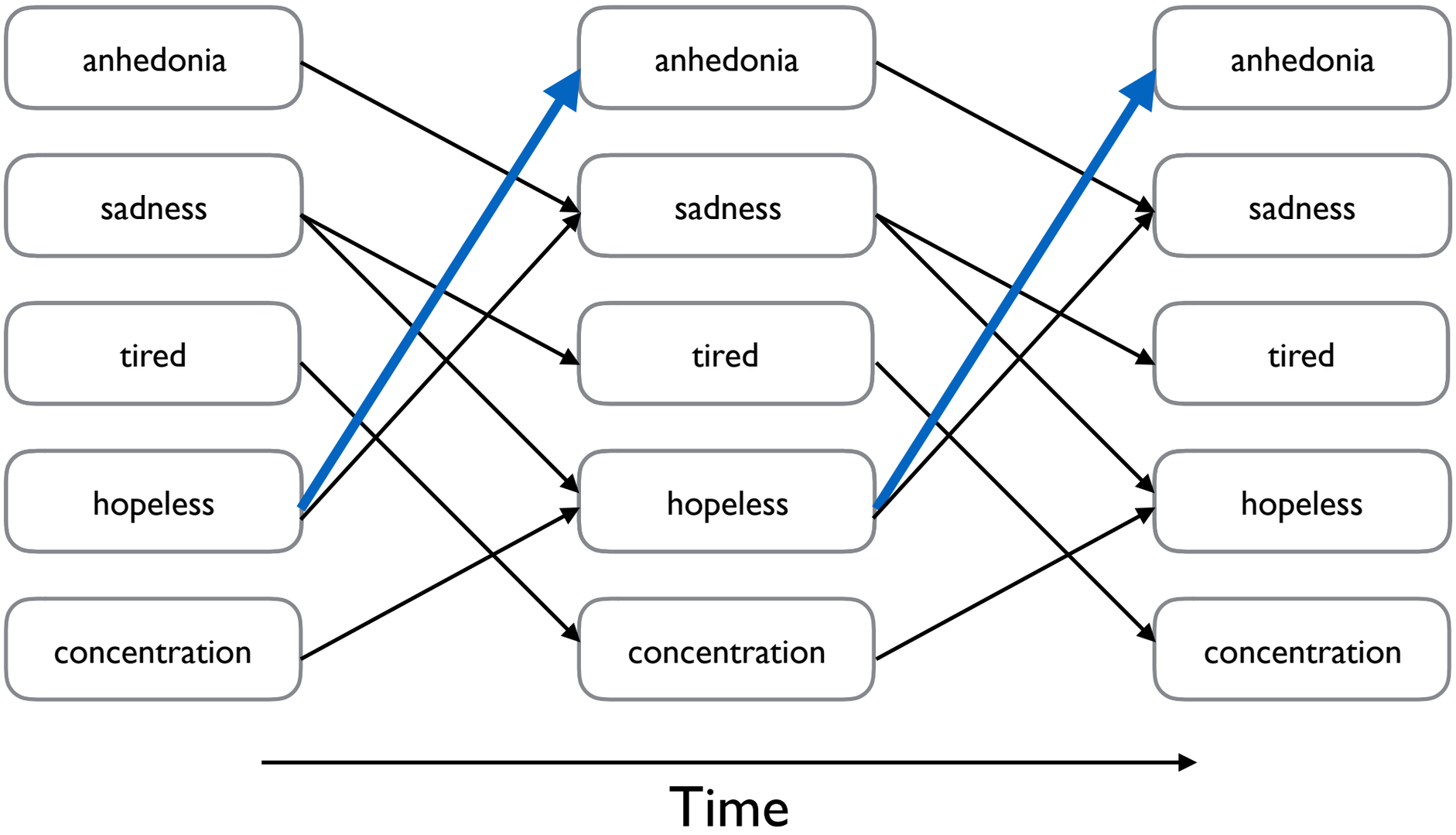
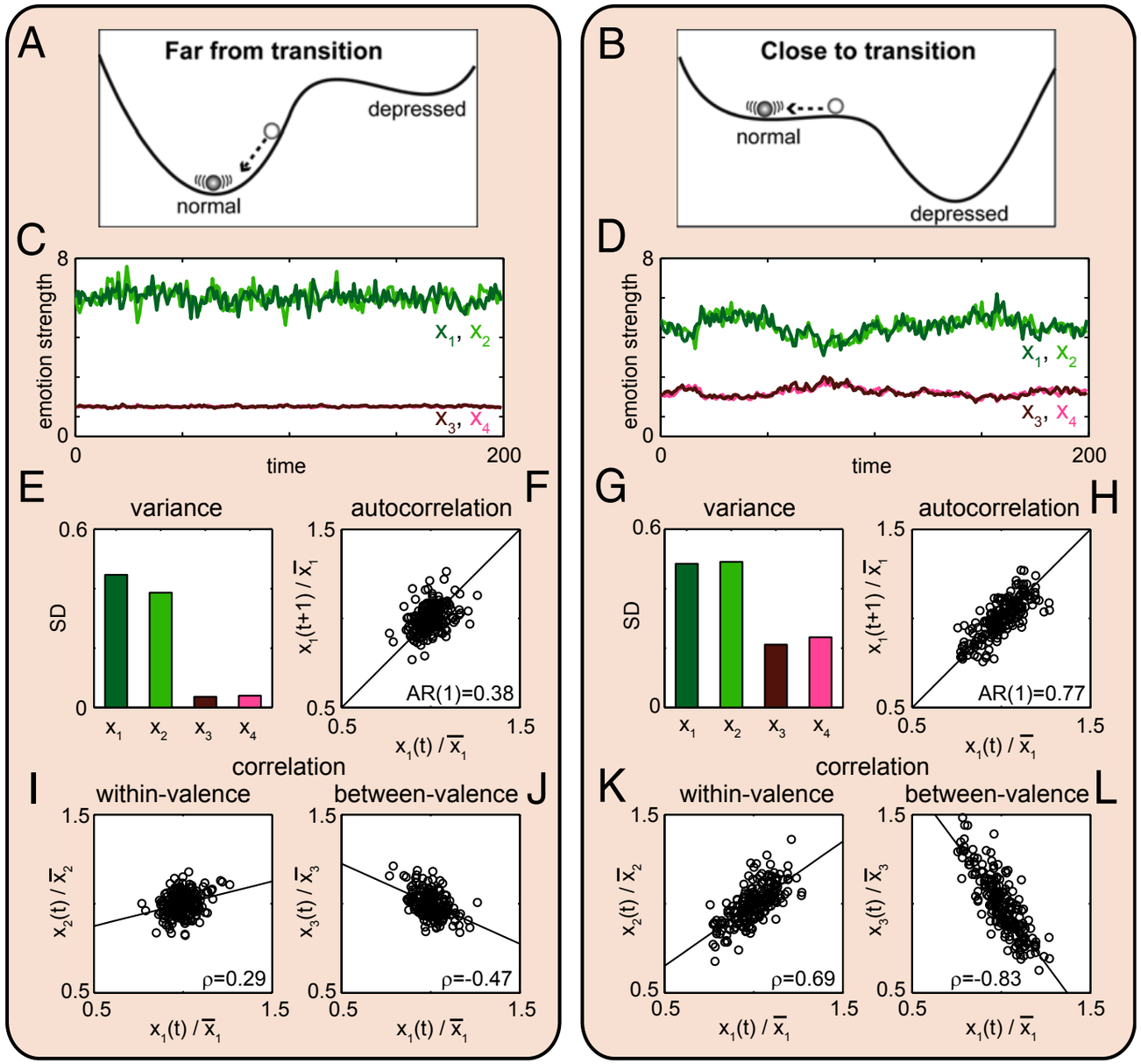
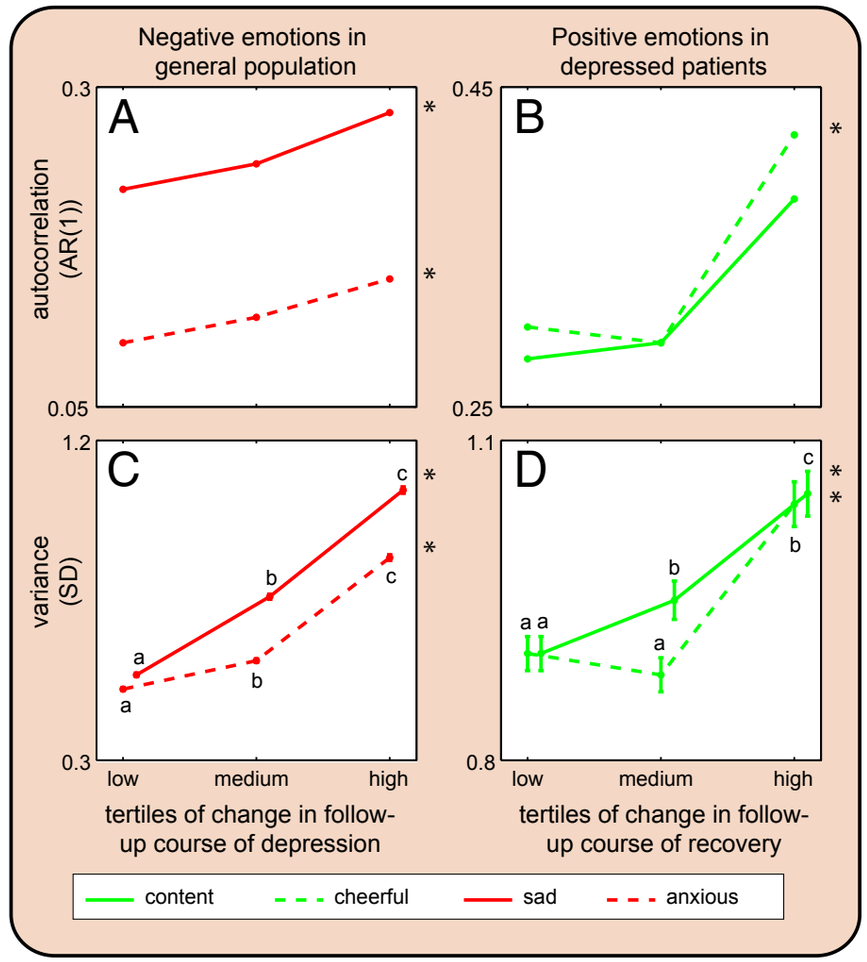


