Decide Already!

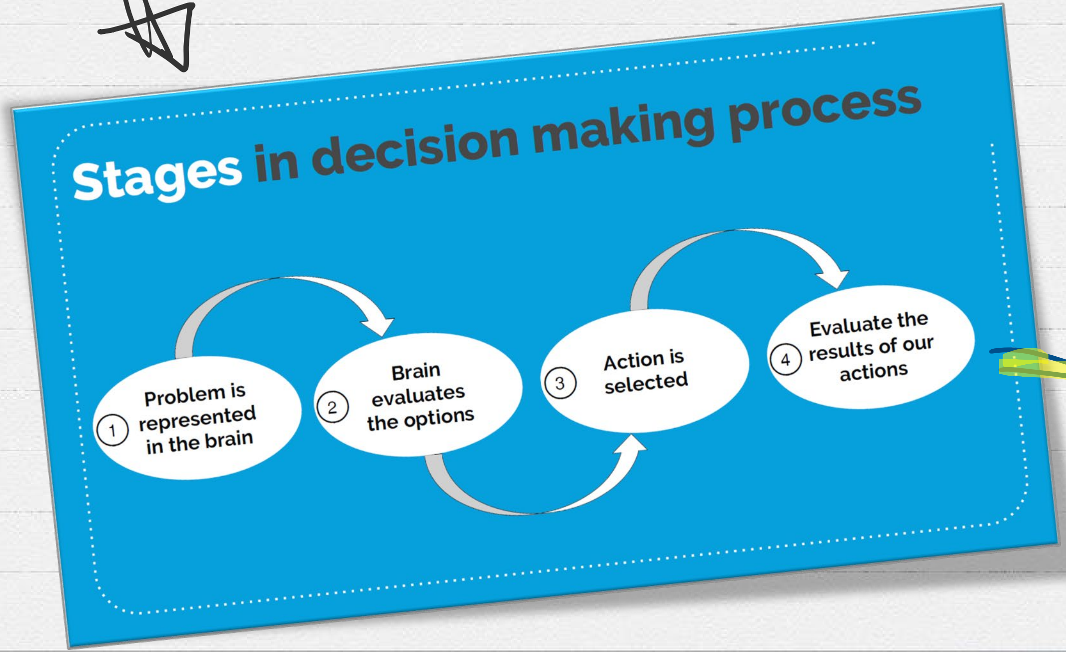
Starring:

ventral Striatum

what is so special about this structure?

mary et boyle, ph.d., department of cognitive science, university of california, san diego.

Recall - Neuroeconomics evaluation process

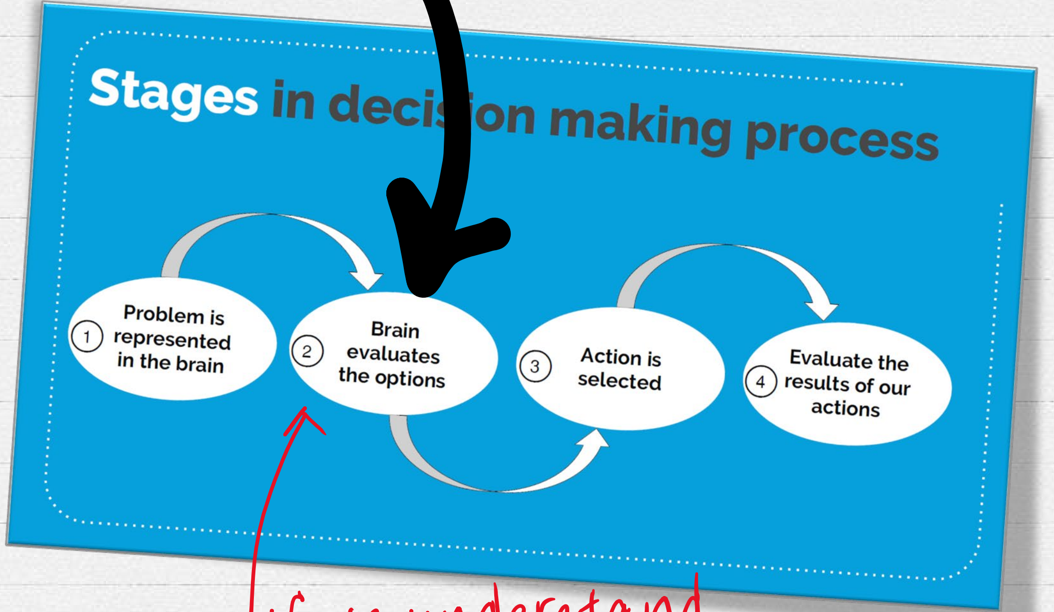


☆ Interaction of emotional & cognitive systems

Learning is based on the outcome of the actions.

EVALUATION STAGE IS THE MOST CRITICAL!

→ Think utility maximization



We will tend to select the option with the ↑↑ expected utility.

If we understand this we can predict decisions!

1.

It is all about

VALUE

How does one assign value?

THE VALUATION PROCESS:

① Objective valuation?

price →

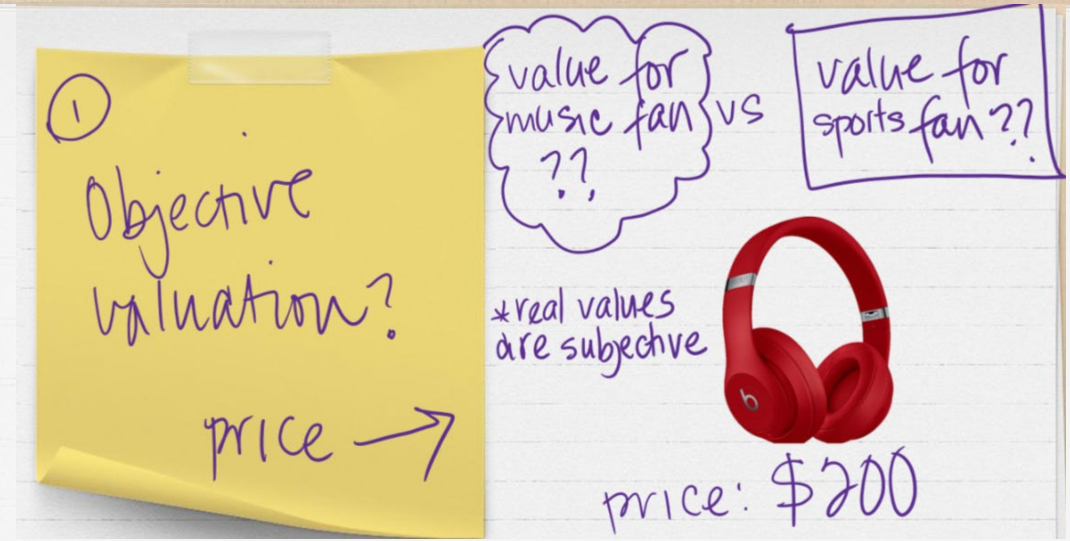
value for music fan ??

vs

value for sports fan ??

*real values are subjective

price: $200

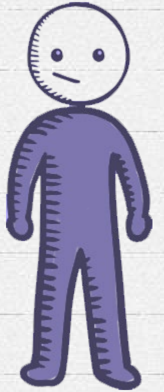


THAT IS WHY REAL VALUATION IS SUBJECTIVE :)

② Expected Utility Theory

↳ a measure of desirability

ECONOMIC THEORY SUGGEST TO US E.U.T.



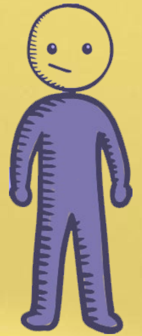
Expected Utility Theory:

EU is the weighted average of all possible outcomes, with the weights being assigned by the probability of outcomes.

this means that we integrate the probabilities of the outcome and the expected values of the outcome.

ESTIMATE ANTICIPATED GAINS AND

estimate the anticipated probabilities of the gains



Prospect theory:

1. CHOICES ARE EVALUATED RELATIVE TO A REFERENCE POINT

2. PEOPLE ARE RISK-AVERSE ABOUT GAINS (rel. to ref. point) & RISK-SEEKING ABOUT LOSSES

3. LOSS AVERSION - losing x hurts more than gaining x helps.

What do these premises predict in terms of our behavior ??

TVERSKY & KAHNEMAN

U ← expected utility

v ← function that assigns a value to the outcome

w ← probability weighting

Prospect theory:
Both the values AND
our estimates of probabilities are subjective!

↳ TVERSKY & KAHNEMAN

Prospect Theory

$$U = \sum_i w(p) v(x)$$

Average firingrate!

Neuroeconomics
Utility

- neuronal populations encode subjective value

NeuroEconomicsUtility Valuation:

It is the average firing rate of a population of neurons which encodes the subjective value of the object.

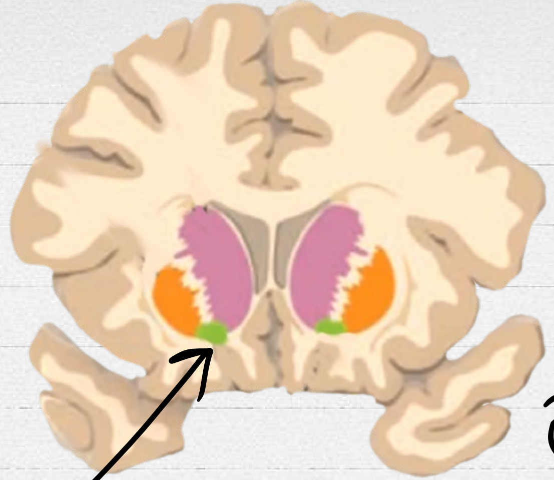
The neuronal firing pattern is what predicts choices.

Subjective Value = r (firing rate) = $\Sigma_i r_n / n$

recall: DA system → rewards.

simple decision:

To eat the apple, or not eat the apple.
That is the decision to be made. ☺



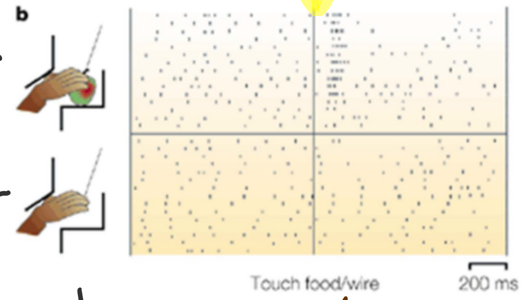
N. Accumbens
(V. striatum)

activation encodes its anticipated value → gain magnitude

Recall

touch food

time @ touch



"Touching a **piece of apple (top) enhances the firing rate** but touching the bare wire or an inedible object that the monkey had previously encountered does not. The traces are aligned to a temporal reference point provided by touching the hidden object (vertical line)."

touch wire

Schultz, W. (2000) NATURE REVIEWS | NEUROSCIENCE VOLUME 1 183

the NAc neurons only fired when the monkey touched a rewarding obj.

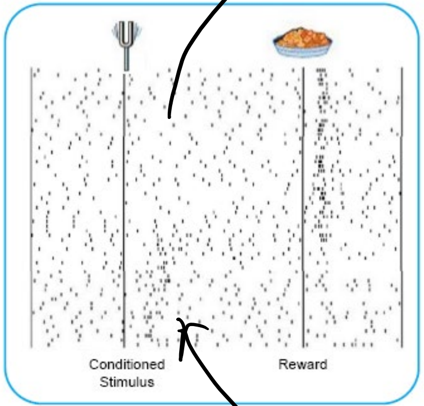
It is important to remember that the neurons do not fire if the object is not rewarding!

(DOPAMINE)

Again – remember – DA Neurons respond to predicted reward.

pavlovian conditioning

Reward and prediction of reward in **N. Accumbens**



Schultz, W. (2006) *Annu. Rev. Psychol.* 57:87–115

earlier stage

conditioned

later stage respond to cue to predict reward.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2008) **363**, 3771–3786
doi:10.1098/rstb.2008.0155
Published online 1 October 2008

Review

Anticipatory affect: neural correlates and consequences for choice

Brian Knutson* **and Stephanie M. Greer**

Department of Psychology, Stanford University, Building 420, Jordan Hall, Stanford, CA 94305, USA

'Anticipatory affect' refers to emotional states that people experience while anticipating significant outcomes. Historically, technical limitations have made it difficult to determine whether anticipatory affect influences subsequent choice. Recent advances in the spatio-temporal resolution of functional magnetic resonance imaging, however, now allow researchers to visualize changes in neural activity seconds before choice occurs. We review evidence that activation in specific brain circuits changes during anticipation of monetary incentives, that this activation correlates with affective experience and that activity in these circuits may influence subsequent choice. Specifically, an activation likelihood estimate meta-analysis of cued response studies indicates that nucleus accumbens (NAcc) activation increases during gain anticipation relative to loss anticipation, while anterior insula activation increases during both loss and gain anticipation. Additionally, anticipatory NAcc activation correlates with self-reported positive arousal, whereas anterior insula activation correlates with both self-reported negative and positive arousal. Finally, NAcc activation precedes the purchase of desirable products and choice of high-risk gambles, whereas anterior insula activation precedes the rejection of overpriced products and choice of low-risk gambles. Together, these findings support a neurally plausible framework for understanding how anticipatory affect can influence choice.

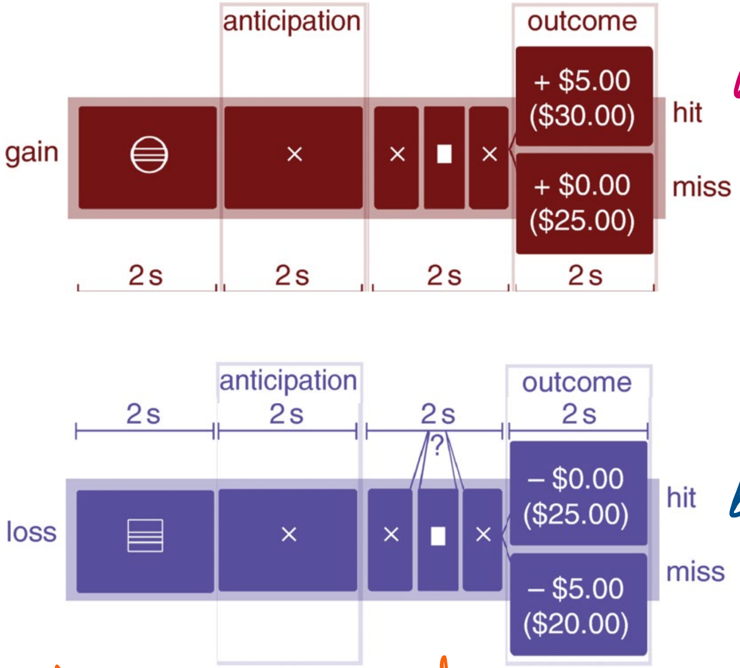
Keywords: anticipation; affect; accumbens; insula; reward; functional magnetic resonance imaging

separates anticipation from outcome.

