

Addiction, Brain Change, and Gambling:
Deep Learning, not Disease

Marc Lewis

Radboud University Nijmegen

Models of Addiction

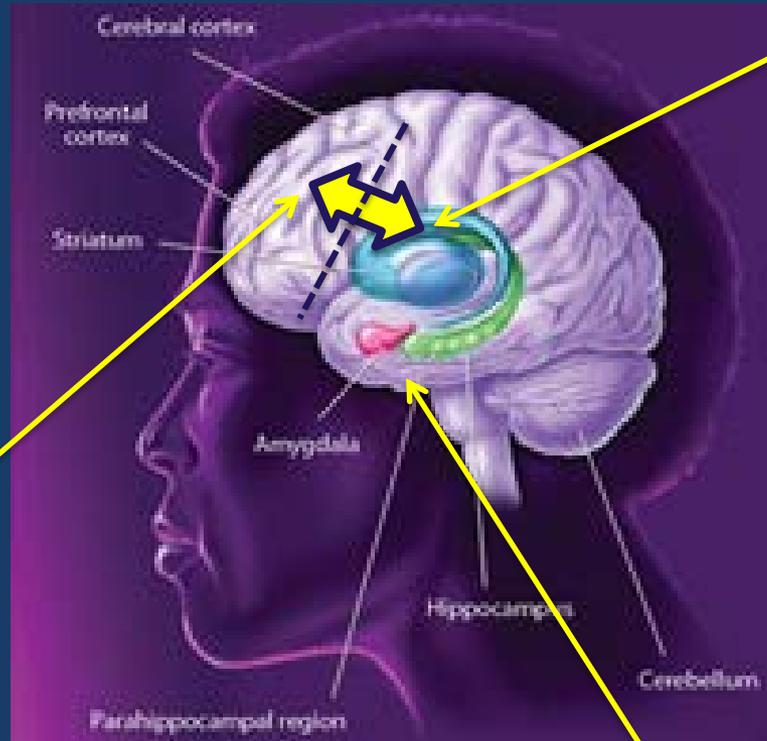
- Disease model
- Choice model
- Social construction of addiction
- Traumatic early history which calls for self-medication
- Developmental-learning model

Addiction defined as a brain disease

- NIDA (National Institute on Drug Abuse):

“Addiction is defined as a **chronic, relapsing brain disease** that is characterized by compulsive drug seeking and use, despite harmful consequences.”

“Brain-imaging studies from drug-addicted individuals show **physical changes** in areas of the brain that are critical for judgment, decision-making, learning and memory, and behavior control.”