# Depression as stable dynamic states

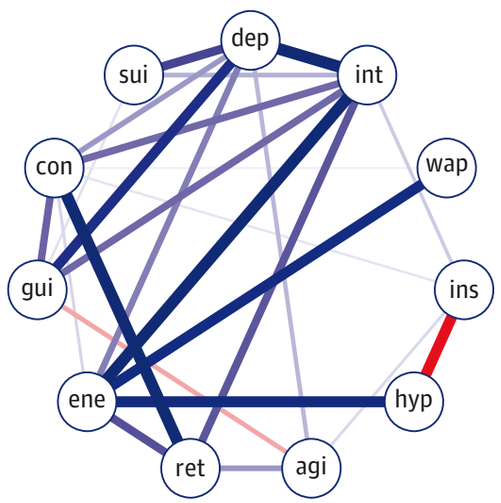


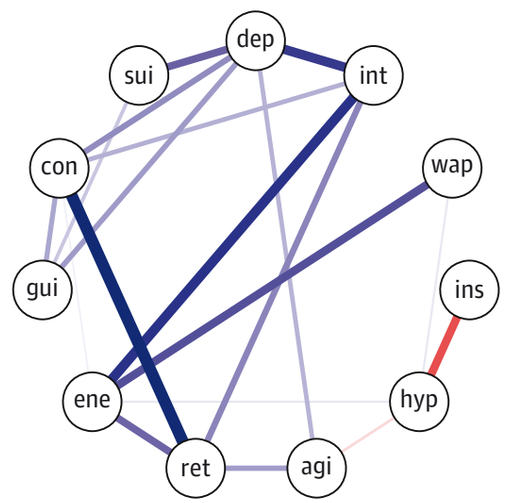

Van de Leemput et al., 2014 PNAS

# Symptom interactions matter

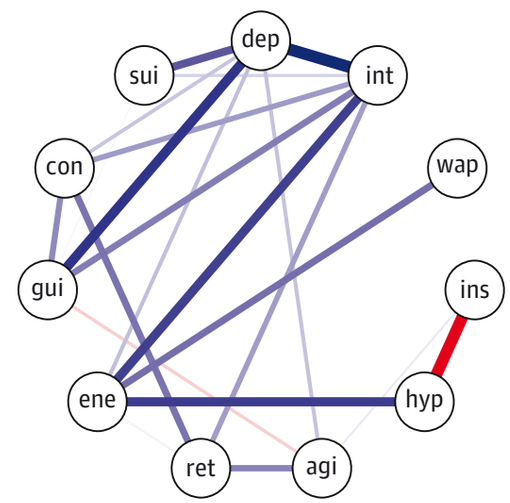
Original data

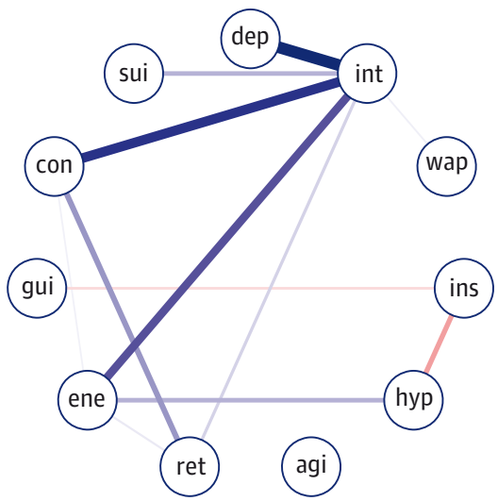


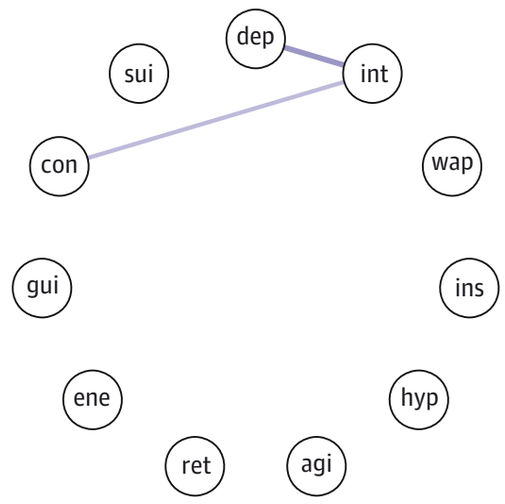

Data after IDS sum score matching

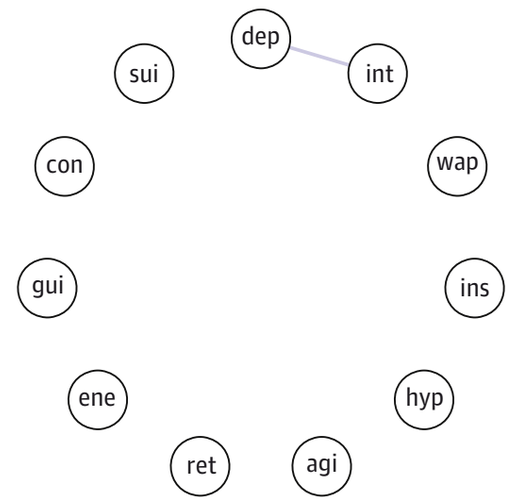



Data after WHODAS II partialing out



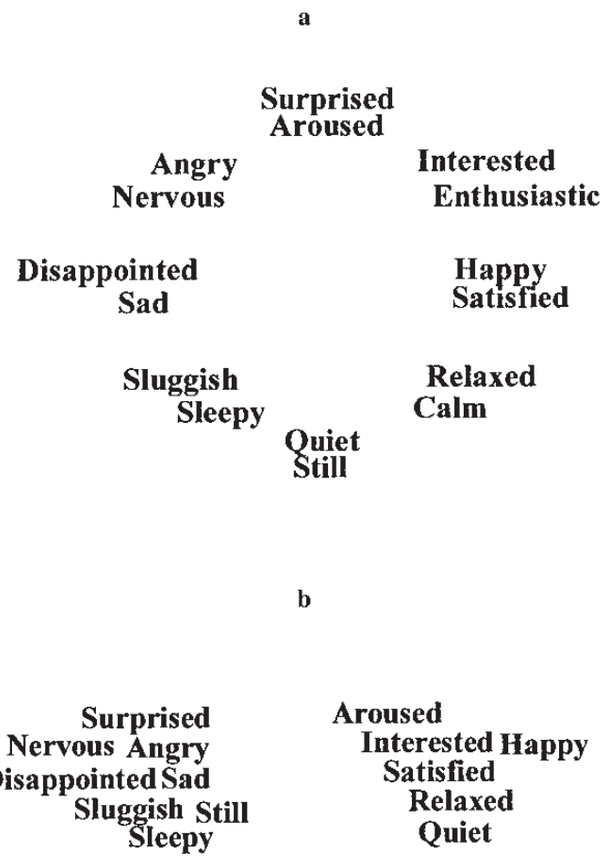



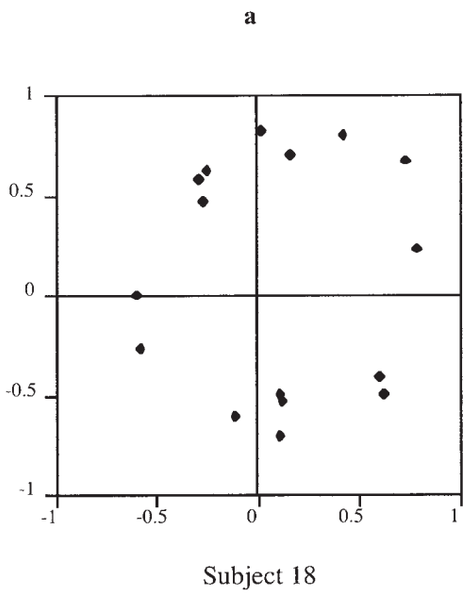



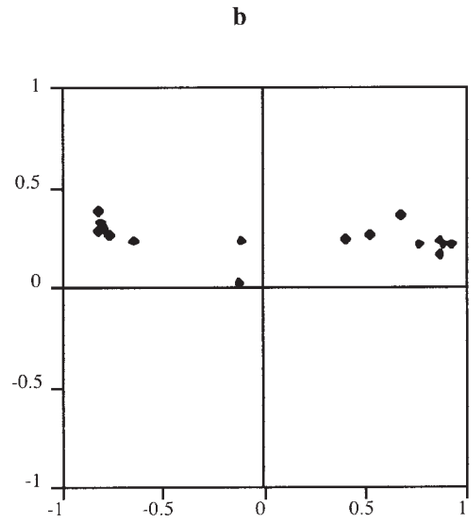

Van Borkulo et al., 2017 JAMA Psych.

# Emotional granularity

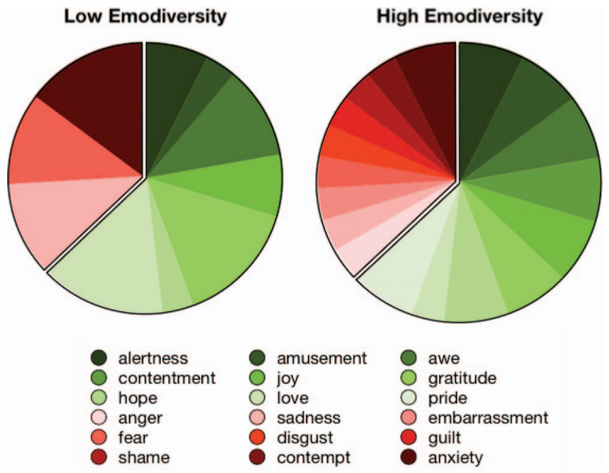



Subject 18




Subject 6




Emodiversity

-doctors visits

-doctors costs to social sec

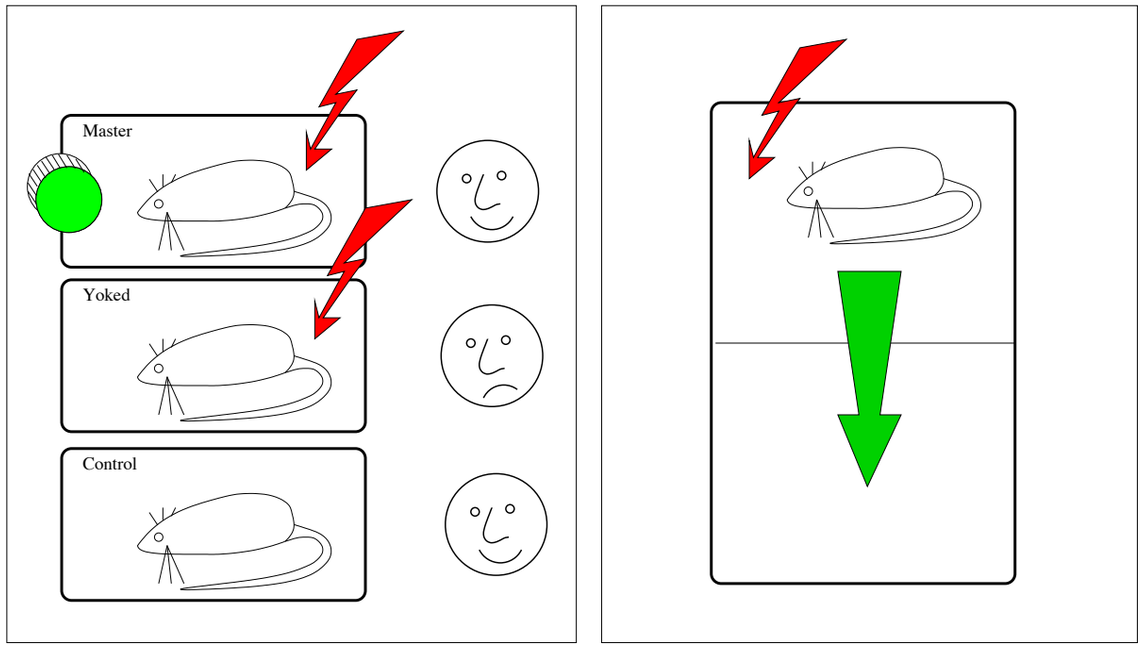
-days in  hospital

-medication costs

FeldmanBarrett 2004 J. Pers. Soc. Psychol.; Quoidbach et al., 2014 J. Exp. Psychol. Gen