CUED RESPONSE STUDIES:

-manipulate:

1. magnatude
2. probability
3. certainity → speeded rxn time & choice



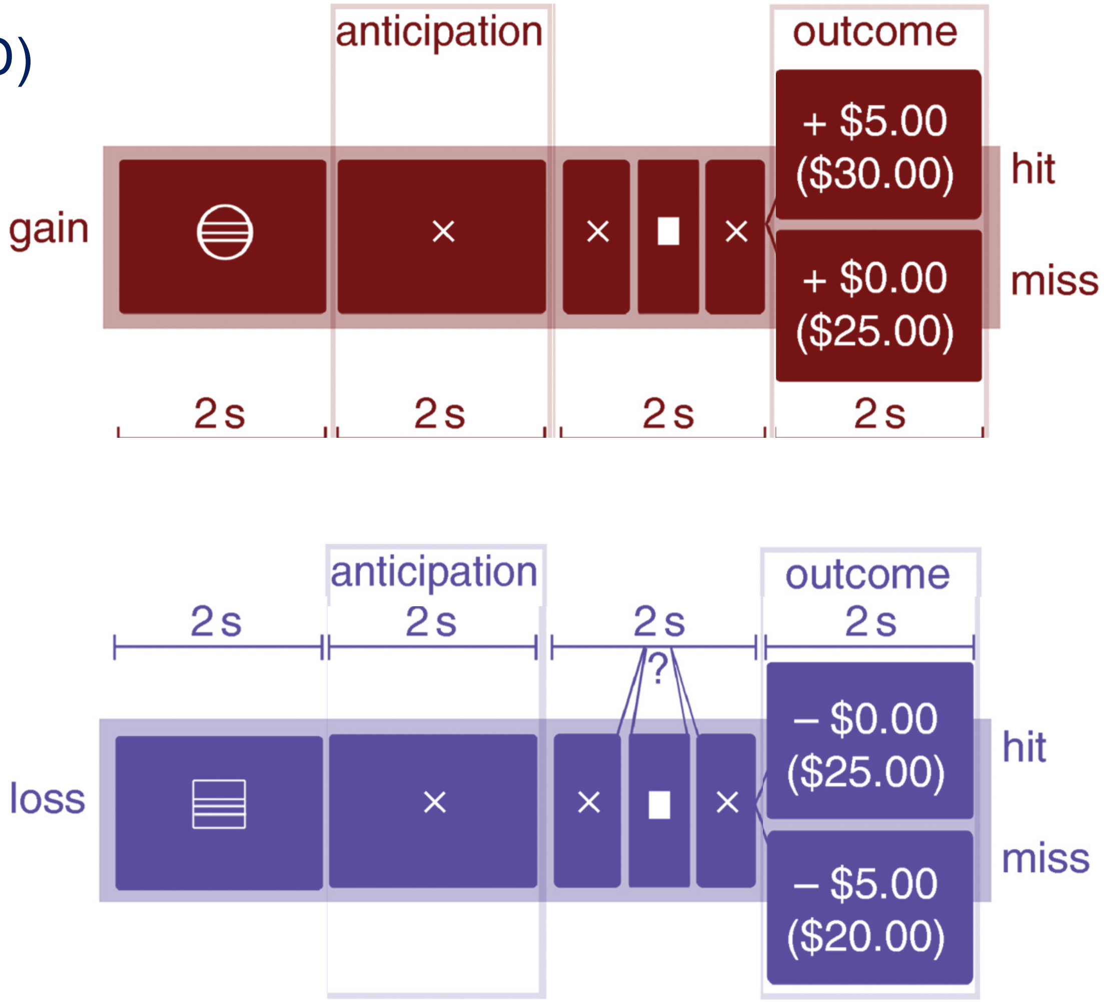
gain vs non.gain

loss vs non.loss

Knutson, B. and Greer, S. M. (2008) Phil. Trans. R. Soc. 363, 3771-3786.

Monetary Incentive Delay (MID) cued response task:

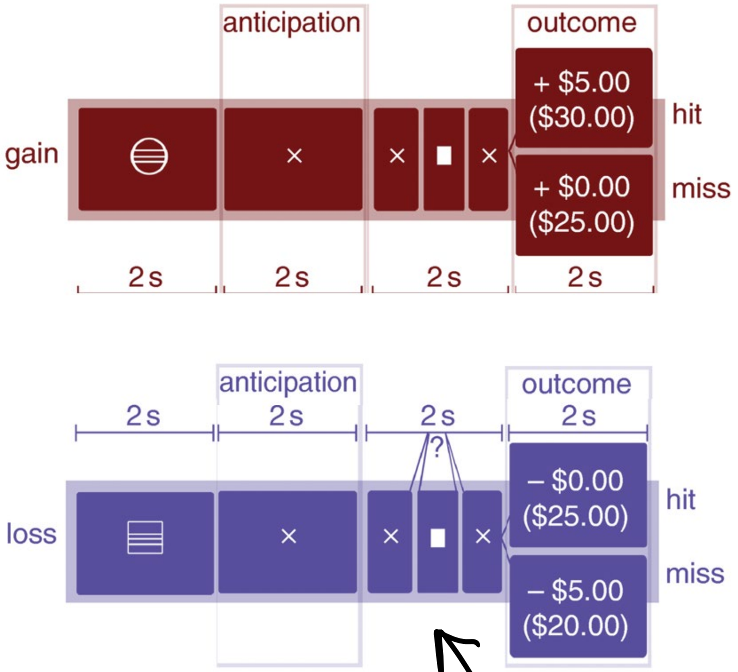
1. Subjects initially see a cue indicating that they will have an opportunity to either gain or avoid losing a certain amount of money.
2. Subjects view a fixation cross.
3. A target briefly appears on the screen – and the subjects attempt to press a button before the target is replaced by a fixation cross.
4. Outcome: subjects see the outcome of their performance on that trial and cumulative earnings.



Knutson, B. and Greer, S. M. (2008) Phil. Trans. R. Soc. 363, 3771-3786.

separates anticipation from outcome.

separation of gain/loss enables one to compare incentive



each condition can lead to either a hit or miss outcome

Knutson, B. and Greer, S. M. (2008) Phil. Trans. R. Soc. 363, 3771-3786.

fMRI study:

Antipates:

$0, 0.20, 1, 5

NAcc is a activated to the anticipated gain magnitude

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2008) **363**, 3771–3786
doi:10.1098/rstb.2008.0155
Published online 1 October 2008

Review

Anticipatory affect: neural correlates and consequences for choice

Brian Knutson* and Stephanie M. Greer

Department of Psychology, Stanford University, Building 420, Jordan Hall, Stanford, CA 94305, USA

'Anticipatory affect' refers to emotional states that people experience while anticipating significant outcomes. Historically, technical limitations have made it difficult to determine whether anticipatory affect influences subsequent choice. Recent advances in the spatio-temporal resolution of functional magnetic resonance imaging, however, now allow researchers to visualize changes in neural activity seconds before choice occurs. We review evidence that activation in specific brain circuits changes during anticipation of monetary incentives, that this activation correlates with affective experience and that activity in these circuits may influence subsequent choice. Specifically, an activation likelihood estimate meta-analysis of cued response studies indicates that nucleus accumbens (NAcc) activation increases during gain anticipation relative to loss anticipation, while anterior insula activation increases during both loss and gain anticipation. Additionally, anticipatory NAcc activation correlates with self-reported positive arousal, whereas anterior insula activation correlates with both self-reported negative and positive arousal. Finally, NAcc activation precedes the purchase of desirable products and choice of high-risk gambles, whereas anterior insula activation precedes the rejection of overpriced products and choice of low-risk gambles. Together, these findings support a neurally plausible framework for understanding how anticipatory affect can influence choice.

Keywords: anticipation; affect; accumbens; insula; reward; functional magnetic resonance imaging

bottom line of paper:

NAcc encodes anticipated gain magnitude.

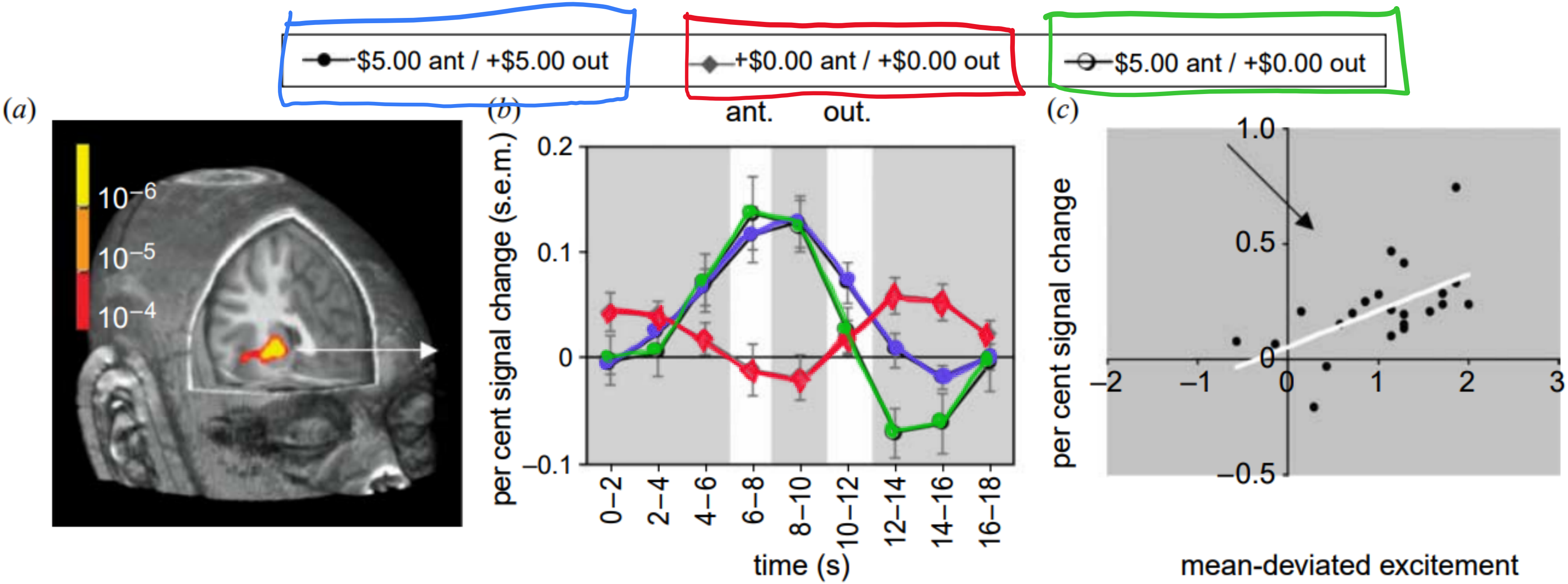


Figure 9. (*a*) NAcc activation elicited by anticipation of monetary gain ($) versus non-gain (zero). (*b*) NAcc activation time courses for large gains and non-gains (s.e.m.). (*c*) Correlation of individual differences in NAcc response to large gain cue and cue-elicited positive arousal (i.e. 'excitement'; $n=24$ and $r=0.58$; Bjork *et al.* 2004; Knutson & Gibbs 2007).

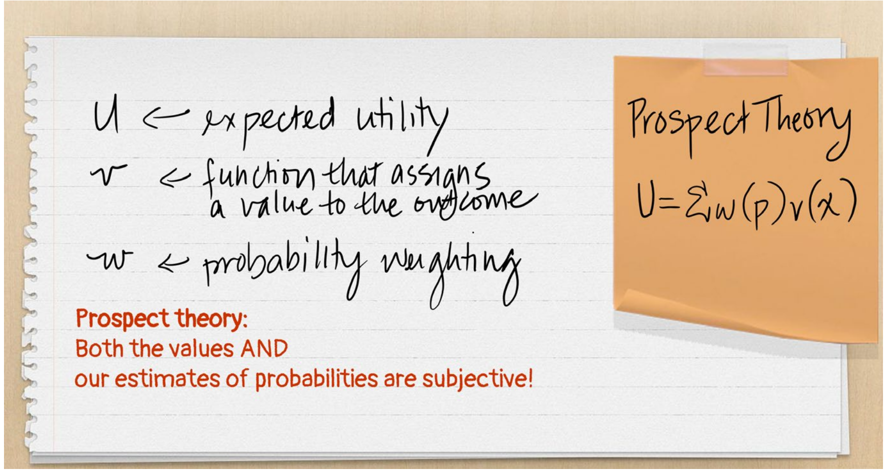
Knutson, B. and Greer, S. M. (2008) Phil. Trans. R. Soc. 363, 3771-3786.

2.

Subjective probabilities and values.

Encoded in the brain.

Recall,



ELSEVIER

NeuroImage

www.elsevier.com/locate/ynimg
NeuroImage 38 (2007) 557 – 563

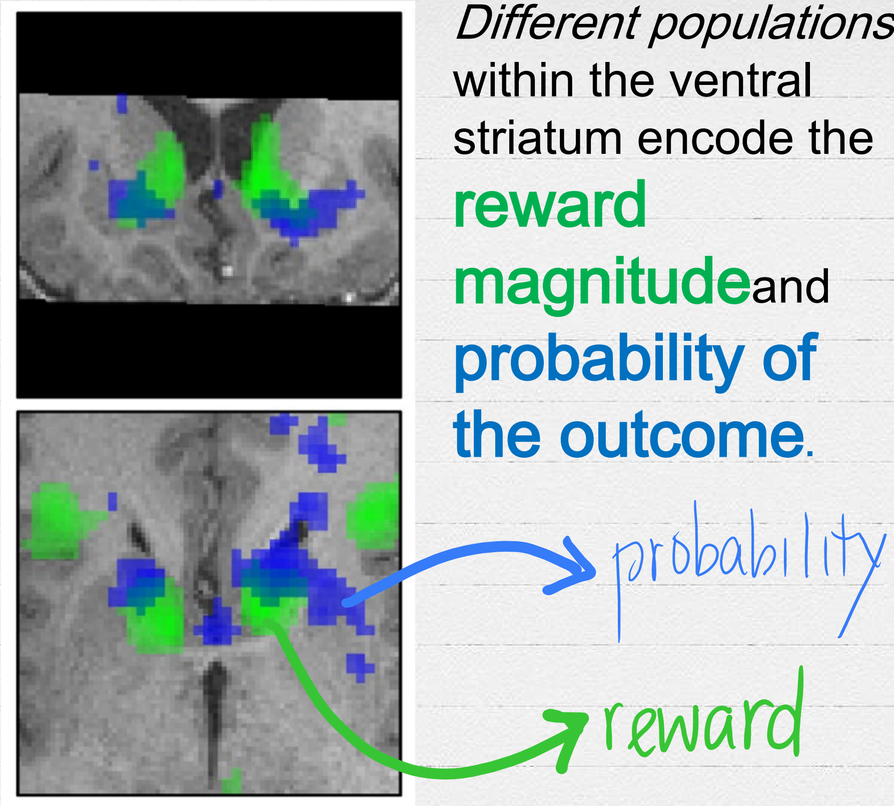
Subregions of the ventral striatum show preferential coding of reward magnitude and probability

Juliana Yacubian,[a,*] Tobias Sommer,[a] Katrin Schroeder,[b] Jan Gläscher,[a] Dieter F. Braus,[b] and Christian Büchel[a]

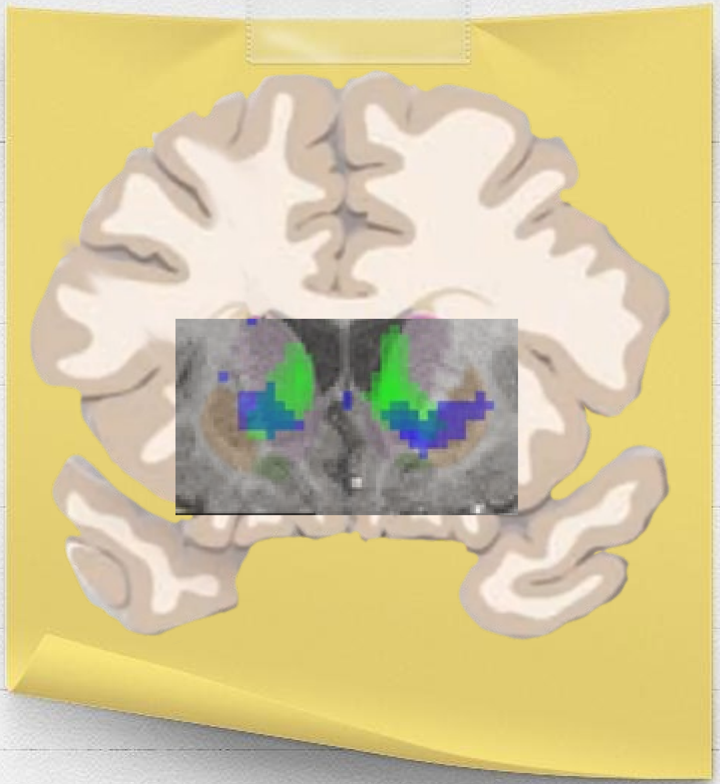
[a]*NeuroImage Nord, Department of Systems Neuroscience, University Medical Center Hamburg-Eppendorf, Martinistr. 52, D-20246, Hamburg, Germany*
[b]*NeuroImage Nord, Department of Psychiatry, University Medical Center Hamburg-Eppendorf, Germany*

Received 24 May 2007; revised 6 August 2007; accepted 13 August 2007
Available online 22 August 2007

Yacubian, J. et al (2007) *NeuroImage* 38: 557–563



Different populations within the ventral striatum encode the **reward magnitude** and **probability of the outcome**.