Striatum:
Nucleus accumbens

The Motivational Engine

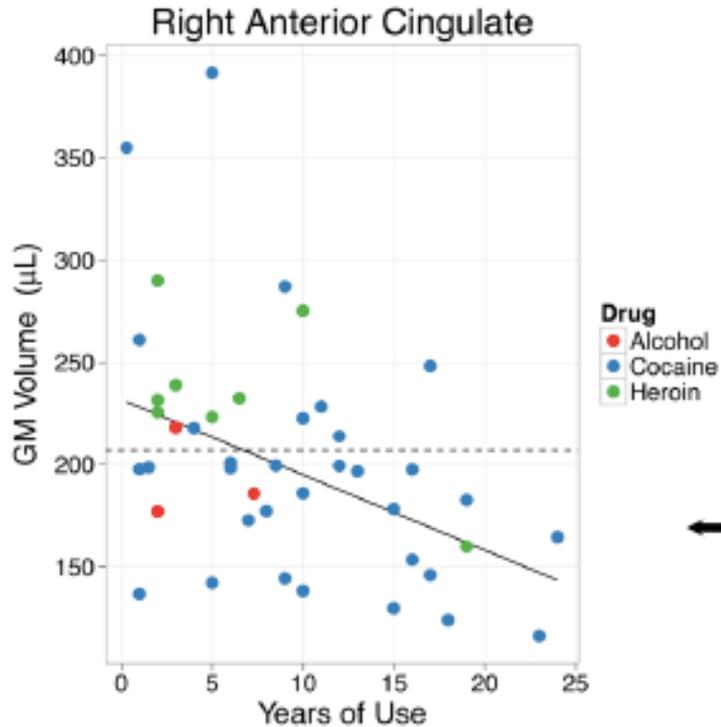
Dorsolateral
prefrontal cortex

The Bridge of the Ship

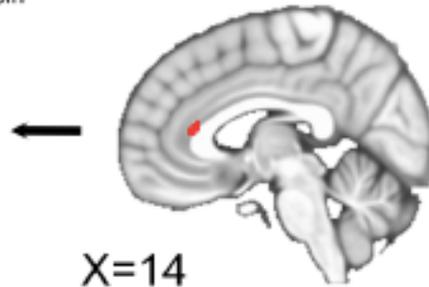
Midbrain: ventral
tegmental area (VTA)

Dopamine Pump

Use it or Lose it?!?

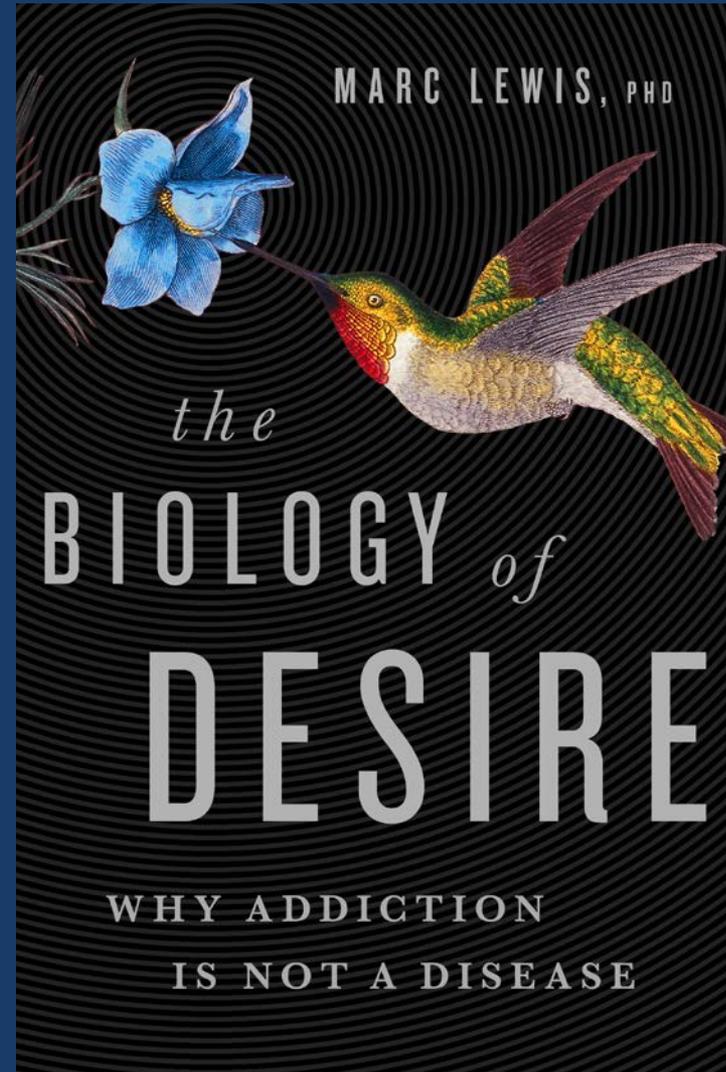


Looks suspiciously like brain disease...?



From Connolly, Bell, Foxe, & Garavan. *PLOS ONE*, vol. 8, 2013.