# Animal models of depression

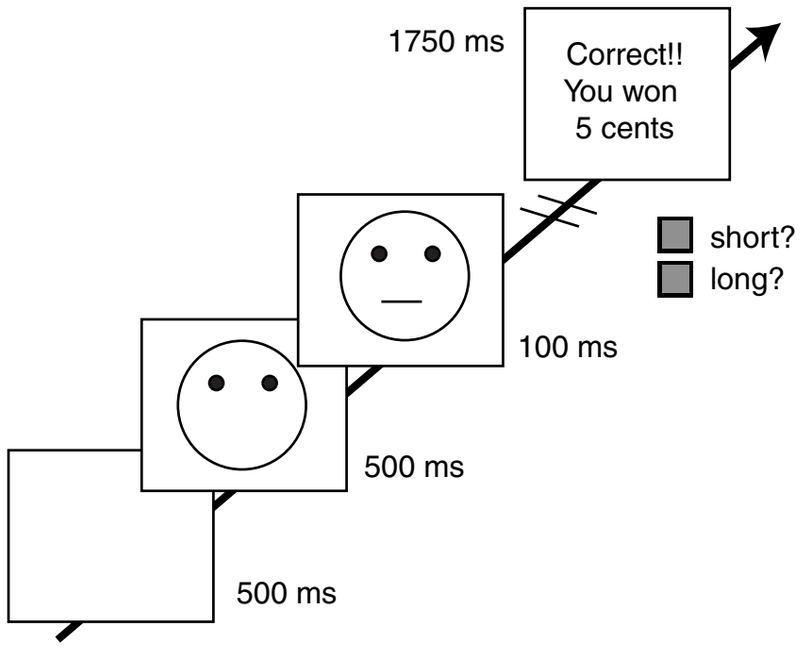
- Learned helplessness
  - Uncontrollable shocks
  - Escape




- Chronic mild stress
  - Chronic bother
  - Sucrose preference

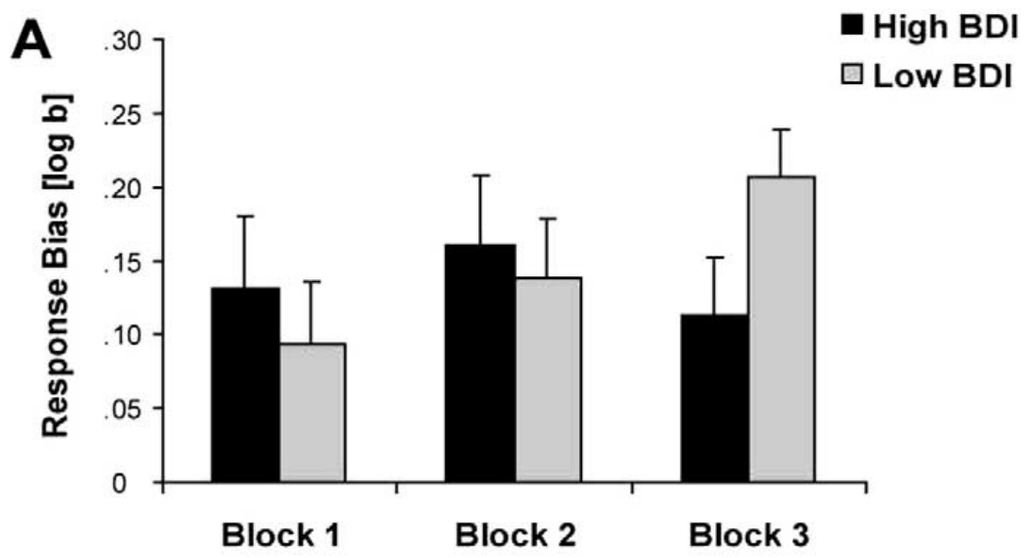
Maier & Seligmann 1967; Willner et al., 1982

# Reward expectation




| | | |
|---|---|---|
| Long = rich: | Long correct: | 75% rewarded |
| | Short correct: | 30% rewarded |

| | | |
|---|---|---|
| Short = rich: | Long correct: | 30% rewarded |
| | Short correct: | 75% rewarded |




Pizzagalli et al., 2005

# Learning or sensitivity?

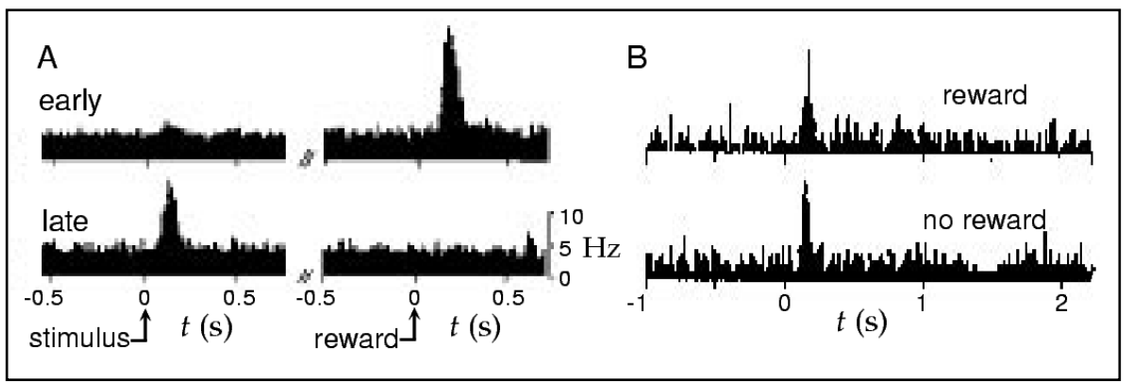
$$\mathcal{Q}_t(a,s) = \mathcal{Q}_{t-1}(a,s) + \epsilon(r_t - \mathcal{Q}_{t-1}(a,s))$$

Kapur and Mann 1992, Muscat et al. 1992, Papp et al. 1994, Willner et al. 1997, Dunlop and Nemeroff 2007, Gershon et al. 2007, Martin-Soelch 2009

# Learning or sensitivity?

$$\mathcal{Q}_t(a,s) = \mathcal{Q}_{t-1}(a,s) + \epsilon(r_t - \mathcal{Q}_{t-1}(a,s))$$

## Dopamine




Montague et al. 1996, Schultz et al. 1997

Kapur and Mann 1992, Muscat et al. 1992, Papp et al. 1994, Willner et al. 1997, Dunlop and Nemeroff 2007, Gershon et al. 2007, Martin-Soelch 2009

# Learning or sensitivity?

Anhedonia

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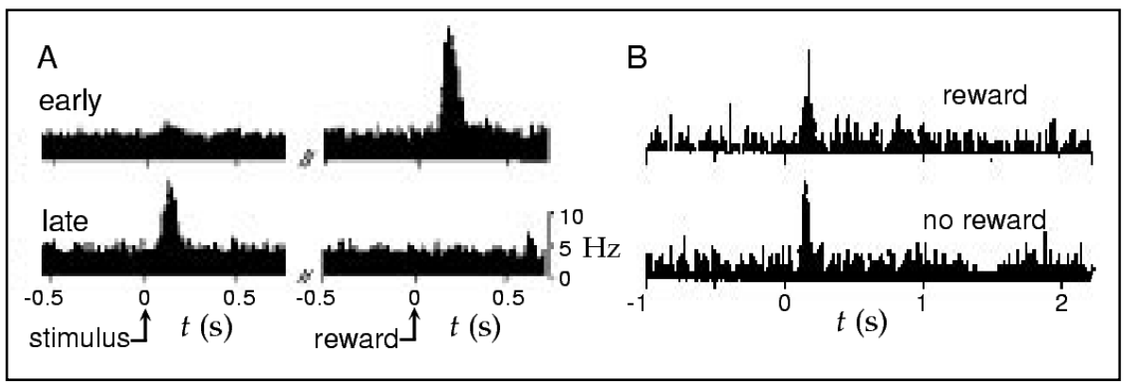
Dopamine

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$\beta$

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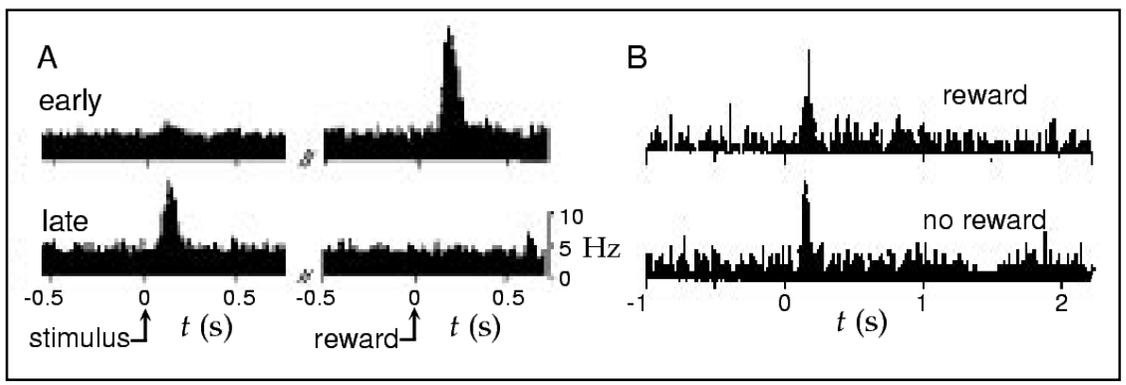


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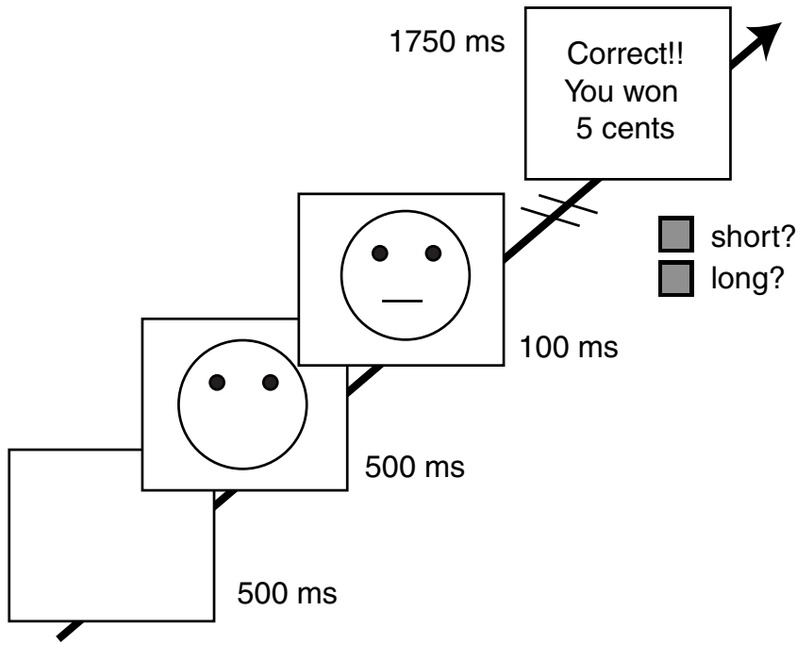
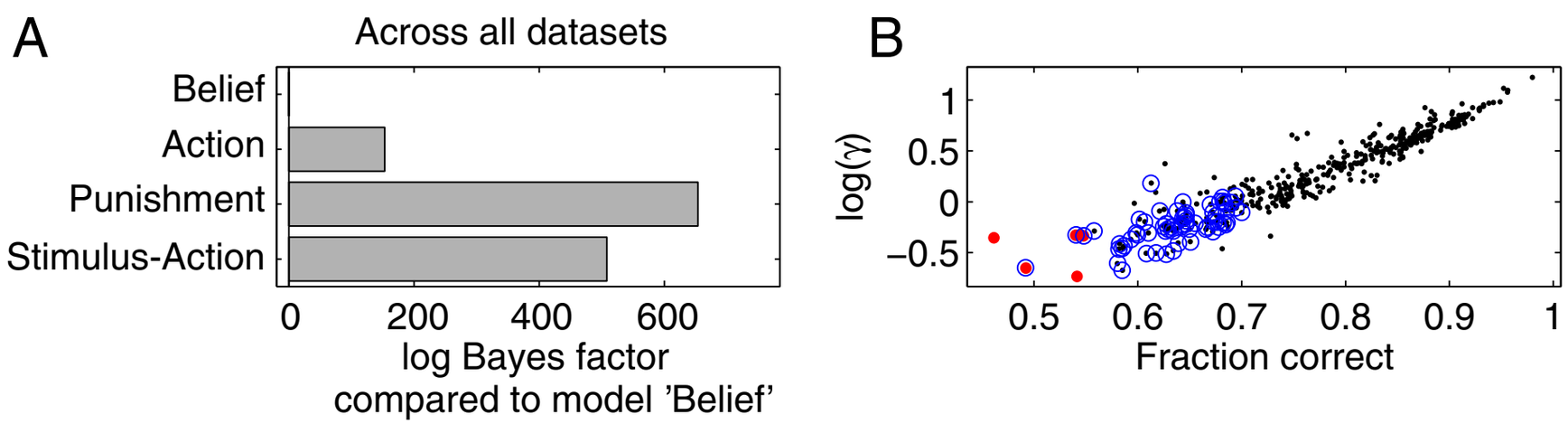
# Modelling: first get the task




$$p(a_t|s_t) = \frac{1}{1+\exp\left[-(\mathcal{W}_t(a_t,s_t) - \mathcal{W}_t(\bar{a}_t,s_t))\right]}$$

$$\mathcal{W}_t(a_t,s_t) = \gamma\mathcal{I}(a_t,s_t) + \zeta\ \mathcal{Q}_t(a_t,s_t) + (1-\zeta)\ \mathcal{Q}_t(a_t,\bar{s}_t)$$