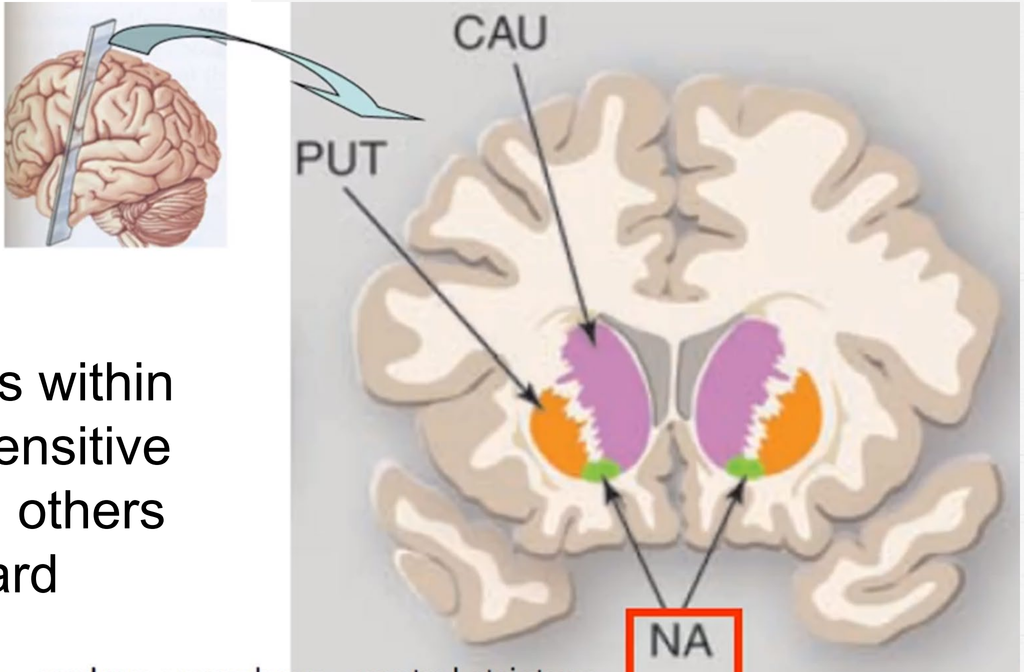


Yacubian, J. et al (2007) *NeuroImage* 38: 557–563

Bottom line:

N. Ac. activity is proportional to the magnitude of an anticipated gain.

There are subpopulations within the v. striatum that are sensitive to reward probability and others that are sensitive to reward magnitude.

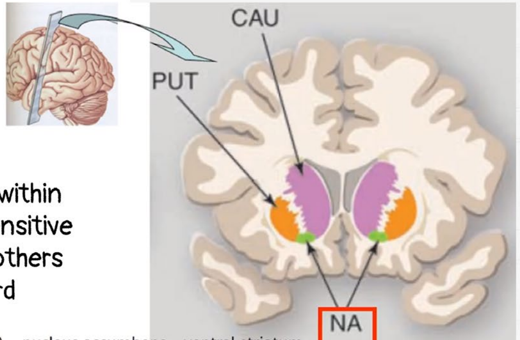


NA – nucleus accumbens = ventral striatum

Bottom line:

NAc. activity is proportional to the magnitude of an anticipated gain.

There are subpopulations within the v. striatum that are sensitive to reward probability and others that are sensitive to reward magnitude.



NA – nucleus accumbens = ventral striatum

Neuronal correlate of expected utility

U ← expected utility

v ← function that assigns a value to the outcome

w ← probability weighting

Prospect theory:
Both the values AND
our estimates of probabilities are subjective!

Prospect Theory

$$U=\sum w(p)v(x)$$

Neuron
Article

Neural Predictors of Purchases

Brian Knutson,[1,*] Scott Rick,[2] G. Elliott Wimmer,[1] Drazen Prelec,[3] and George Loewenstein[2]
[1] Psychology and Neuroscience, Stanford University, Building 420, Jordan Hall, Stanford, CA 94305, USA
[2] Social and Decision Sciences, Carnegie Mellon University, 208 Porter Hall, Pittsburgh, PA 15213, USA
[3] MIT Sloan School of Management, Massachusetts Institute of Technology, E56-320, Cambridge, MA 02139, USA
*Correspondence: knutson@psych.stanford.edu
DOI 10.1016/j.neuron.2006.11.010

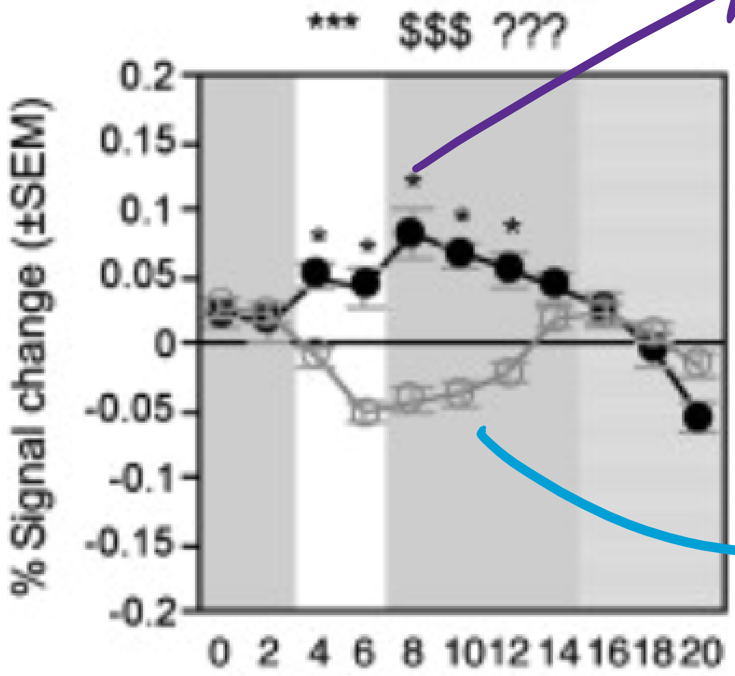
Knutson, B. et al (2007) Neuron 53, 147-156

SUMMARY

Microeconomic theory maintains that purchases are driven by a combination of consumer preference and price. Using event-related fMRI, we investigated how people weigh these factors to make purchasing decisions. Consistent with neuroimaging evidence suggesting that distinct circuits anticipate gain and loss, product preference activated the nucleus accumbens (NAcc), while excessive prices activated the insula and deactivated the mesial prefrontal cortex (MPFC) prior to the purchase decision. Activity from each of these regions independently predicted immediately subsequent purchases above and beyond self-report variables. These findings suggest that activation of distinct neural circuits related to anticipatory affect precedes and supports consumers' purchasing decisions.

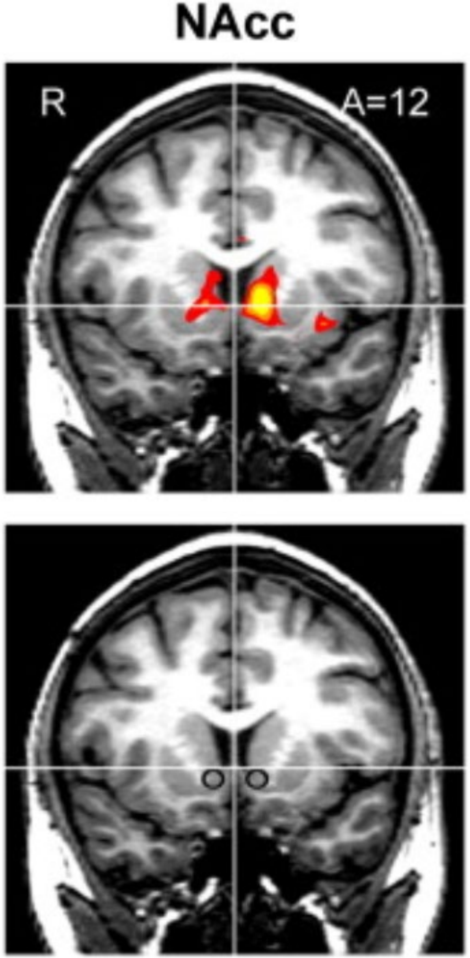
Knutson, B. et al (2007) Neuron 53, 147-156

N. Ac. Predicts shopping decisio



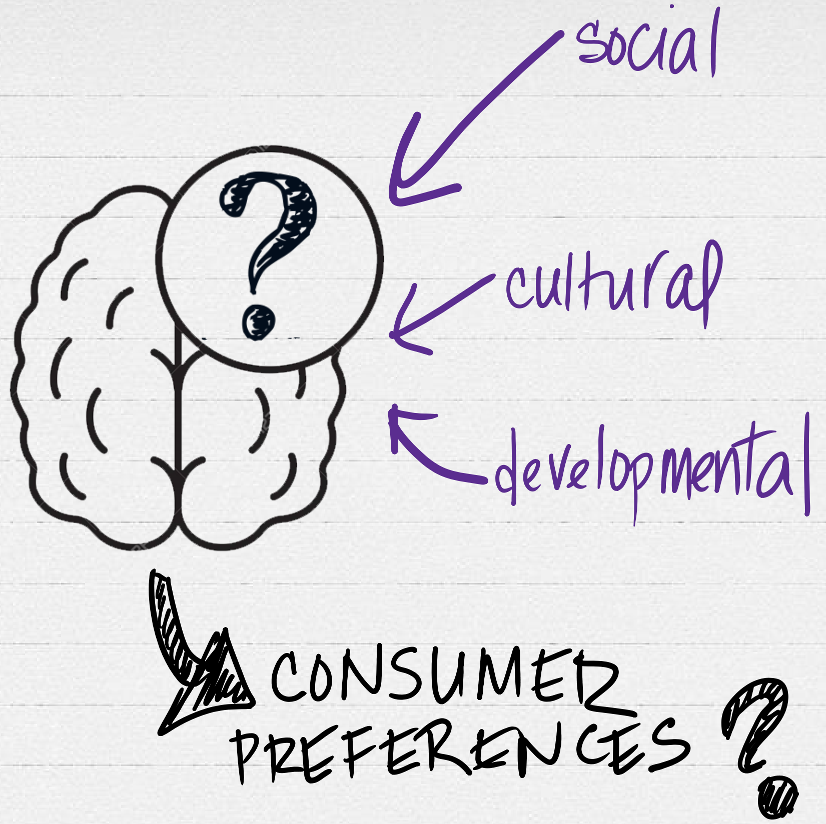
purchase product

did not purchase



Knutson, B. et al (2007) Neuron 53, 147-156

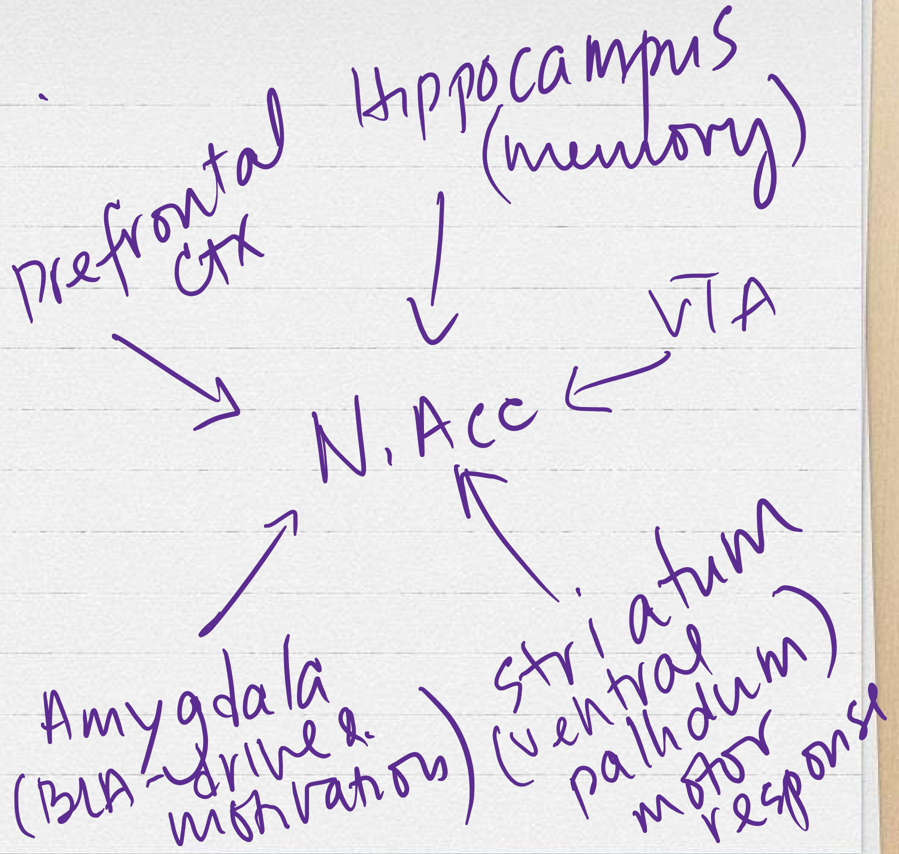
How are consumer preferences represented in the brain?