Instruction  Reward/bias component




Huys et al., 2013

# Learning or sensitivity?

Huys et al., 2013

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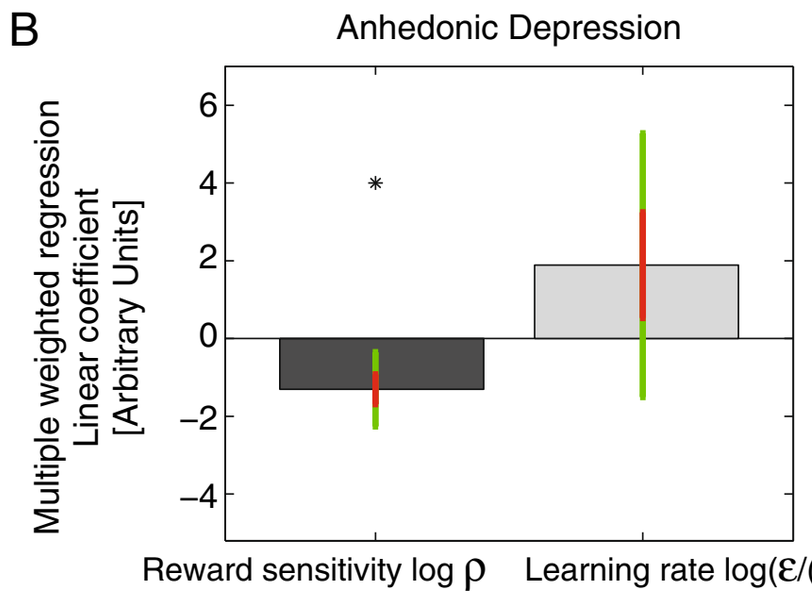
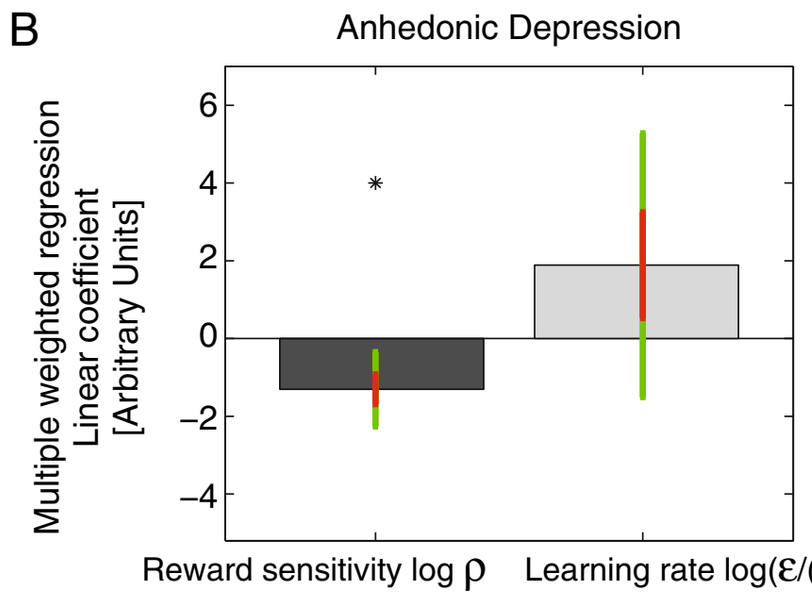
- Correlation of anhedonia is with reward sensitivity, not learning rate




Huys et al., 2013

# Learning or sensitivity?

- Correlation of anhedonia is with reward sensitivity, not learning rate
- But: correlations




Huys et al., 2013

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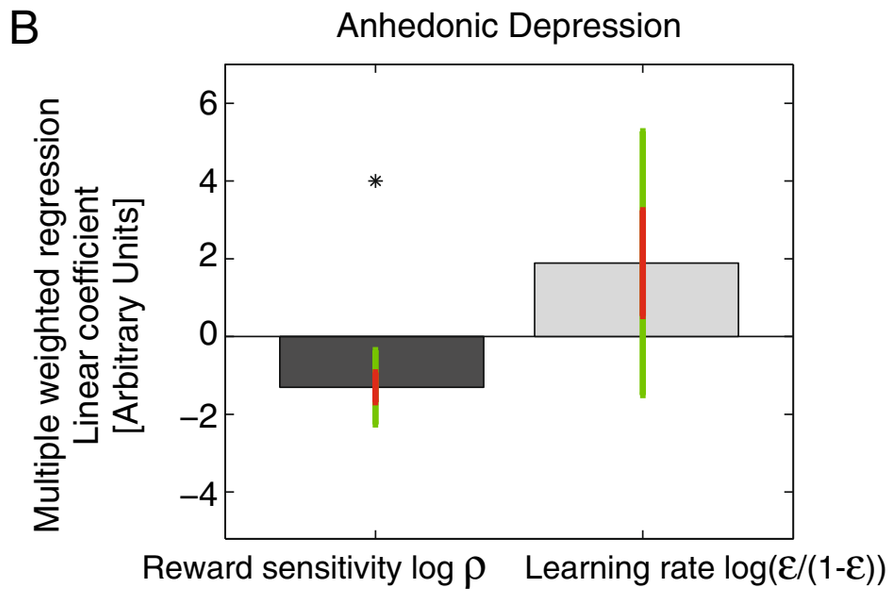


Huys et al., 2013

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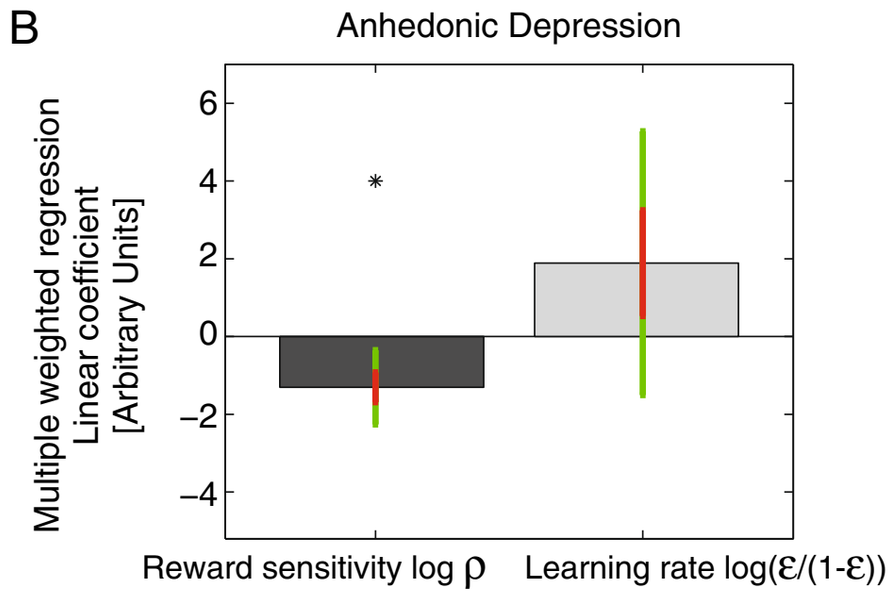


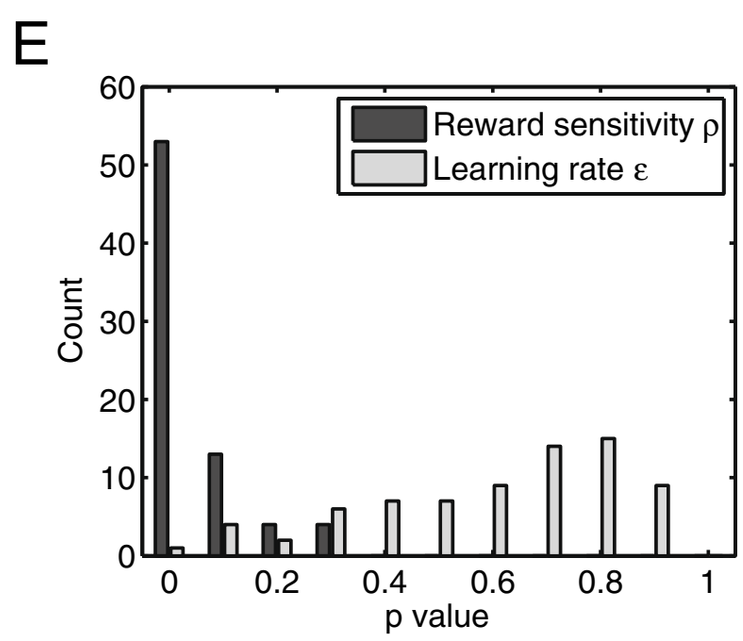


Huys et al., 2013

# Learning or sensitivity?

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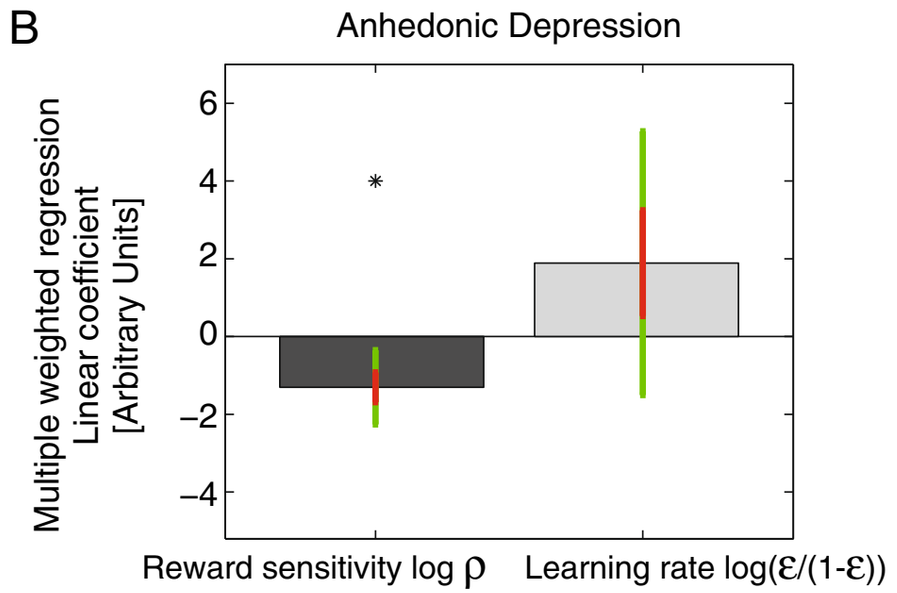
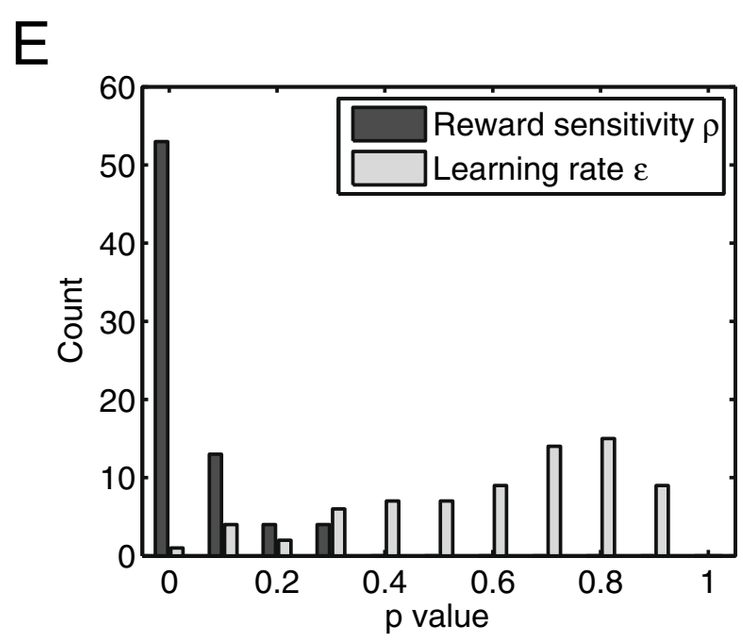
- But: correlations
- Fit, generate surrogate data, examine correlations - has the model really captured something about the data?
- Not that they can't learn, but don't care.