STRATEGIC

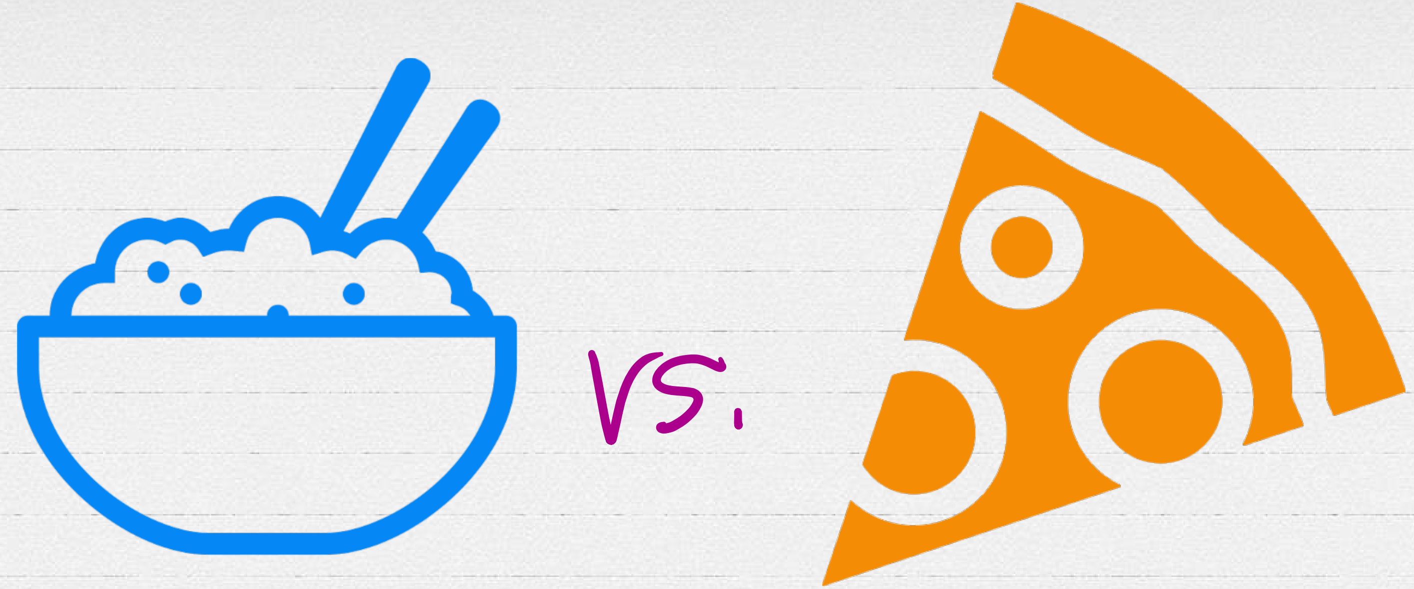
Nucleus Accumbens

- critical connections to other areas

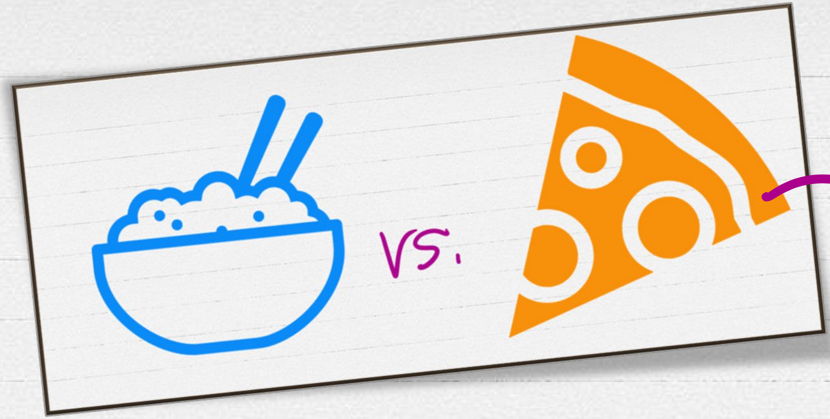


3.
Choosing Among Multiple

Encoded in the OFC.



Complex decisions? Make a choice between two different lunch options?



orbitofrontal ctx is critical

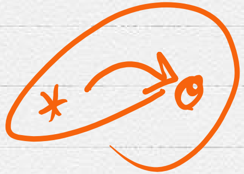
* OFC: integration of multiple info. sources.

OFC- compares and integrates info. regarding rewards.

Orbital Frontal Ctx:

1. OFC processes decisions w/ reward.

2. supervises the Nuc. Acc.



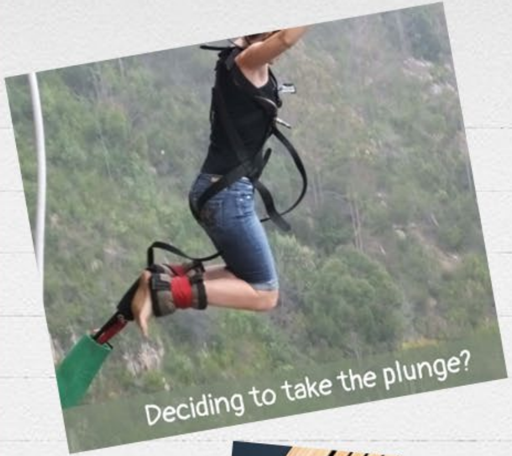
OFC is critical for decisions & selection between multiple options.

4.
Decisions with Costs?

Who decides?

Deciding to take the plunge?

Deciding to take the risk of eating the deadly delicacy?


Deciding to take the plunge?


Deciding to take the risk of eating the deadly delicacy?

Making decisions with potential costs.

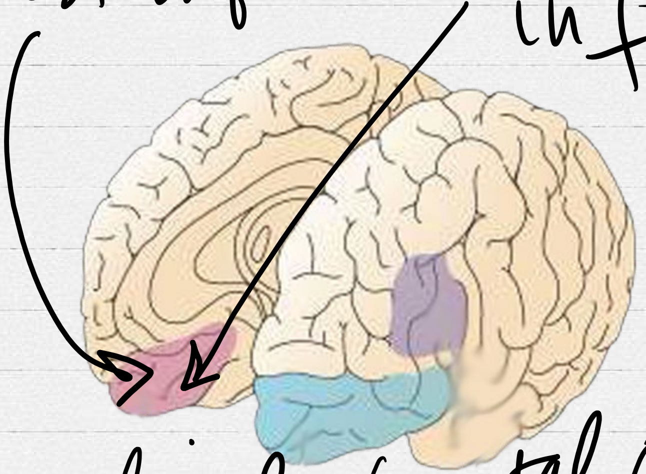
How the brain integrates costs and benefits during decision making

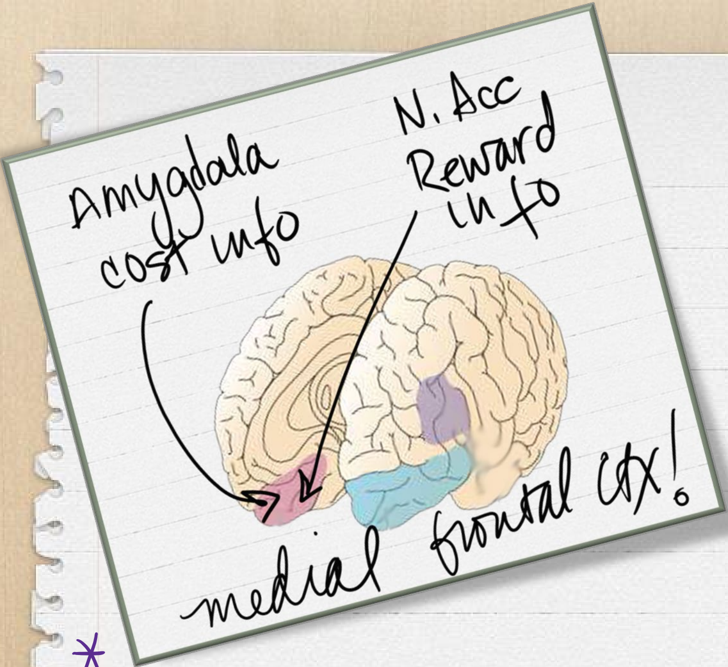
Ulrike Basten[a,1], Guido Biele[b,c,d,1], Hauke R. Heekeren[b,c], and Christian J. Fiebach[a,e,f,2]

[a]Department of Psychology, Goethe University Frankfurt, D-60325 Frankfurt, Germany; [b]Max Planck Institute for Human Development, D-14195 Berlin, Germany; [c]Department of Education and Psychology, Cluster of Excellence "Languages of Emotion", and Dahlem Institute for Neuroimaging of Emotion (D.I.N.E.), Freie Universität, Berlin, D-14195 Berlin, Germany; [d]Center for the Study of Human Cognition, University of Oslo, N-0136 Oslo, Norway; [e]Bernstein Center for Computational Neurosciences, Heidelberg/Mannheim, D-69120 Heidelberg, Germany; and [f]Donders Institute for Brain, Cognition, and Behavior, Radboud University Nijmegen, 6525 HR, Nijmegen, The Netherlands

Edited by Leslie G. Ungerleider, National Institute of Mental Health, Bethesda, MD, and approved November 3, 2010 (received for review July 20, 2009)

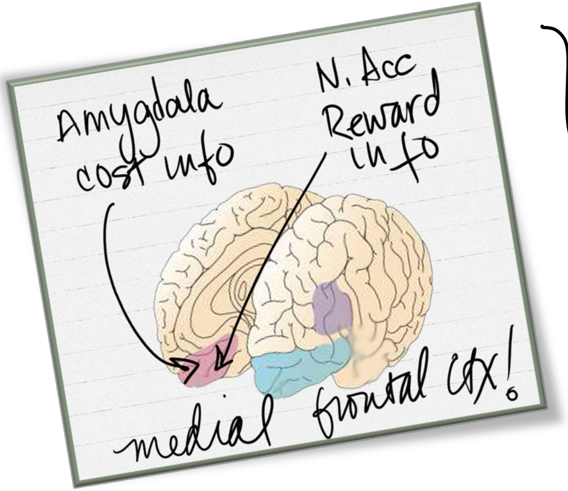
Amygdala evals.
⇓
potential
costs!

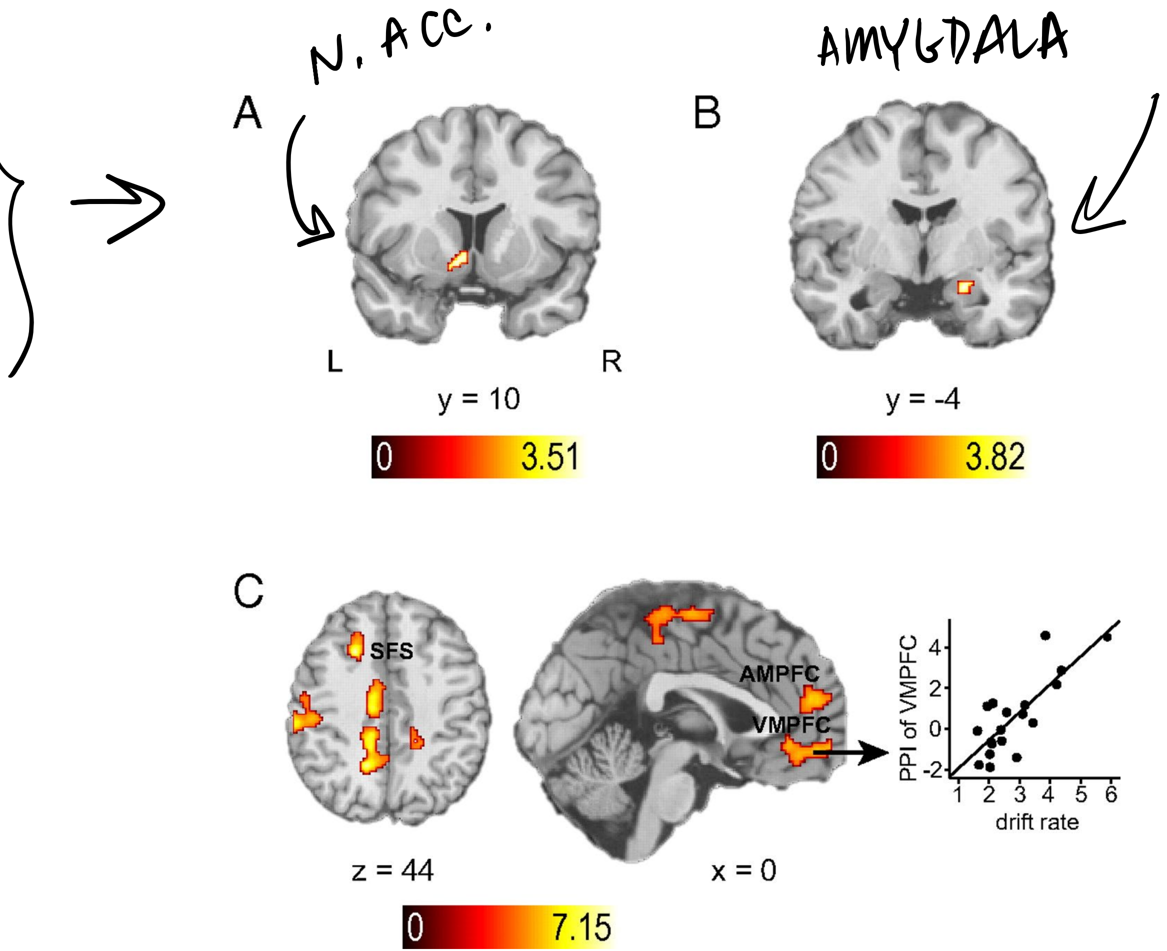




* The activity in vmPFC is proportional to the difference between NAcc & Amg.

the medial frontal does a cost-benefit analysis of reward v risks.





Neural Representations of Reward and Loss Expectation Signals.

Basten, U. et. al. (2009) PNAS, 107(50):21767–21772

5.
Got Regrets?

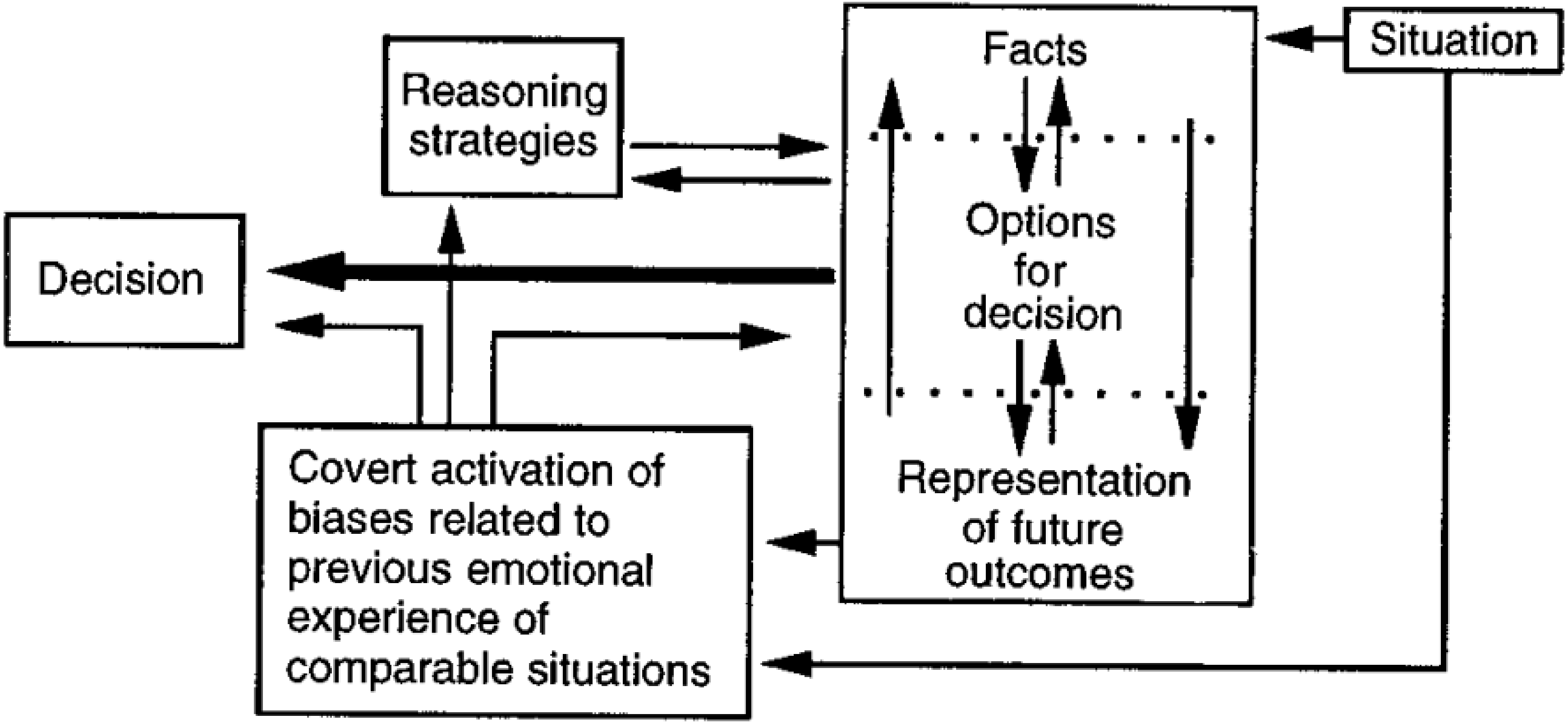
Learning from past decisions.

Deciding Advantageously Before Knowing the Advantageous Strategy

Antoine Bechara, Hanna Damasio, Daniel Tranel,
Antonio R. Damasio*

Deciding advantageously in a complex situation is thought to require overt reasoning on declarative knowledge, namely, on facts pertaining to premises, options for action, and outcomes of actions that embody the pertinent previous experience. An alternative possibility was investigated: that overt reasoning is preceded by a nonconscious biasing step that uses neural systems other than those that support declarative knowledge. Normal participants and patients with prefrontal damage and decision-making defects performed a gambling task in which behavioral, psychophysiological, and self-account measures were obtained in parallel. Normals began to choose advantageously before they realized which strategy worked best, whereas prefrontal patients continued to choose disadvantageously even after they knew the correct strategy. Moreover, normals began to generate anticipatory skin conductance responses (SCRs) whenever they pondered a choice that turned out to be risky, before they knew explicitly that it was a risky choice, whereas patients never developed anticipatory SCRs, although some eventually realized which choices were risky. The results suggest that, in normal individuals, nonconscious biases guide behavior before conscious knowledge does. Without the help of such biases, overt knowledge may be insufficient to ensure advantageous behavior.

Bechara, A. et al, (1997) Science, 275



Bechara, A. et al, (1997) Science, 275

Update

TRENDS in Cognitive Sciences Vol.9 No.4 April 2005

Full text provided by www.sciencedirect.com

Research Focus

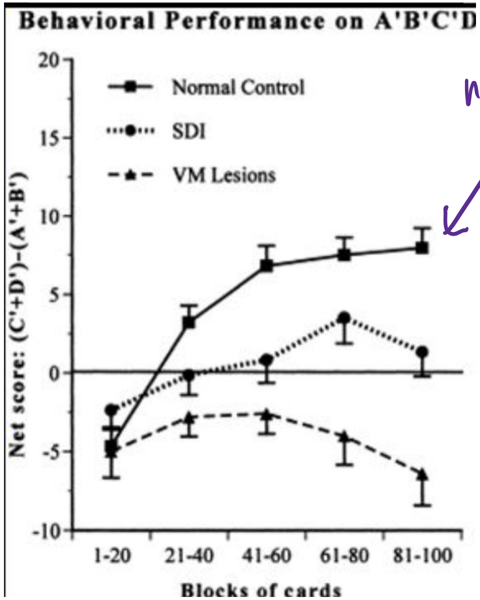
The Iowa Gambling Task and the somatic marker hypothesis: some questions and answers

A. Bechara, H. Damasio, D. Tranel and A.R. Damasio

Department of Neurology (Division of Cognitive Neuroscience), University of Iowa College of Medicine, Iowa, USA

Recall:

subjects with vmPFC damage do not learn from mistakes. ← high losses from "bad decks"

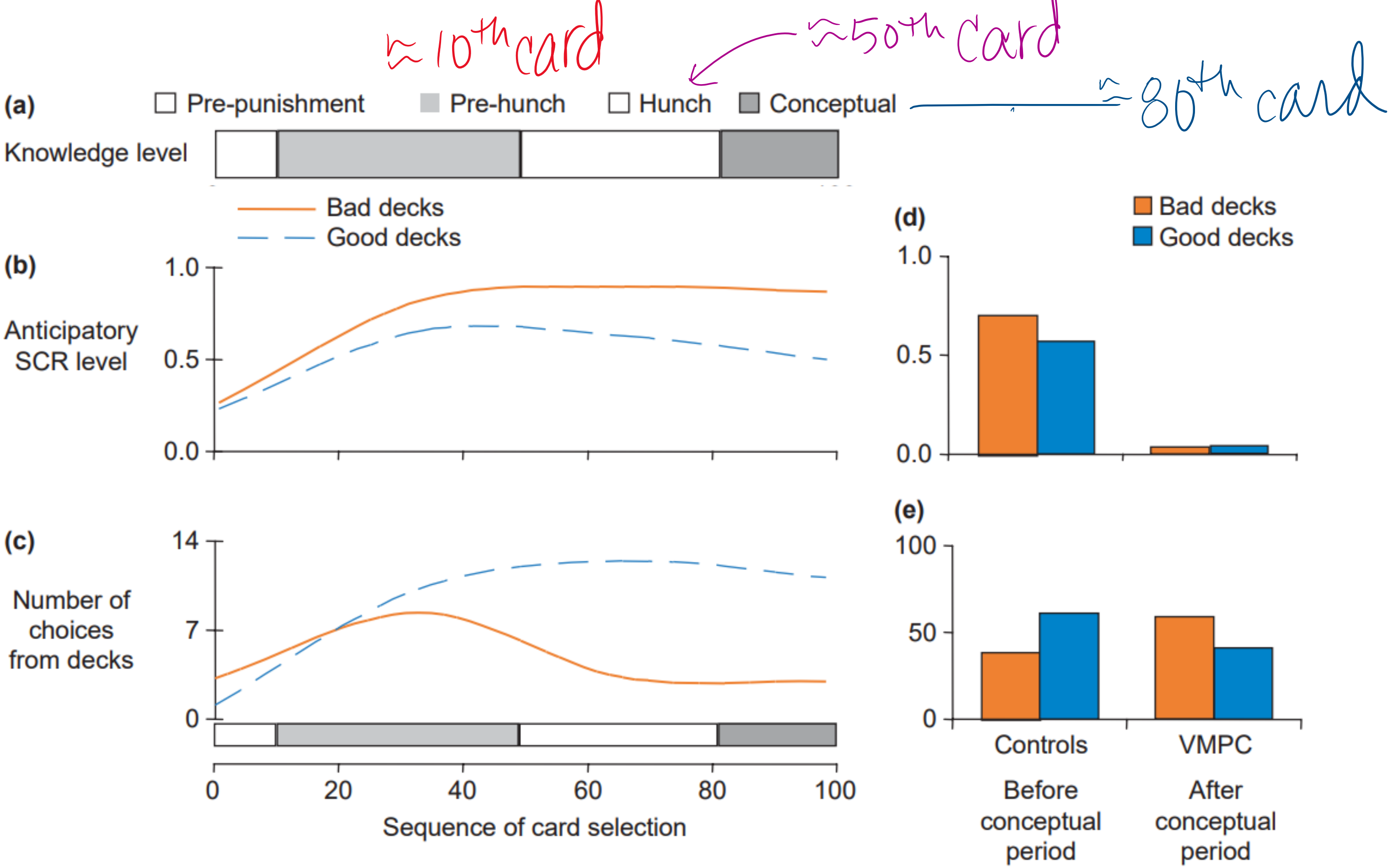


normal subjects switch strategy & use "good" decks.

The Iowa Gambling Task

	"Bad" decks		"Good" decks	
	A	B	C	D
Gain per card	\$100	\$100	\$50	\$50
Loss per 10 cards	\$1250	\$1250	\$250	\$250
Net per 10 cards	–\$250	–\$250	+\$250	+\$250

Bechara, A. et al, (1997) Science, 275, Bechara, A. et al. (2005) *TRENDS in Cognitive Sciences* 9(4).



Bechara, A. et al. (2005) *TRENDS in Cognitive Sciences* 9(4).

Patients with VMPFC damage

1. perform poorly on risk-taking tasks (eg gambling)

2. Don't have anticipatory SCR before risky decisions.

Developmental Psychology
2004, Vol. 40, No. 6, 1148–1158

0012-1649/04/$12.00 DOI: 10.1037/0012-1649.40.6.1148

Adolescents' Performance on the Iowa Gambling Task: Implications for the Development of Decision Making and Ventromedial Prefrontal Cortex

Catalina J. Hooper, Monica Luciana, Heather M. Conklin, and Rebecca S. Yarger
University of Minnesota, Twin Cities Campus

Healthy adolescents (79 girls, 66 boys), ages 9–17, completed the Iowa Gambling Task (IGT; A. Bechara, A. R. Damasio, H. Damasio, & S. W. Anderson, 1994) as well as working memory (digit span) and behavioral inhibition (go/no-go) tasks. Cross-sectional age-related changes were seen on all 3 tasks. Gender differences were seen in IGT deck preference and attentional variables (i.e., go/no-go hit rate and forward digit span). After age, gender, and general intellectual abilities were controlled for, IGT performance was not predicted by working memory or behavioral inhibition scores. Findings suggest that the ventromedial prefrontal cortex or its connections are functionally maturing during adolescence in a manner that can be distinguished from maturation of other prefrontal regions. Development of these functions may continue into young adulthood.

Hooper, C. J., et al (2004) *Developmental Psychology,* Vol. 40, No. 6, 1148 –1158 shifting good deck preference with ↑↑ age

good deck choice

bad deck choice

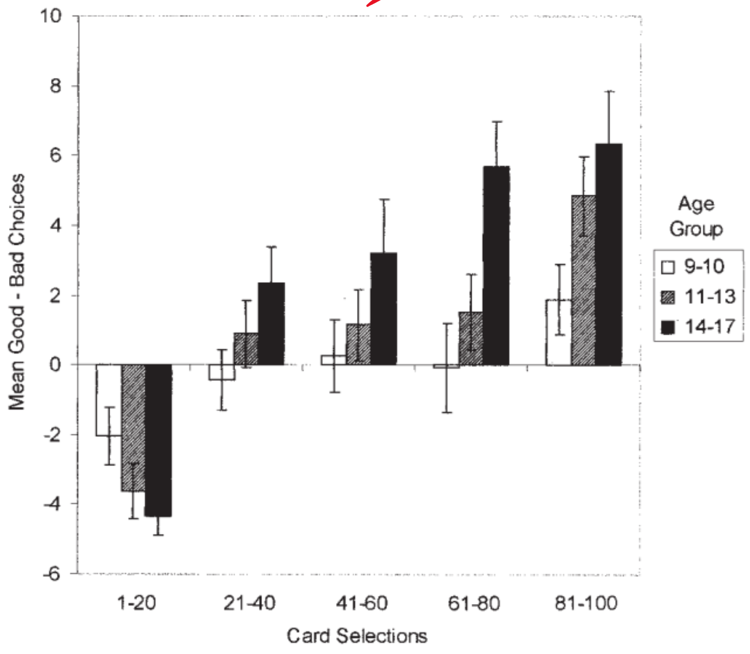


Figure 1. Mean (± *SE*) number of selections from advantageous – disadvantageous decks by healthy 9–10-year-olds (n = 49), 11–13-year-olds (n = 54), and 14–17-year-olds (n = 42) across blocks of 20 card selections in the Iowa Gambling Task.

"Findings suggest that the ventromedial prefrontal cortex or its connections are functionally maturing during adolescence in a manner that can be distinguished from maturation of other prefrontal regions. Development of these functions may continue into young adulthood."

Hooper, C. J., et al (2004) *Developmental Psychology*, Vol. 40, No. 6, 1148 –1158

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Behavioral Sciences

The neuroscience of adolescent decision-making

Catherine A Hartley[1] and Leah H Somerville[2]

Adolescence is a phase of the lifespan associated with greater independence, and thus greater demands to make self-guided decisions in the face of risks, uncertainty, and varying proximal and distal outcomes. A new wave of developmental research takes a neuroeconomic approach to specify what decision processes are changing during adolescence, along what trajectory they are changing, and what neurodevelopmental processes support these changes. Evidence is mounting to suggest that multiple decision processes are tuned differently in adolescents and adults including reward reactivity, uncertainty-tolerance, delay discounting, and experiential assessments of value and risk. Unique interactions between prefrontal cortical, striatal, and salience processing systems during adolescence both constrain and amplify various component processes of mature decision-making.

Hartley, C. A. and Somerville, L. H. (2015) *Current Opinion in Behavioral Sciences*, 5:108–115

6.
What about price?

How does price affect valuation process?

Marketing actions can modulate neural representations of experienced pleasantness

Hilke Plassmann*, John O'Doherty*, Baba Shiv†, and Antonio Rangel*‡

*Division of the Humanities and Social Sciences, California Institute of Technology, MC 228-77, Pasadena, CA 91125; and †Stanford Graduate School of Business, Stanford University, 518 Memorial Way, Littlefield L383, Stanford, CA94305

Edited by Leslie G. Ungerleider, National Institutes of Health, Bethesda, MD, and approved December 3, 2007 (received for review July 24, 2007)

Despite the importance and pervasiveness of marketing, almost nothing is known about the neural mechanisms through which it affects decisions made by individuals. We propose that marketing actions, such as changes in the price of a product, can affect neural representations of experienced pleasantness. We tested this hypothesis by scanning human subjects using functional MRI while they tasted wines that, contrary to reality, they believed to be different and sold at different prices. Our results show that increasing the price of a wine increases subjective reports of flavor pleasantness as well as blood-oxygen-level-dependent activity in medial orbitofrontal cortex, an area that is widely thought to encode for experienced pleasantness during experiential tasks. The paper provides evidence for the ability of marketing actions to modulate neural correlates of experienced pleasantness and for the mechanisms through which the effect operates.

Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

PASADENA, Calif.-- A rose by any other name might smell as sweet, but slap on a hefty price tag, and our opinion of it might go through the roof. At least that's the case with the taste of wine, say scientists from the California Institute of Technology and Stanford University.

Antonio Rangel, an associate professor of economics at Caltech, and his colleagues found that changes in the stated price of a sampled wine influenced not only how good volunteers thought it tasted, but the activity of a brain region that is involved in our experience of pleasure. In other words, "prices, by themselves, affect activity in an area of the brain that is thought to encode the experienced pleasantness of an experience," Rangel says.

Rangel and his colleagues had 20 volunteers taste five wine samples which, they were told, were identified by their different retail prices: $5, $10, $35, $45, and $90 per bottle. While the subjects tasted and evaluated the wines, their brains were scanned using functional magnetic resonance imaging, or fMRI.

The subjects consistently reported that they liked the taste of the $90 bottle better than the $5 one, and the $45 bottle better than the $35 one. Scans of their brains supported their subjective reports; a region of the brain called the medial orbitofrontal cortex, or mOFC, showed higher activity when the subjects drank the wines they said were more pleasurable.

Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

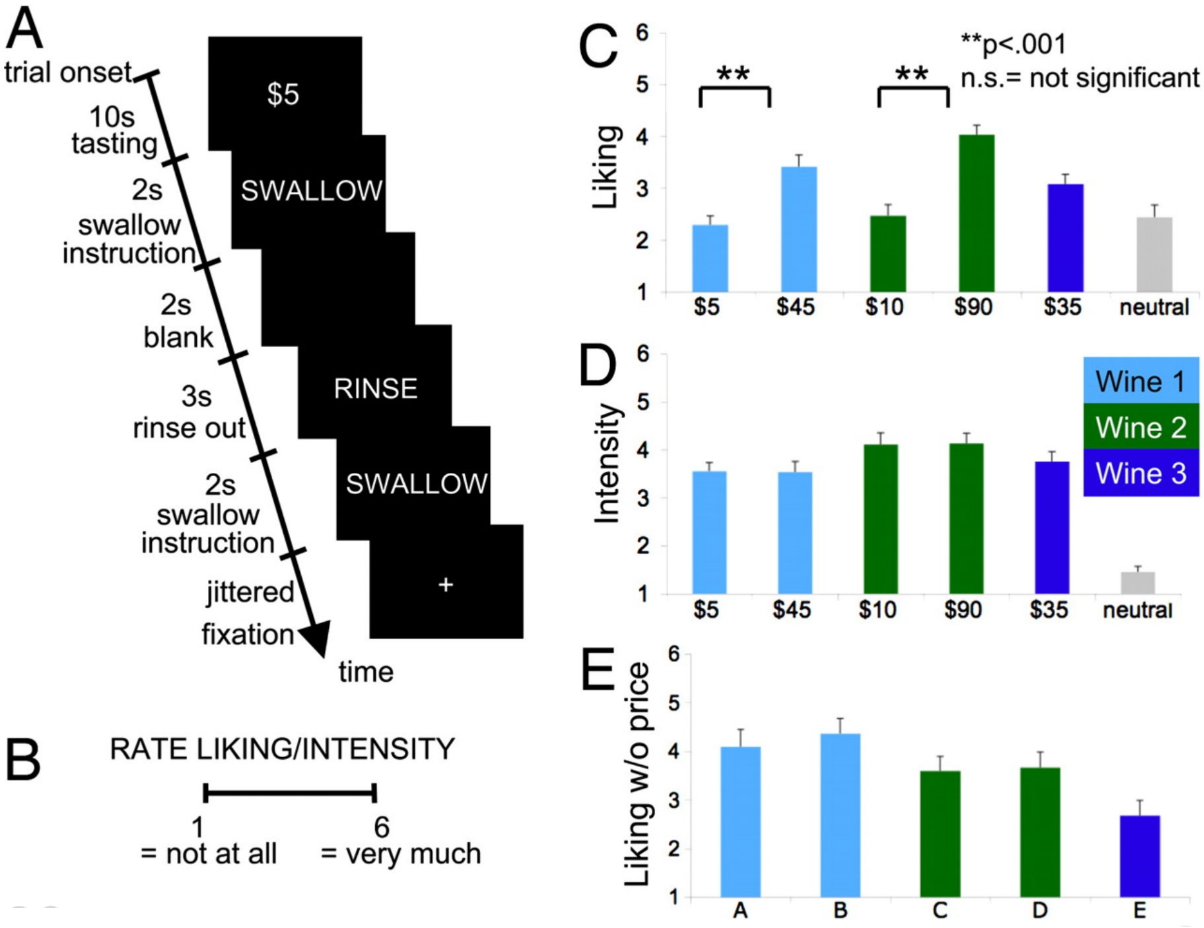
http://www.caltech.edu/news/wine-study-shows-price-influences-perception-1374

There was a catch to the experiment, however. Although the subjects had been told that they would taste five different, variously priced wines, they actually had sampled only three. Wines 1 and 2 were used twice, but labeled with two different prices. For example, wine 2 was presented as the $90 wine (its actual retail price) and also as the $10 wine. When the subjects were told the wine cost $90 a bottle, they loved it; at $10 a bottle, not so much. In a follow-up experiment, the subjects again tasted all five wine samples, but without any price information; this time, they rated the cheapest wine as their most preferred.

rank by taste → cheapest was best.

Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

http://www.caltech.edu/news/wine-study-shows-price-influences-perception-1374



Reported pleasantness for the wines during the cued price trials.

Taste intensity ratings for the wines during the cued price trials.

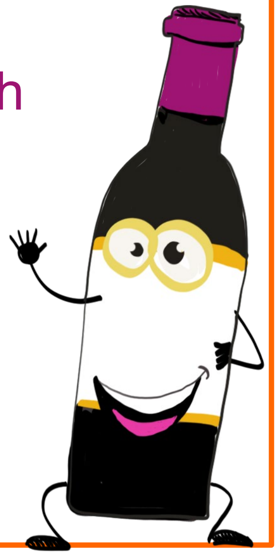
Reported pleasantness for the wines obtained during a postexperimental session without price cues.

Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

Previous marketing studies have shown that it is possible to change people's reports of how good an experience is by changing their beliefs about the experience. For example, says Rangel, moviegoers will report liking a movie more when they hear beforehand how good it is. "Our study goes beyond that to show that

"the neural encoding of the quality of an experience is actually modulated by a variable such as price, which most people believe is correlated with experienced pleasantness."

Antonio Rangel



Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

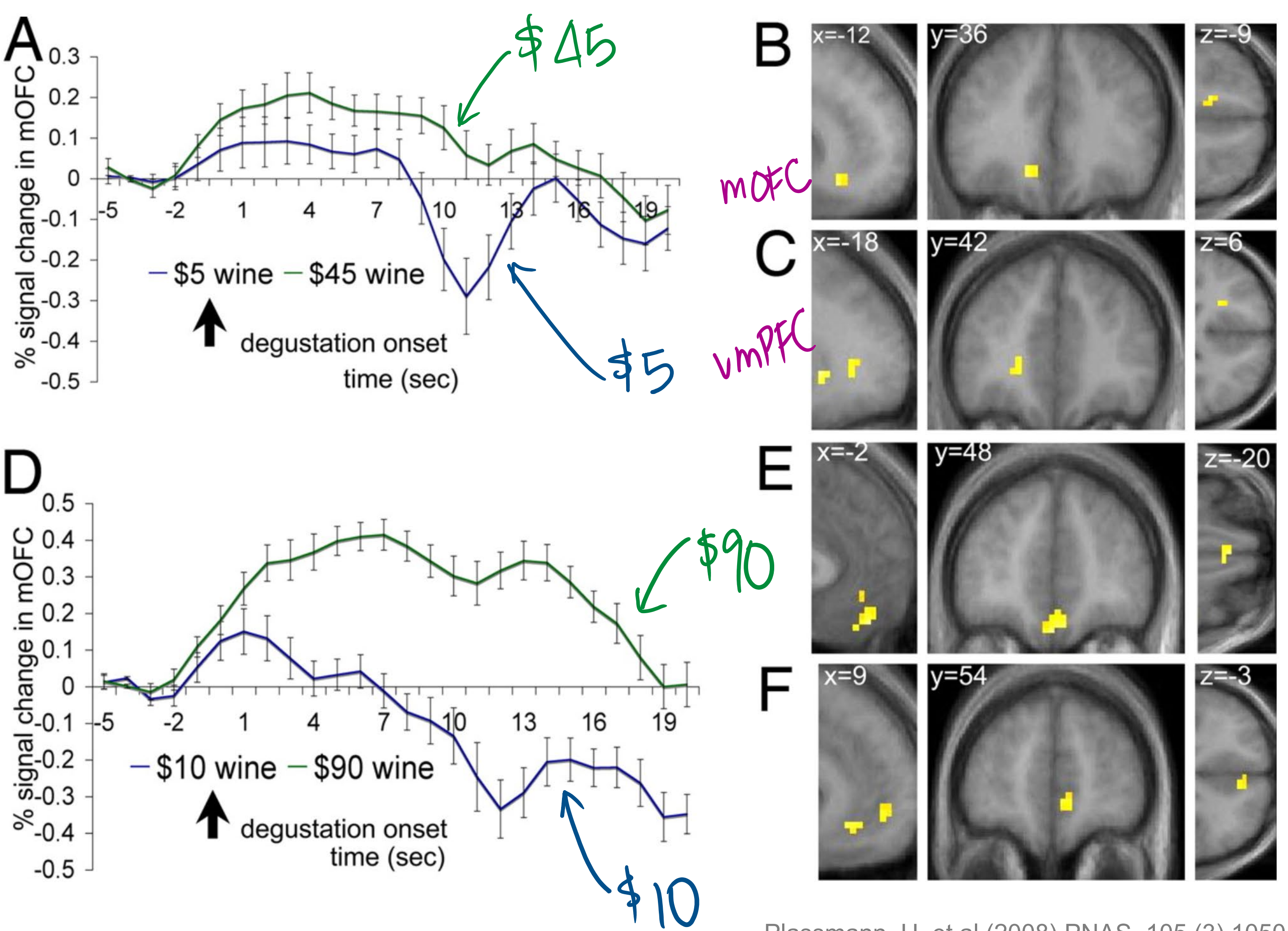
http://www.caltech.edu/news/wine-study-shows-price-influences-perception-1374

"The area of their brain that is thought to encode for the pleasantness of the experience was more active when they drank wine they believed had higher prices."

Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

http://www.caltech.edu/news/wine-study-shows-price-influences-perception-1374

WINE #1



WINE #2

Price can modulate the decision value signal in mOFC.

Plassmann, H. et al (2008) PNAS 105 (3) 1050-1054

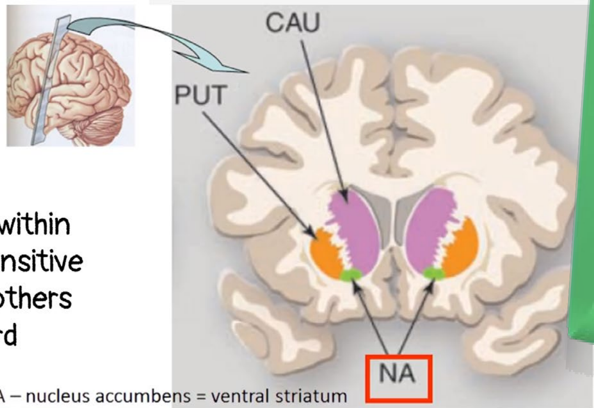
7.
evaluation?

Brain utilizes distinct networks in the evaluation process.

Bottom line:

NAc. activity is proportional to the magnitude of an anticipated gain.

There are subpopulations within the v. striatum that are sensitive to reward probability and others that are sensitive to reward magnitude.