Huys et al., 2013

# No primary impairment

- diminished interest or pleasure in response to stimuli that were previously perceived as rewarding
- What is “stimuli”?
  - sucrose preference test
    - standard animal assessment of anhedonia, Willner 1997
  - Dichter et al., 2010
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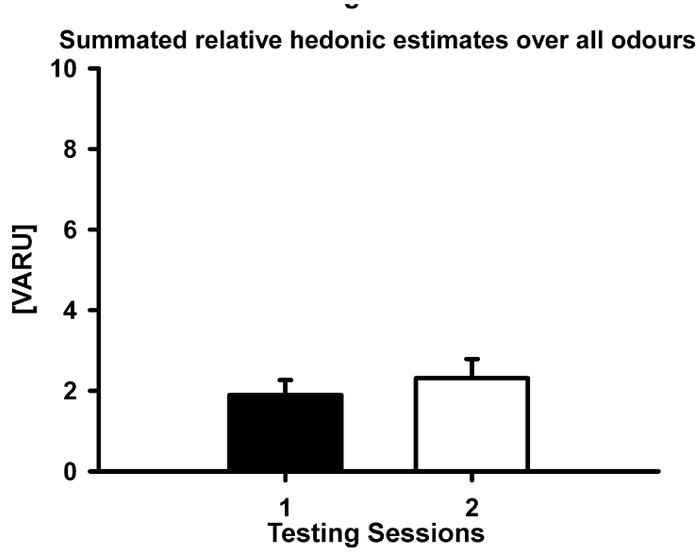
  - Pain (e.g. Baer et al., 2005)



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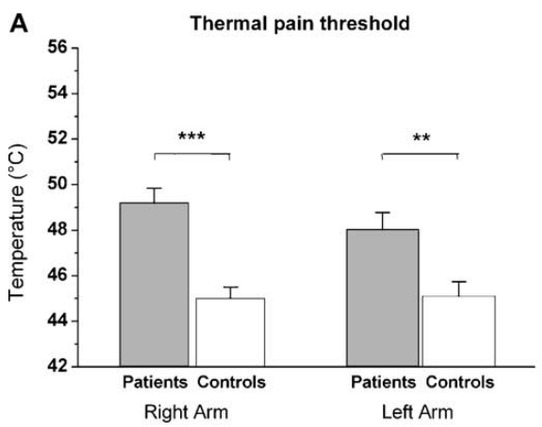


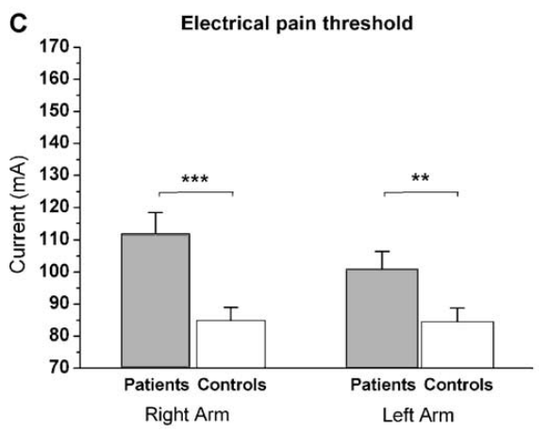


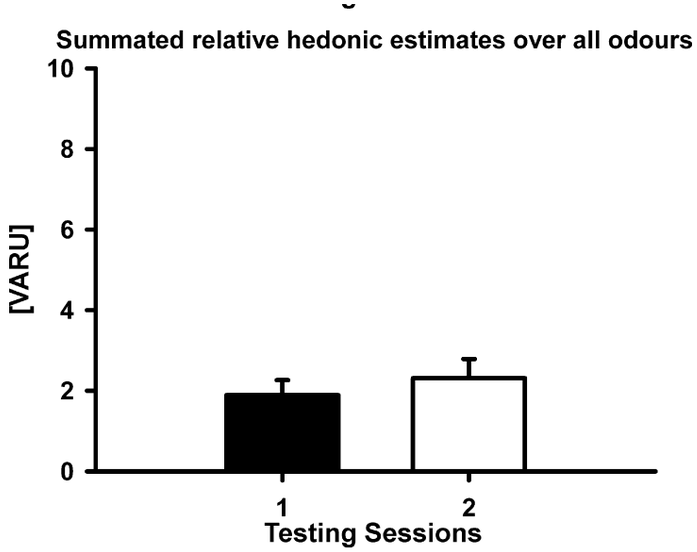

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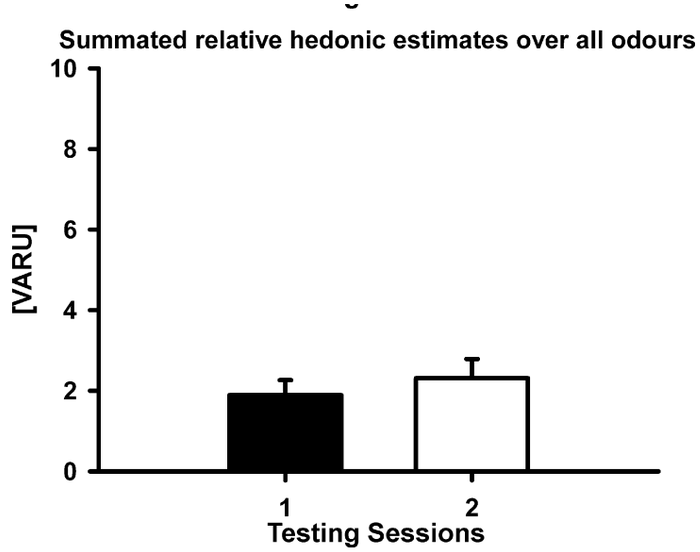

# Or is there?

- Reduced “emotional” responses to more complex “affective” stimuli

Bylsma et al., 2008

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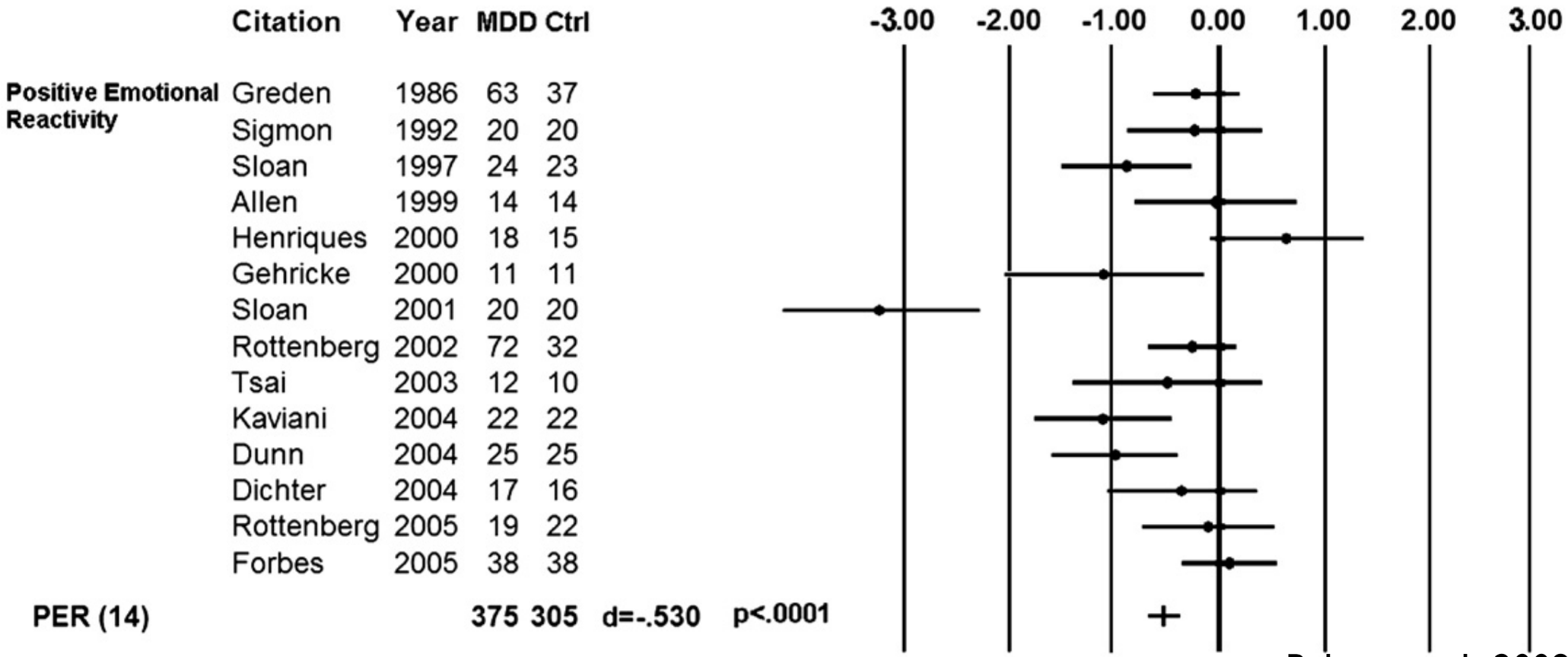



Bylsma et al., 2008

Bylsma et al., 2008

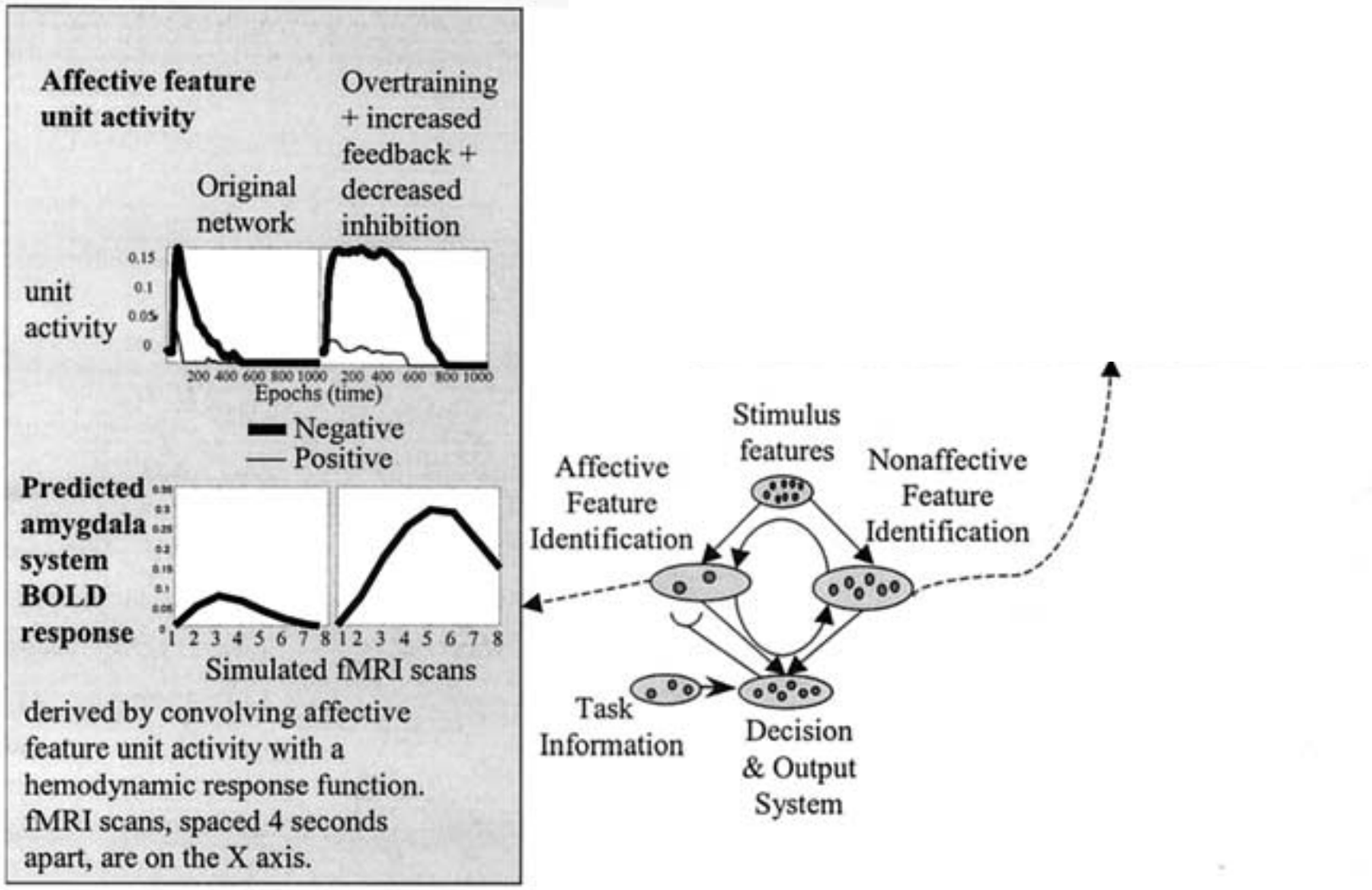
# Dysfunctional attitudes

| ATTITUDES | TOTALLY AGREE | AGREE VERY MUCH | AGREE SLIGHTLY | NEUTRAL | DISAGREE SLIGHTLY | DISAGREE VERY MUCH | TOTALLY DISAGREE |
|---|---|---|---|---|---|---|---|
| REMEMBER, ANSWER EACH STATEMENT ACCORDING TO THE WAY YOU THINK MOST OF THE TIME. | | | | | | | |
| 1. It is difficult to be happy unless one is good looking, intelligent, rich and creative. | | | | | | | |
| 2. Happiness is more a matter of my attitude towards myself than the way other people feel about me. | | | | | | | |
| 3. People will probably think less of me if I make a mistake. | | | | | | | |
| 4. If I do not do well all the time, people will not respect me. | | | | | | | |
| 5. Taking even a small risk is foolish because the loss is likely to be a disaster. | | | | | | | |
| 6. It is possible to gain another person's respect without being especially talented at anything. | | | | | | | |
| 7. I cannot be happy unless most people I know admire me. | | | | | | | |
| 8. If a person asks for help, it is a sign of weakness. | | | | | | | |

| ATTITUDES | TOTALLY AGREE | AGREE VERY MUCH | AGREE SLIGHTLY | NEUTRAL | DISAGREE SLIGHTLY | DISAGREE VERY MUCH | TOTALLY DISAGREE |
|---|---|---|---|---|---|---|---|
| 9. If I do not do as well as other people, it means I am an inferior human being. | | | | | | | |
| 10. If I fail at my work, then I am a failure as a person. | | | | | | | |
| 11. If you cannot do something well, there is little point in doing it at all. | | | | | | | |
| 12. Making mistakes is fine because I can learn from them. | | | | | | | |
| 13. If someone disagrees with me, it probably indicates he does not like me. | | | | | | | |
| 14. If I fail partly, it is as bad as being a complete failure. | | | | | | | |
| 15. If other people know what you are really like, they will think less of you. | | | | | | | |
| 16. I am nothing if a person I love doesn't love me. | | | | | | | |
| 17. One can get pleasure from an activity regardless of the end result. | | | | | | | |
| 18. People should have a reasonable likelihood of success before undertaking anything. | | | | | | | |

Weissman and Beck 1978

# Sticky aversive info




Siegle et al., 1999, 2002

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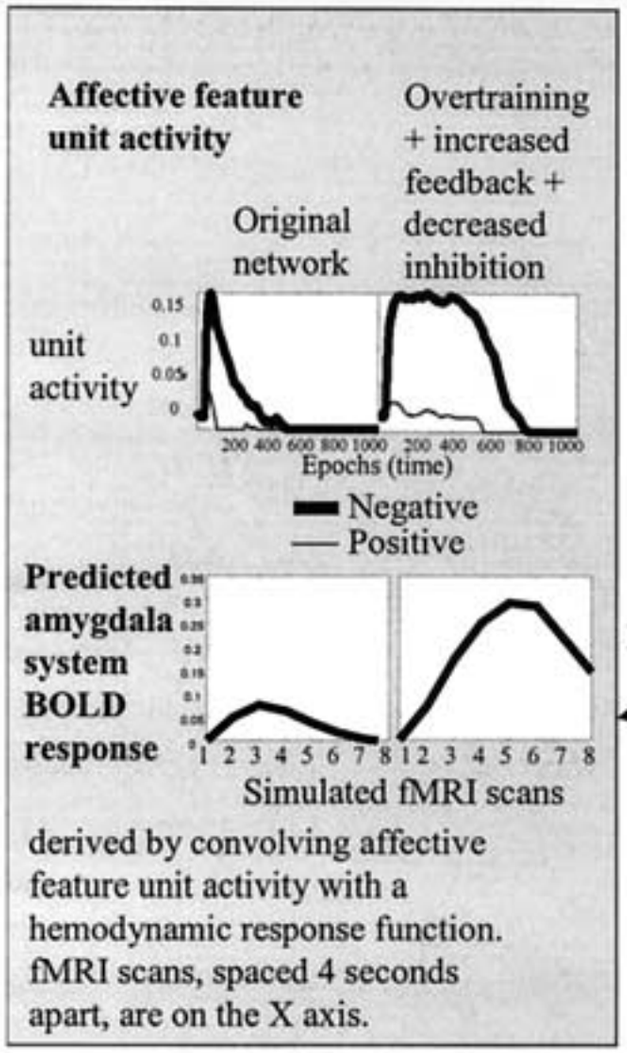