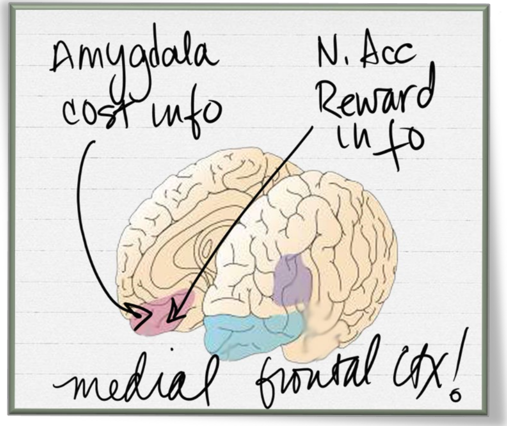


NA – nucleus accumbens = ventral striatum

N. Acc. subj. value
Anticipated gain magnitude
← risk seeking

Integration of information
vmPFC & mOFC

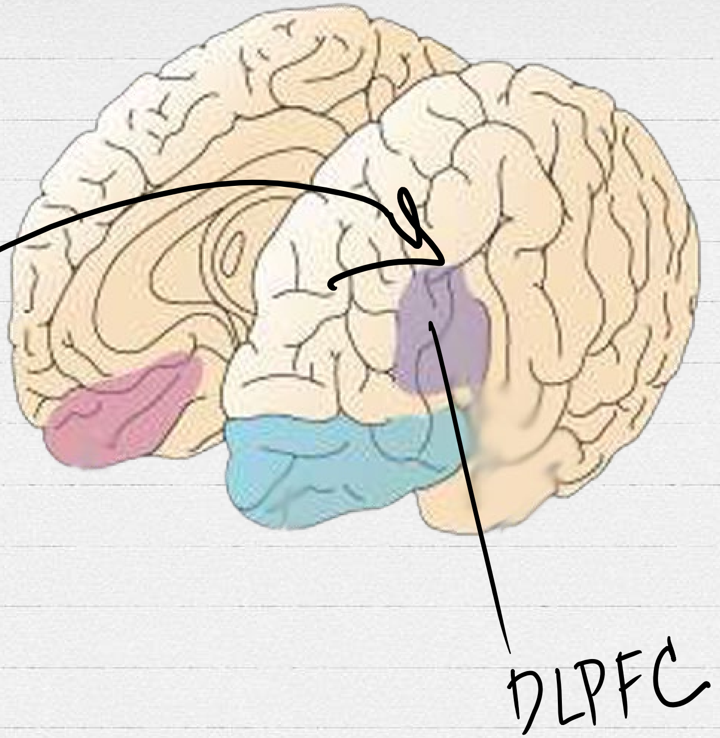
expected outcome learning*



Amygdala:
→ cost estimation
→ rigid learning
→ framing

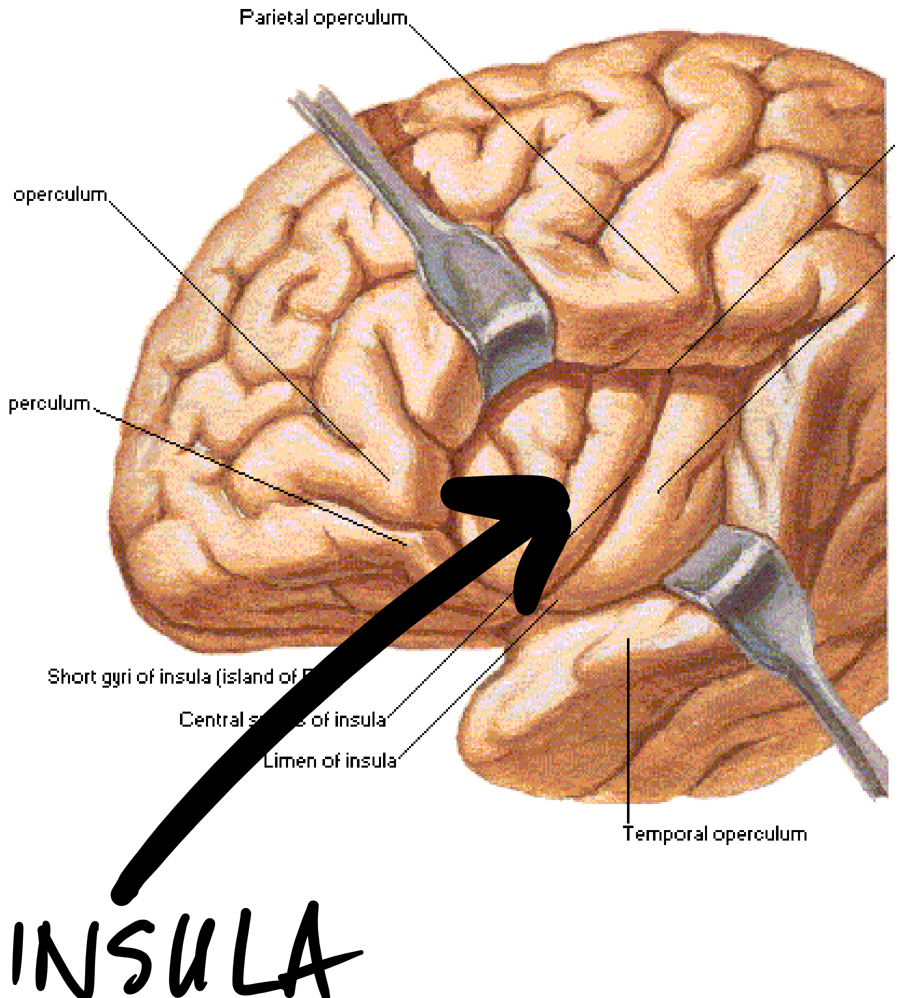
Dorsolateral Prefrontal Ctx

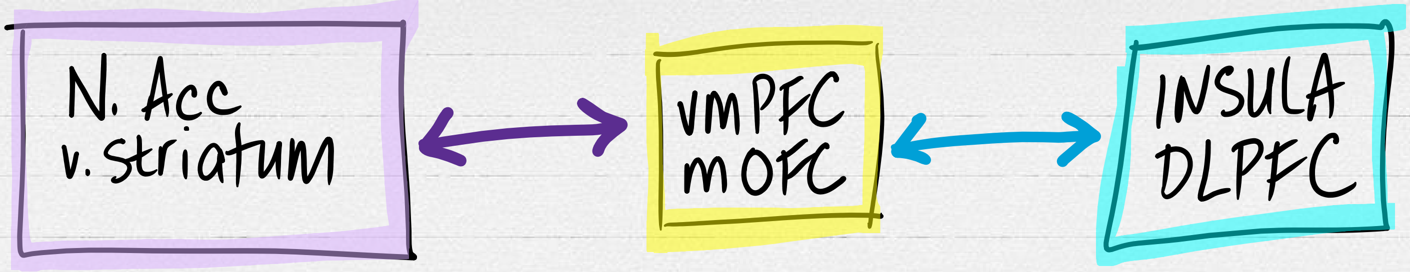
cognitive control & planning



INSULA

- emotional interface between decisions & emotional arousal




N. Acc
v. striatum
vmPFC
mOFC
INSULA
DLPFC

8.
Emotions?

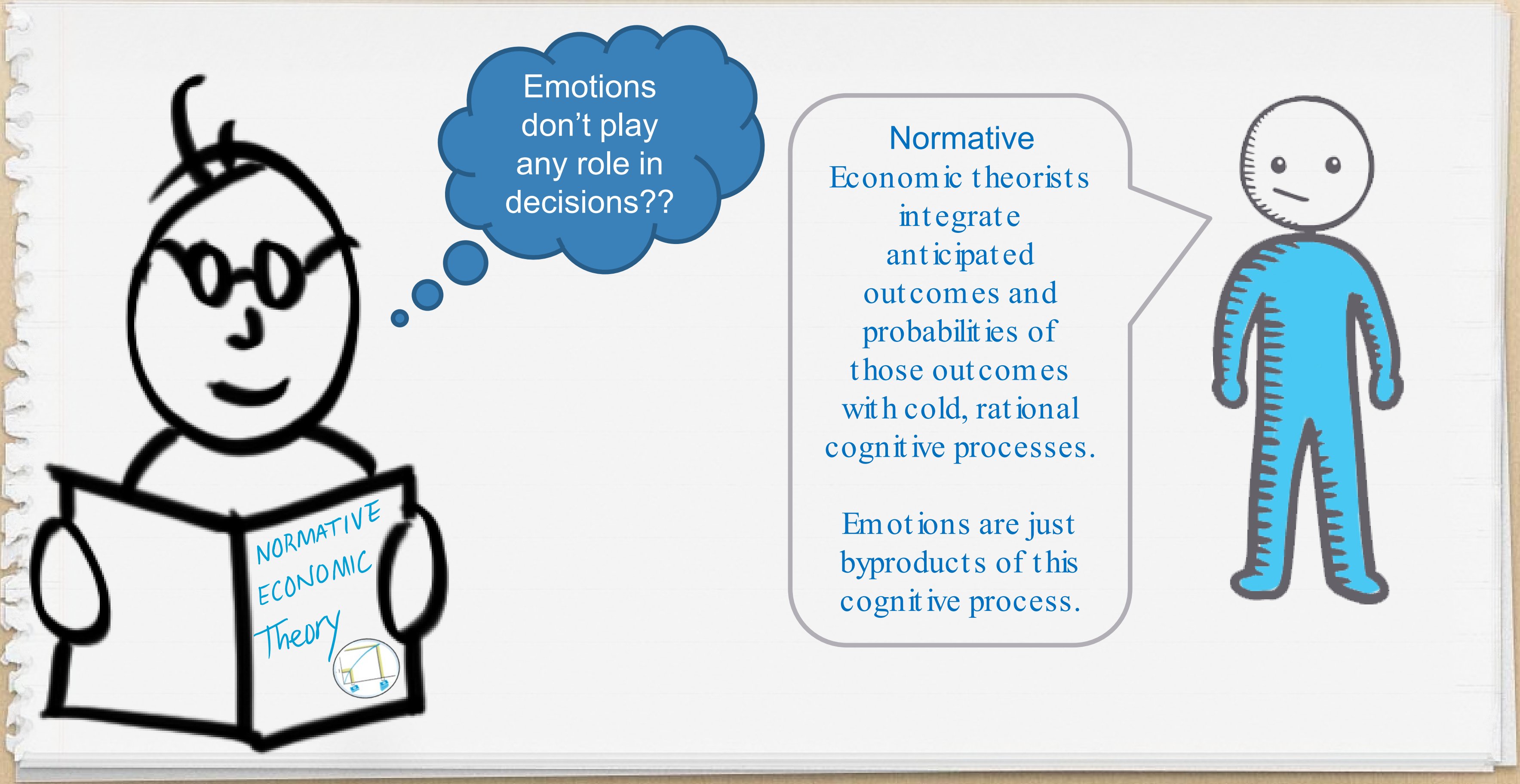
What role to they play
in decision-making?

CHAPTER 9

The Role of Emotion in Economic Behavior

SCOTT RICK and GEORGE LOEWENSTEIN

Rick, S. and Loewenstein, G. (2008) "The Role of Emotion in Economic Behavior", in *Handbook of Emotions,* Lewis, et al. Guilford Press.


Emotions don't play any role in decisions??
NORMATIVE ECONOMIC Theory
Normative
Economic theorists integrate anticipated outcomes and probabilities of those outcomes with cold, rational cognitive processes.
Emotions are just byproducts of this cognitive process.

Consequentialist Models of Decision Making

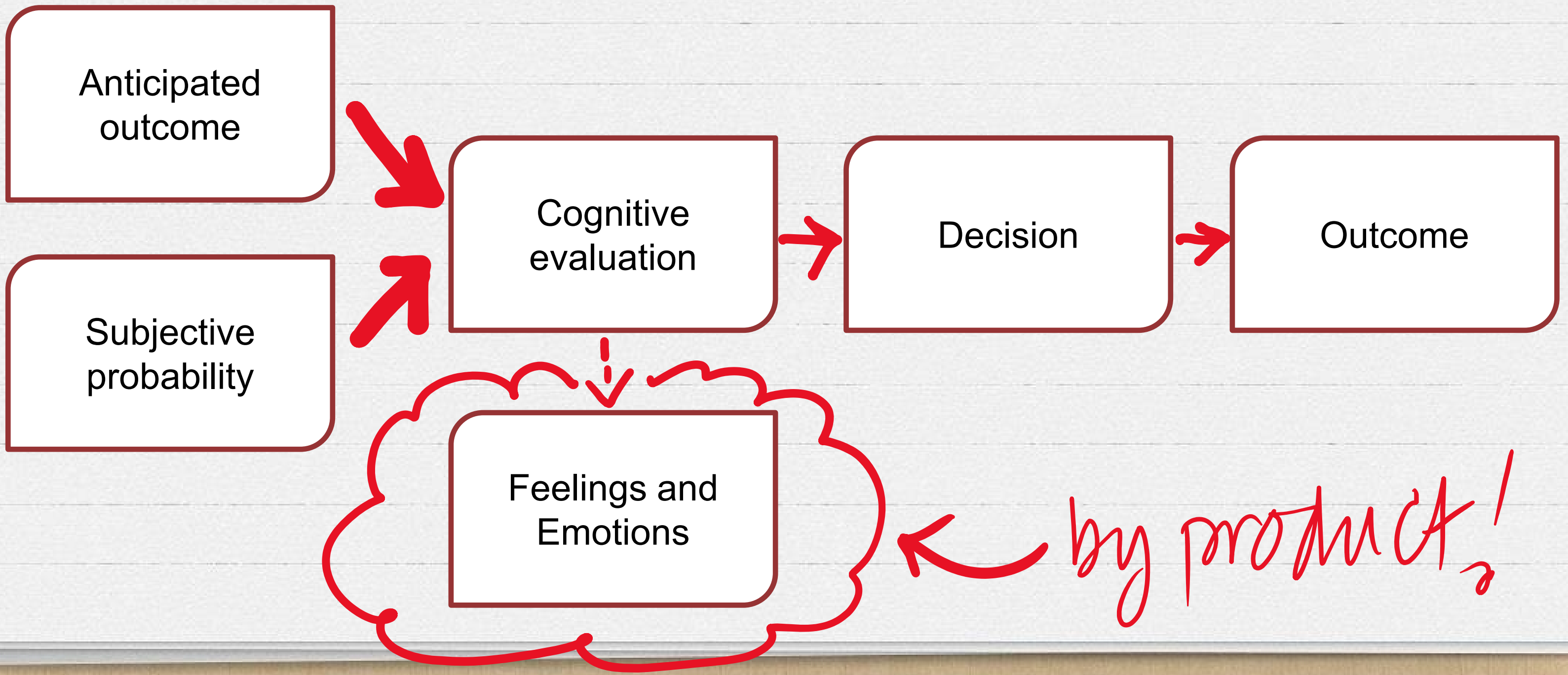
Economic models of decision making are consequentialist in nature; they assume that decision makers choose between alternative courses of action by assessing the desirability and likelihood of their consequences, and integrating this information through some type of expectation-based calculus. Economists refer to the desirability of an outcome as its "utility," and decision making is depicted as a matter of maximizing utility.

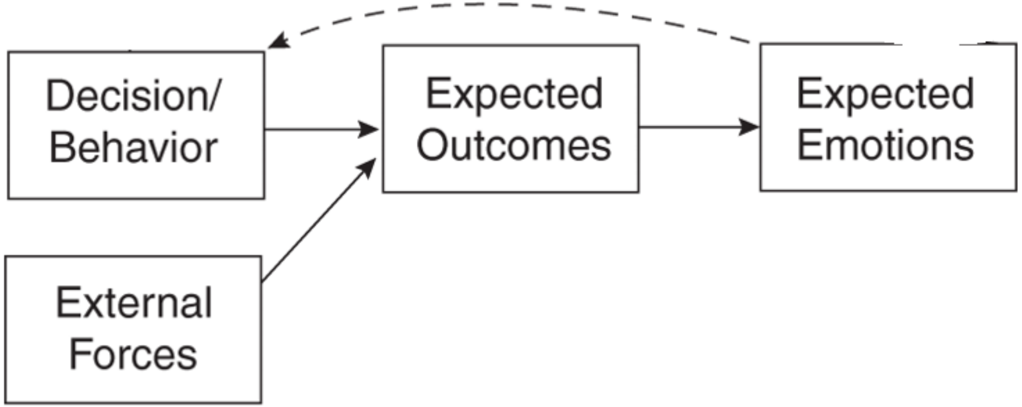
This does not, however, imply that consequentialist decision makers are devoid of emotion or immune to its influence. To see why, it is useful to draw a distinction between "expected" and "immediate" emotions (Loewenstein, Weber, Hsee, & Welch, 2001; Loewenstein & Lerner, 2003). Expected emotions are those that are anticipated to occur as a result of the outcomes associated with different possible courses of action. For example, if Laura, a potential investor, were deciding whether to purchase a stock, she might imagine the disappointment she would feel if she bought it and it declined in price, the elation she would experience if it increased in price, and possibly emotions such as regret and relief that she might experience if she did not purchase the stock and its price either rose or fell. The key feature of expected emotions is that they are experienced when the outcomes of a decision materialize, but not at the moment of choice, at the moment of choice they are only cognitions about future emotions.

not at the moment of choice!

Rick, S. and Loewenstein, G. (2008) "The Role of Emotion in Economic Behavior", in *Handbook of Emotions,* Lewis, et al. Guilford Press.

Consequentialist model:





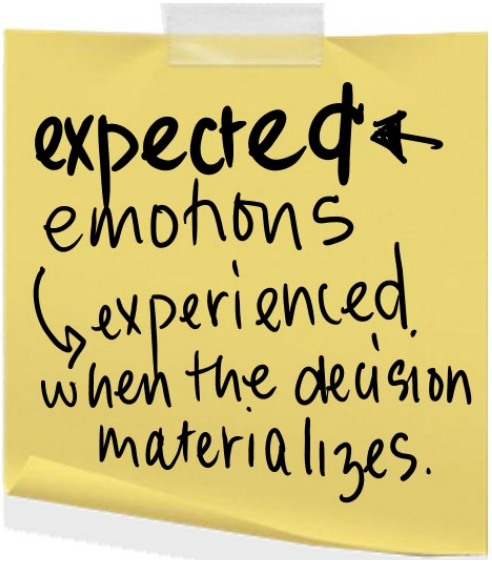


FIGURE 9.1. Consequentialist model of decision making.

Rick, S. and Loewenstein, G. (2008) "The Role of Emotion in Economic Behavior", in *Handbook of Emotions,* Lewis, et al. Guilford Press.

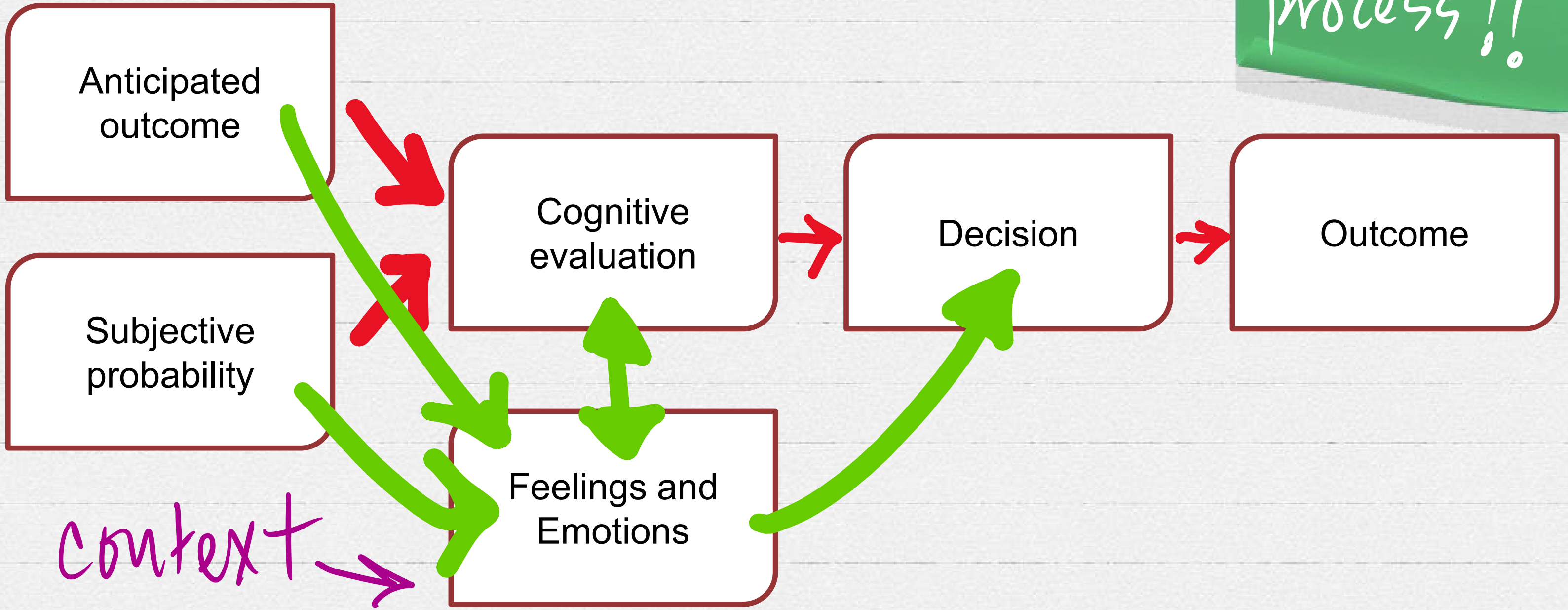
Immediate emotions:

Immediate emotions, by contrast, are experienced at the moment of choice and fall into one of two categories. "Integral" emotions, like expected emotions, arise from thinking about the consequences of one's decision, but integral emotions, unlike expected emotions, are experienced at the moment of choice. For example, in the process of deciding whether to purchase the stock, Laura might experience immediate fear at the thought of the stock's losing value. "Incidental" emotions are also experienced at the moment of choice, but arise from dispositional or situational sources objectively unrelated to the task at hand (e.g., the TV program playing in the background as Laura called her brokerage house).[1]

Rick, S. and Loewenstein, G. (2008) "The Role of Emotion in Economic Behavior", in *Handbook of Emotions,* Lewis, et al. Guilford Press.