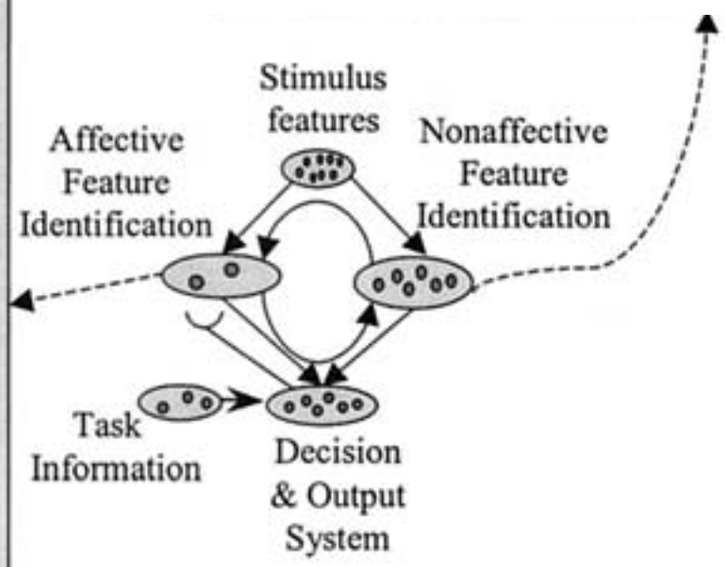


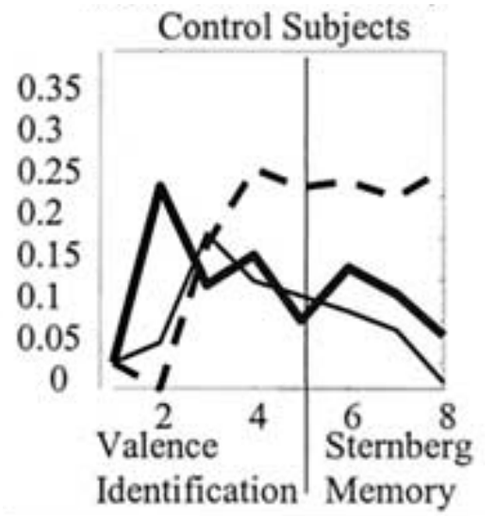


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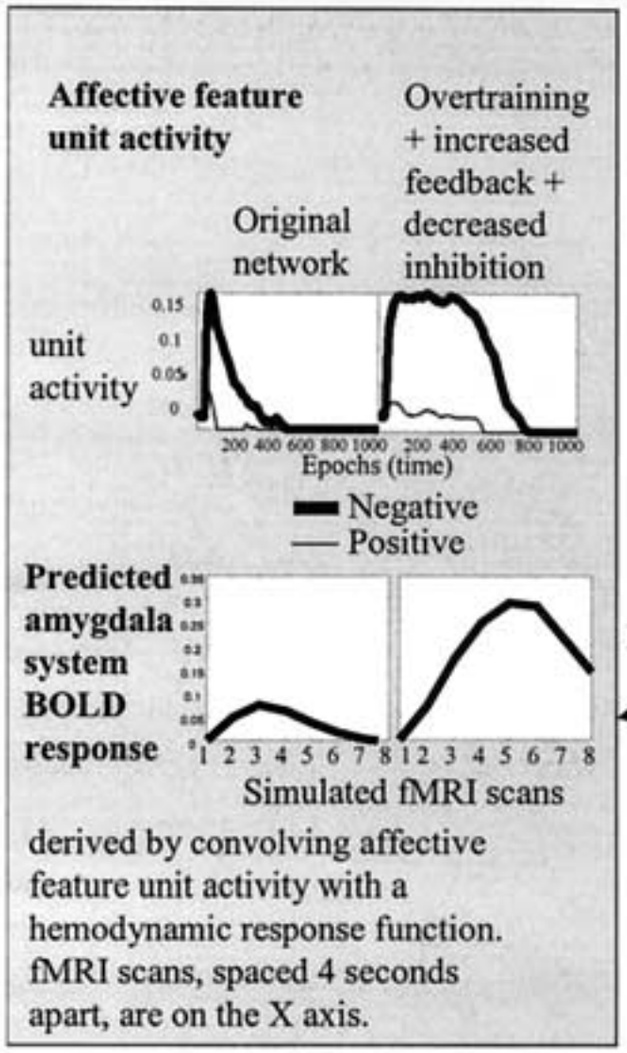
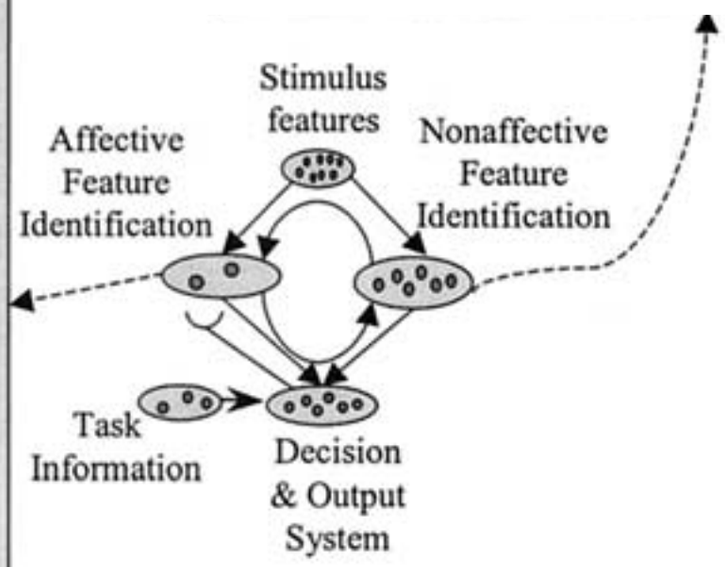
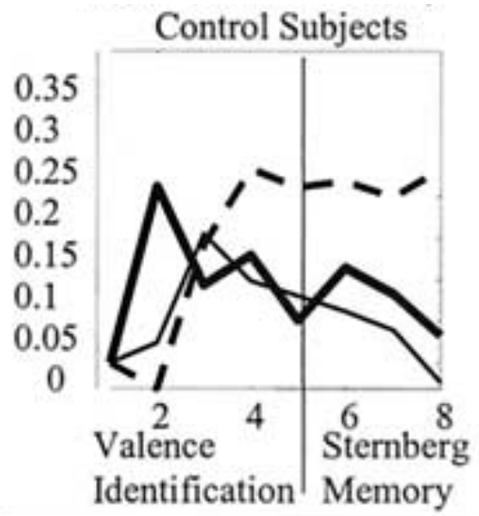
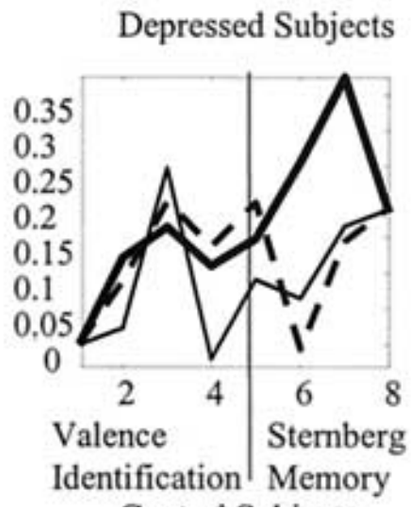
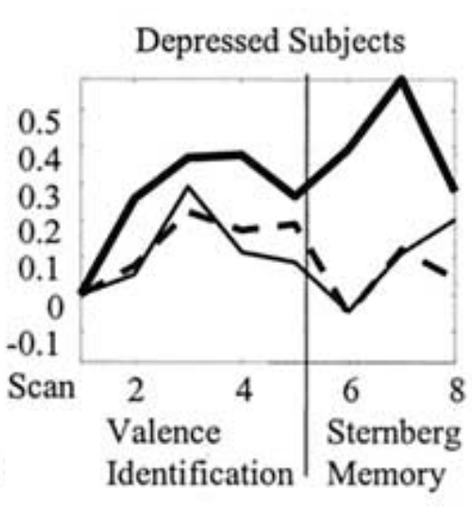


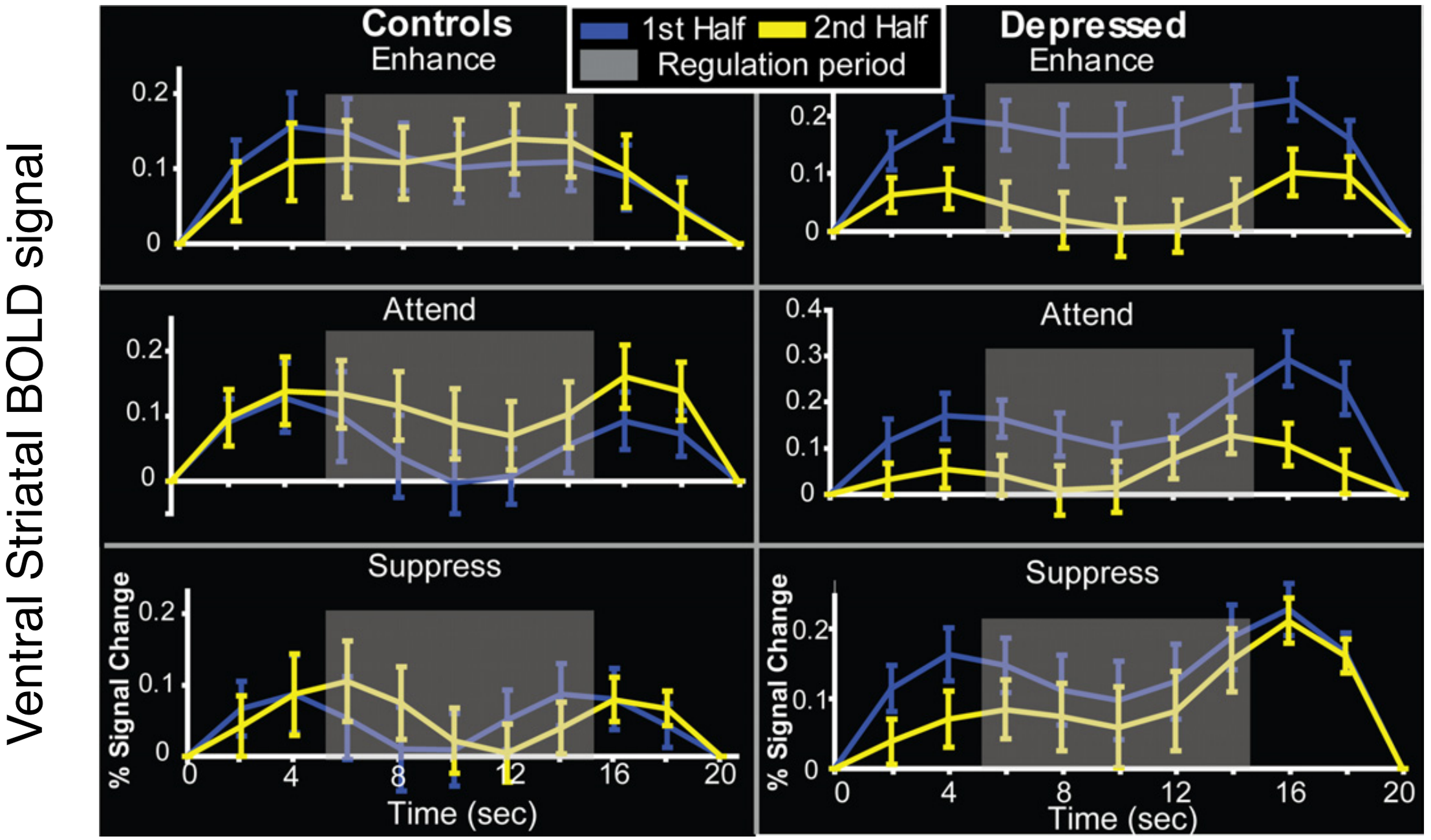




Siegle et al., 1999, 2002

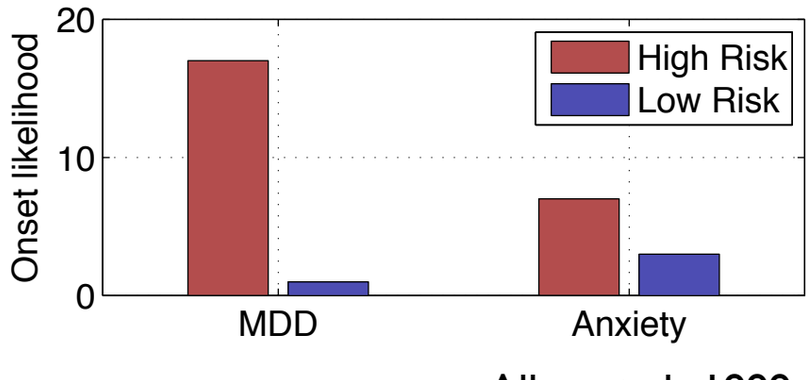
# Maintaining positive affect




Heller et al., 2009

# Attributional style

- Hopeless attributions are a risk factor for developing depression




Alloy et al., 1999,

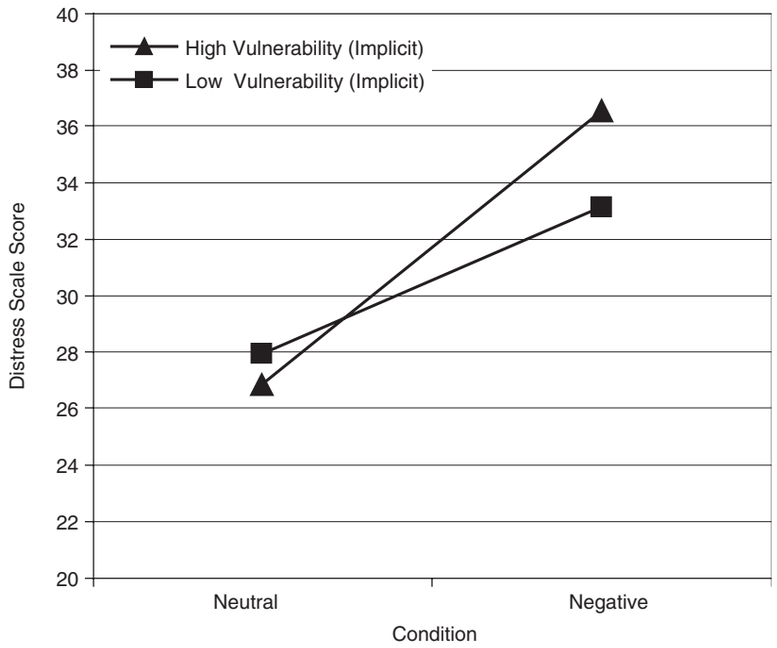
Table 3
*Frequency of Symptom Presentation in the Prodromal and Residual Phases (N = 331 Episodes)*

| Symptom | Prodromal frequency | Residual frequency |
|---|---|---|
| Depressed mood | 95 | 79 |
| Decreased appetite | 42 | 40 |
| Weight loss | 13 | 12 |
| Increased appetite | 10 | 12 |
| Weight gain | 20 | 17 |
| Initial insomnia | 29 | 30 |
| Middle insomnia | 13 | 10 |
| Early waking | 11 | 14 |
| Hypersomnia | 23 | 22 |
| Decreased energy | 38 | 35 |
| Decreased interest or pleasure | 82 | 75 |
| Self-blame | 51 | 55 |
| Decreased concentration | 78 | 75 |
| Indecision | 6 | 8 |
| Suicidality | 6 | 5 |
| Psychomotor agitation | 6 | 5 |
| Psychomotor retardation | 10 | 7 |
| Crying more frequently | 34 | 31 |
| Inability to cry | 4 | 2 |
| Hopelessness | 195 | 201 |
| Worrying/Brooding | 104 | 118 |
| Decreased self-esteem | 195 | 199 |
| Irritability | 85 | 72 |
| Dependency | 45 | 46 |
| Self-pity | 24 | 28 |
| Somatic complaints | 5 | 4 |
| Decreased effectiveness | 38 | 37 |
| Helplessness | 35 | 28 |
| Decreased initiation of voluntary responses | 19 | 23 |

Iacoviello et al., 2010

# Implicit vs explicit attributions

- Acute consequence
  - implicit: IAT self-worth
  - explicit: CSQ




Haeffel et al., 2007, Haeffel 2011

# Implicit vs explicit attributions

- Acute consequence
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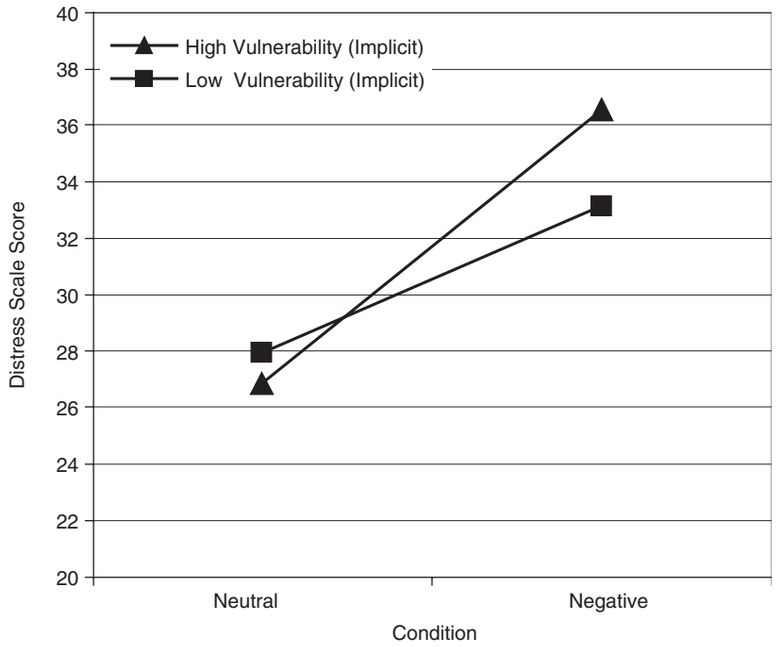


- Chronic consequence
  - @ 5 weeks only CSQ survives to predict BDI response to acute life stressor

Haeffel et al., 2007, Haeffel 2011

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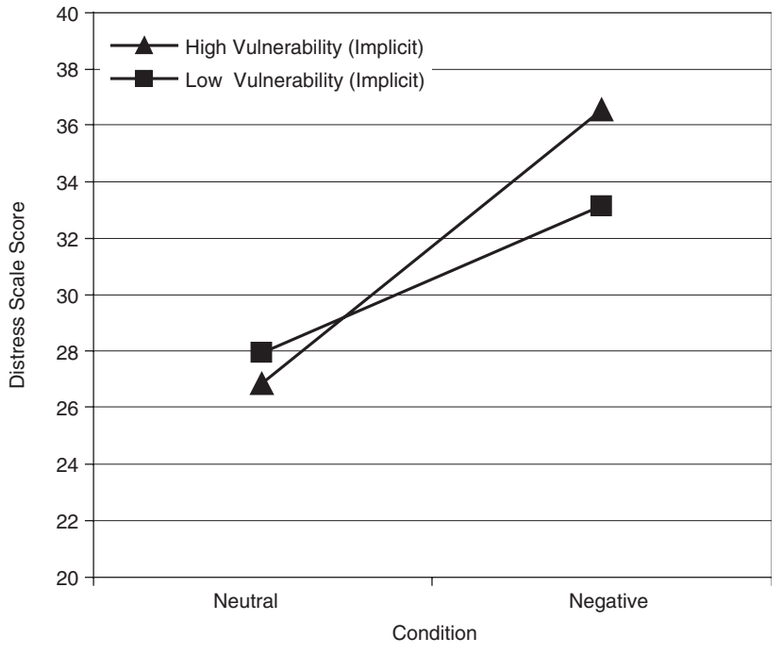


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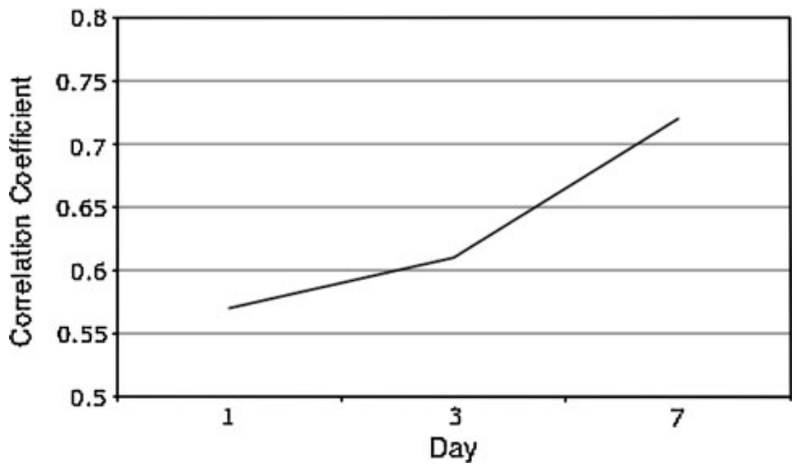
- Evolution over time




Haeffel et al., 2007, Haeffel 2011

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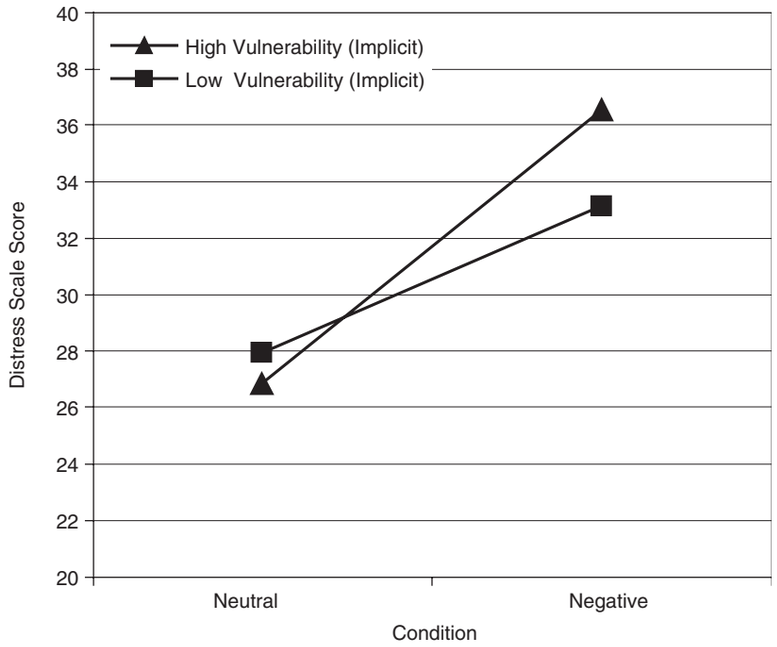


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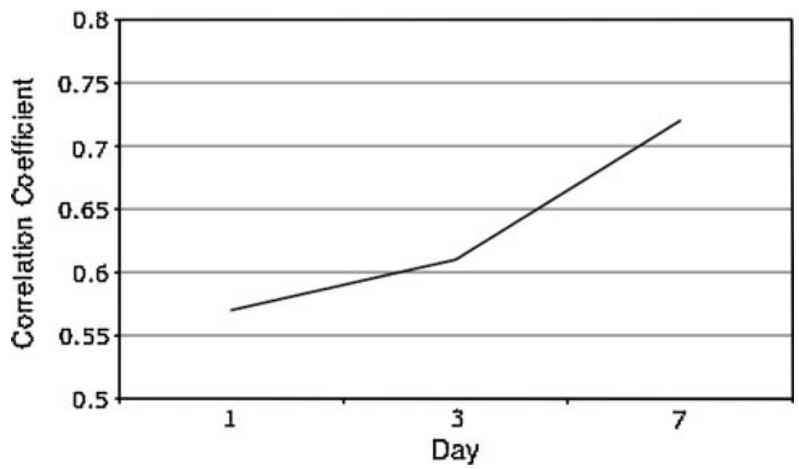
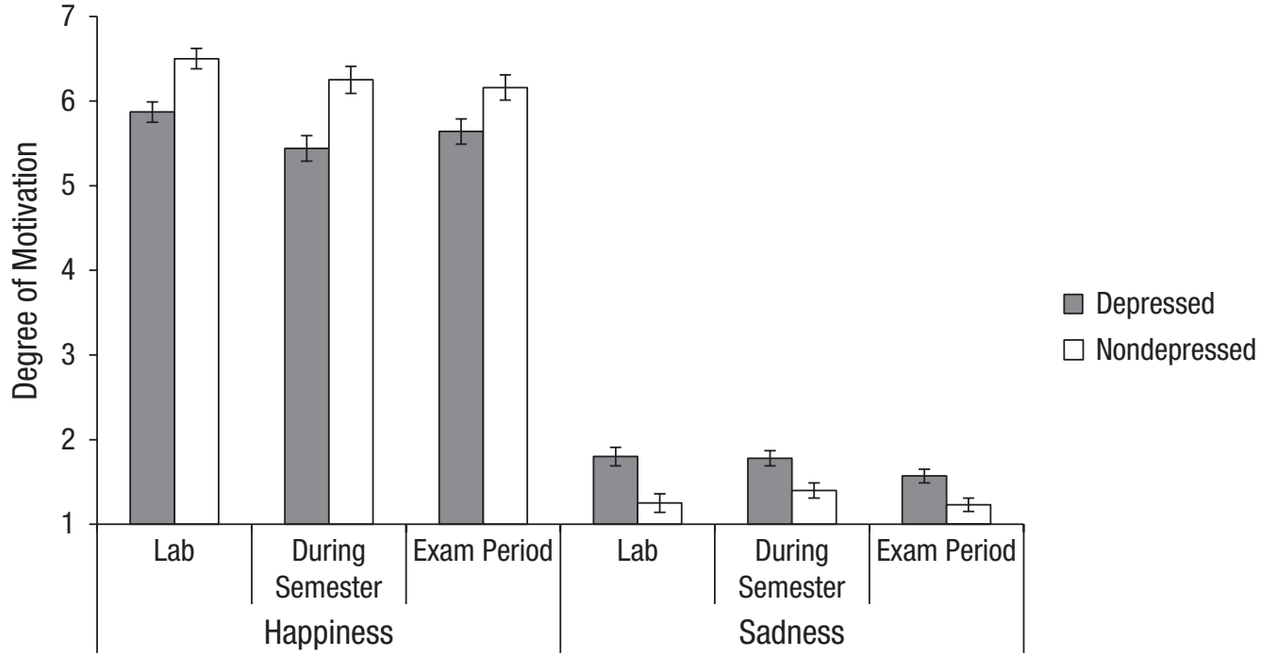



- -> explicit interpretations determine long-term outcome
- -> both implicit and explicit determine immediate outcome

Haeffel et al., 2007, Haeffel 2011

# Emotion regulation in depression

- Is effective - but less frequently used (Ehring et al., 2010).
- Motivation to feel particular emotions is altered:




Milgram et al., 2018 Clin Psychol Sci

# Human emotions

- Innate “affective” behavioural reflexes exist in humans
  - Relate to mental health
- But: emotions are not “emotional reflexes”
  - Facial expression, recognition
  - Physiological variability
  - Neural representations
- Have an important **interoceptive** component
- Are extremely variable
- Depend fundamentally on interpretation - on the “**model**” we build of our world and how we choose to sample it - “**metareasoning**”