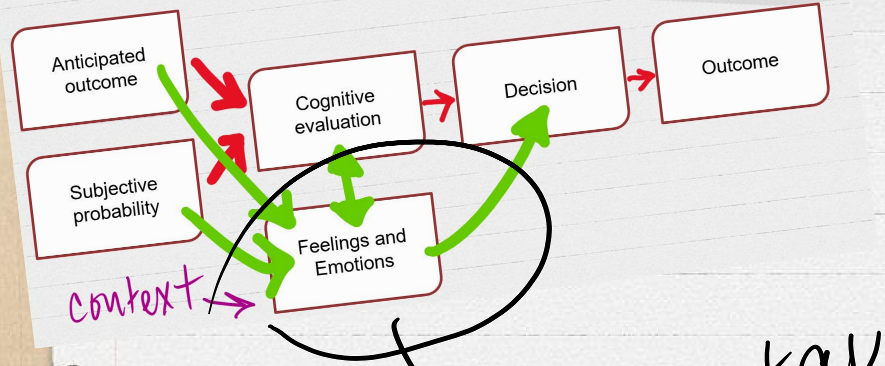
Behavioral Economics model

Emotions are critical to decision process!!



Behavioral Economics model

Emotions are critical to decision process!!



takes place in the emotional centers of the brain.

9.
emotional regulation

Self-regulating emotions in the brain.

nature neuroscience

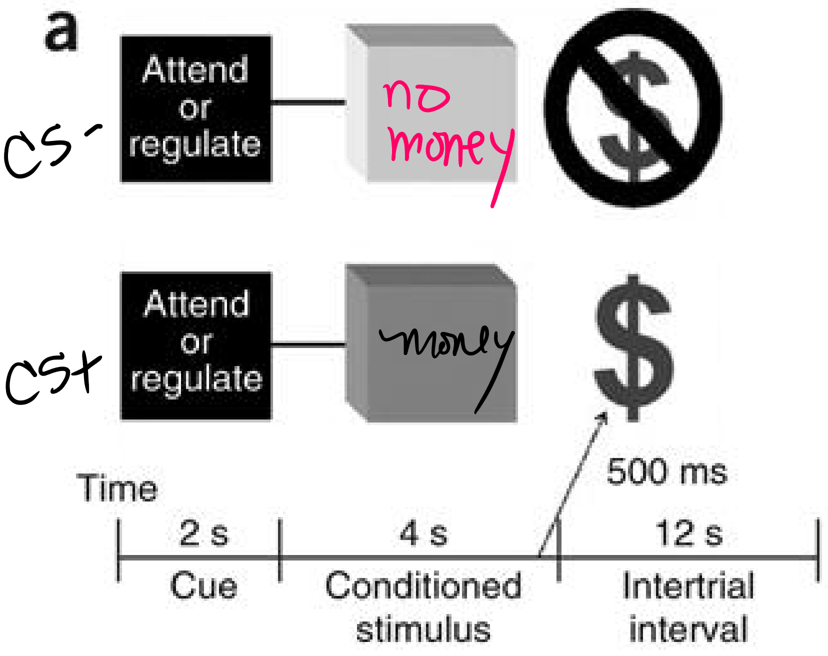
Regulating the expectation of reward via cognitive strategies

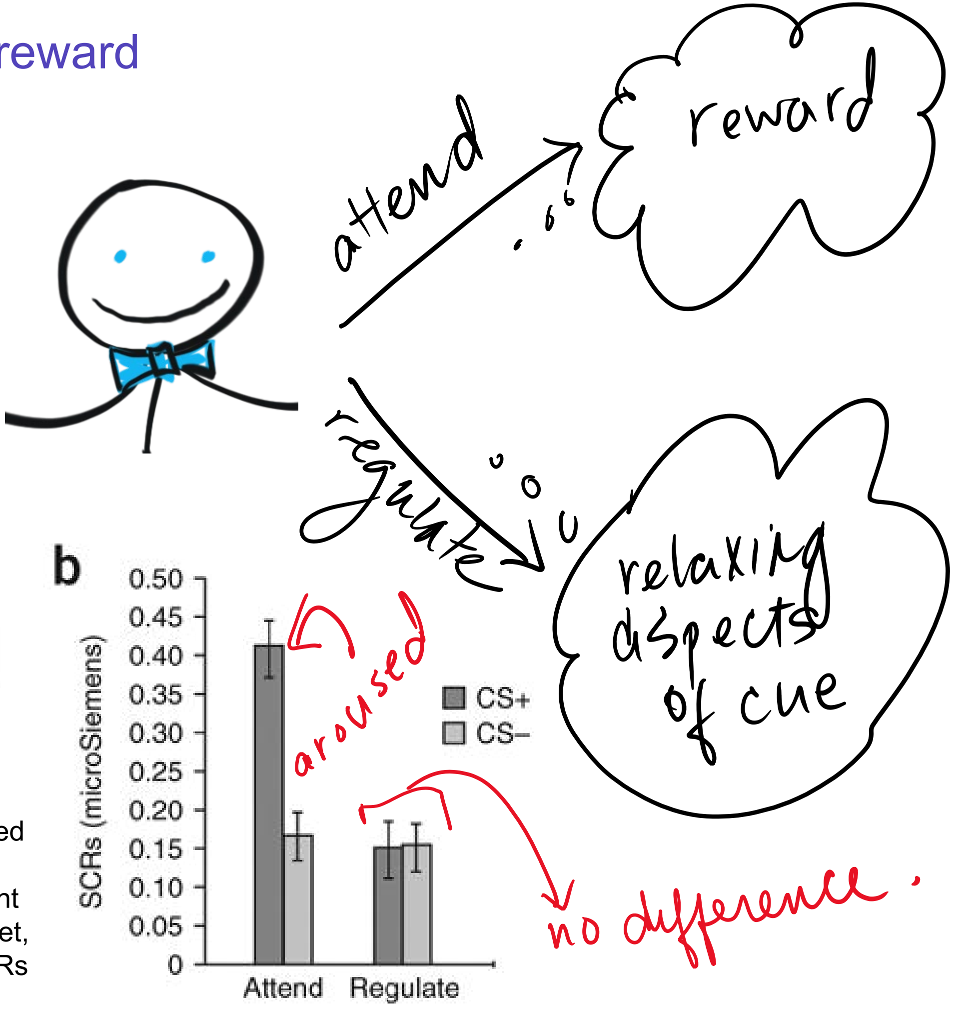
Mauricio R Delgado[1], M Meredith Gillis[2] & Elizabeth A Phelps[2]

Previous emotion regulation research has been successful in altering aversive emotional reactions. It is unclear, however, whether such strategies can also efficiently regulate expectations of reward arising from conditioned stimuli, which can at times be maladaptive (for example, drug cravings). Using a monetary reward-conditioning procedure with cognitive strategies, we observed attenuation in both the physiological (skin conductance) and neural correlates (striatum) of reward expectation as participants engaged in emotion regulation.

Delgado, M. R. et al (2008) Nat. Neurosci 2008 Aug; 11(8): 880–881

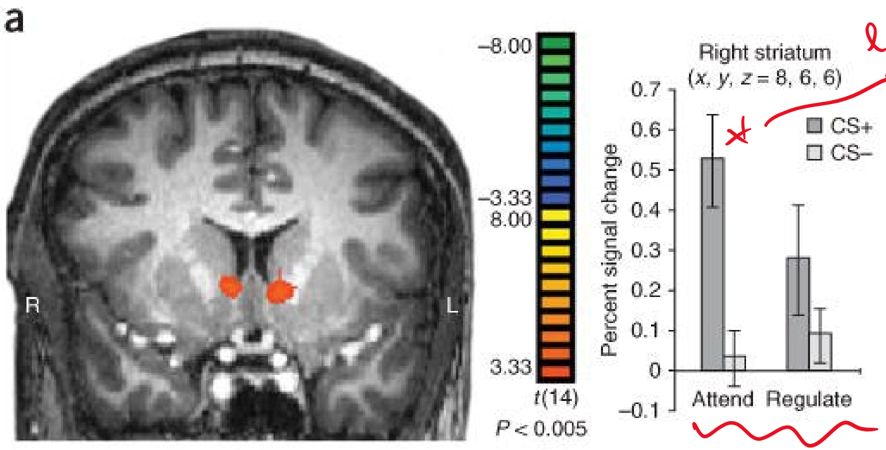
color of the cue determines the monetary reward





Depiction of task-related events and behavioral results. (a) Participants were presented with two conditioned stimuli (CS, colored squares depicted in figure as dark and light gray squares). The CS+ trial (dark gray) predicted a potential monetary reward ($4.00), whereas the CS− trial (light gray) predicted no monetary reward ($0). Prior to conditioned stimuli onset, the cues ‘Attend’ or ‘Regulate’ served as instructions for that trial. (b) SCRs from 15 participants showing an interaction between type of conditioned stimulus (CS+, CS−) and type of instruction (attend, regulate; ± s.e.m.).

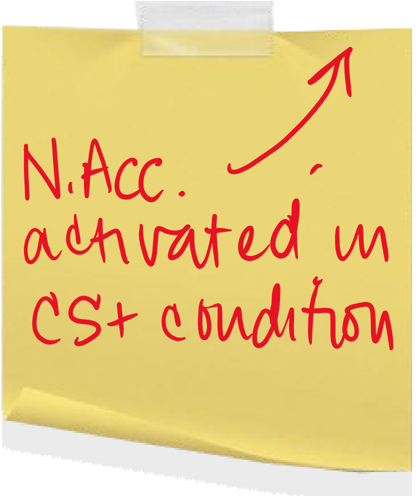
Delgado, M. R. et al (2008) Nat. Neurosci 2008 Aug; 11(8): 880–881

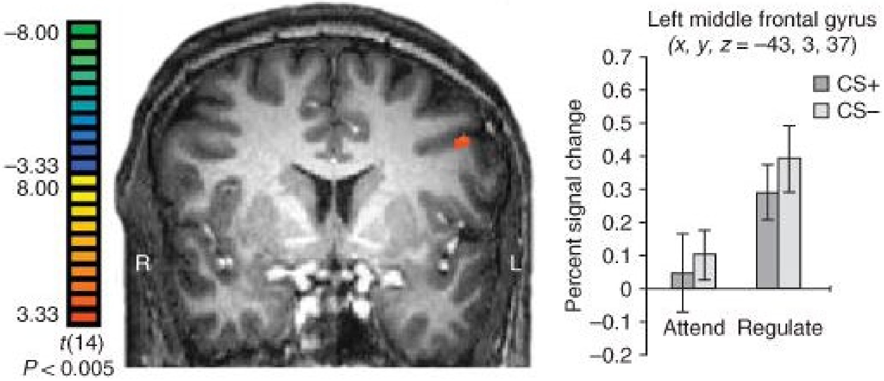


Neuroimaging results.

(**a**) Activation of the striatum bilaterally identified by a contrast of attend CS+ versus CS− trials (expectation of reward). Mean beta weights from both ROIs showed an interaction between type of condition stimulus (CS+, CS−) and instruction (attend, regulate; ± s.e.m.).

(**b**) Mean beta weights for left middle frontal gyrus ROI showing elevated responses during the regulate CS+ compared with the attend CS+ condition (± s.e.m.).

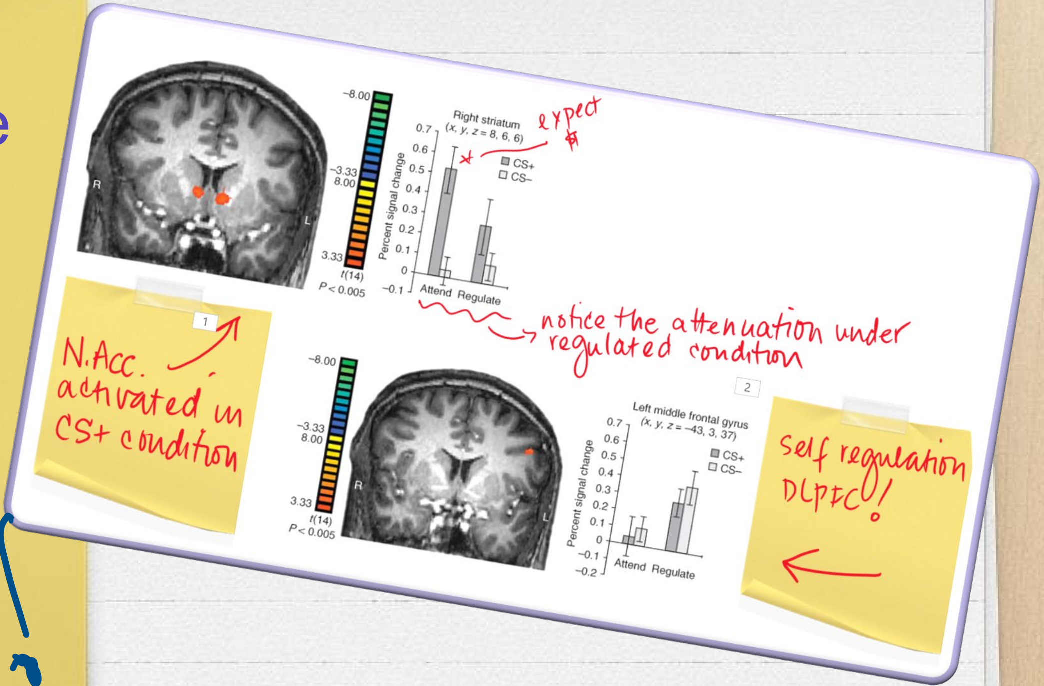




Delgado, M. R. et al (2008) Nat. Neurosci 2008 Aug; 11(8): 880–881

DLPFC can regulate activity in the N.Accumbens during the decision making process.

wow!



Delgado, M. R. et al (2008) Nat. Neurosci 2008 Aug; 11(8): 880–881