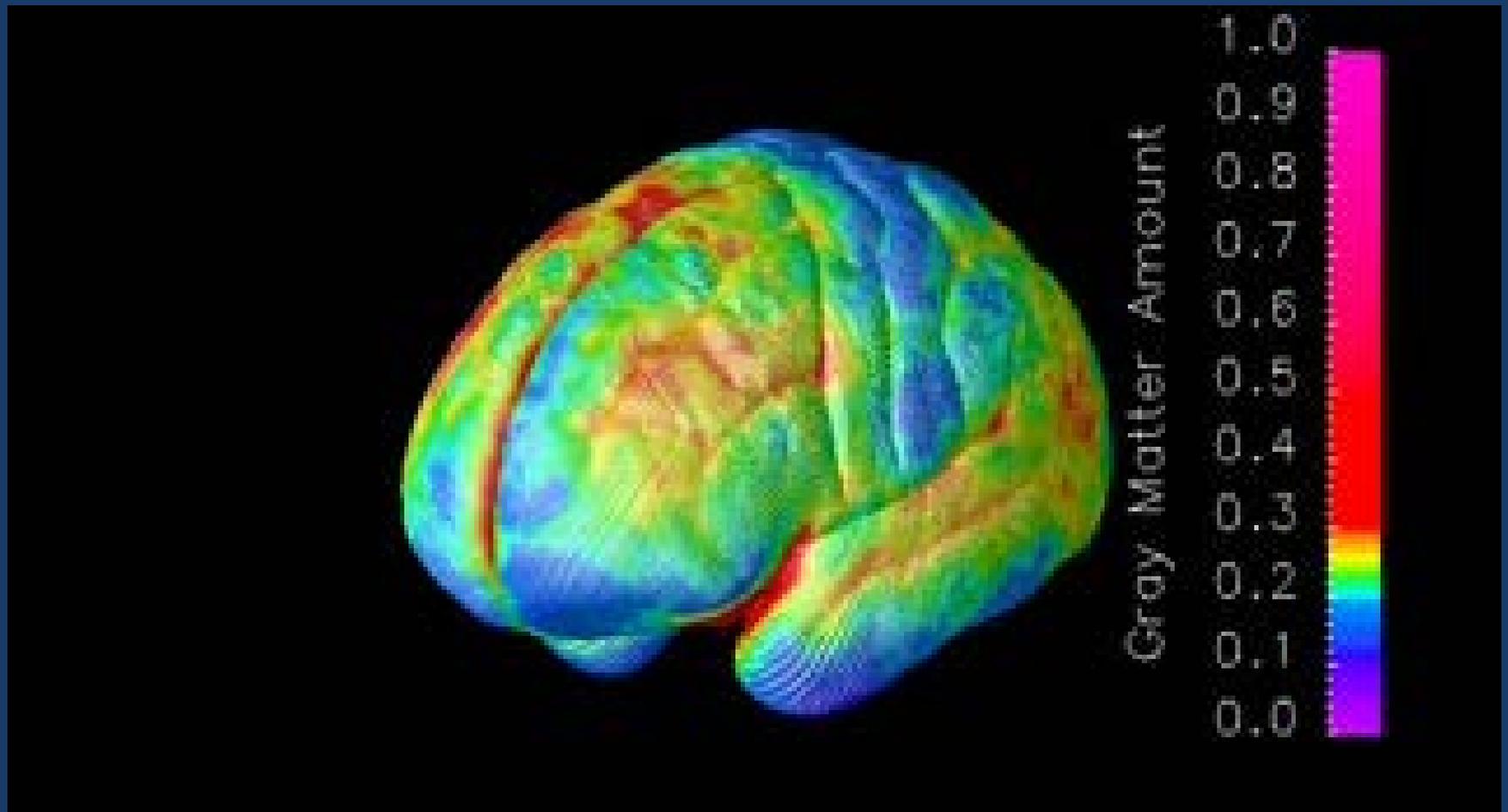
Or is the disease model wrong?



Reinterpreting the neural data...

- If brains change with learning and development, then *brain change doesn't necessarily mean brain disease*
- But how do brains change with development?

Changes in cortical density from age 4 through age 20 (from averaged MRI data)

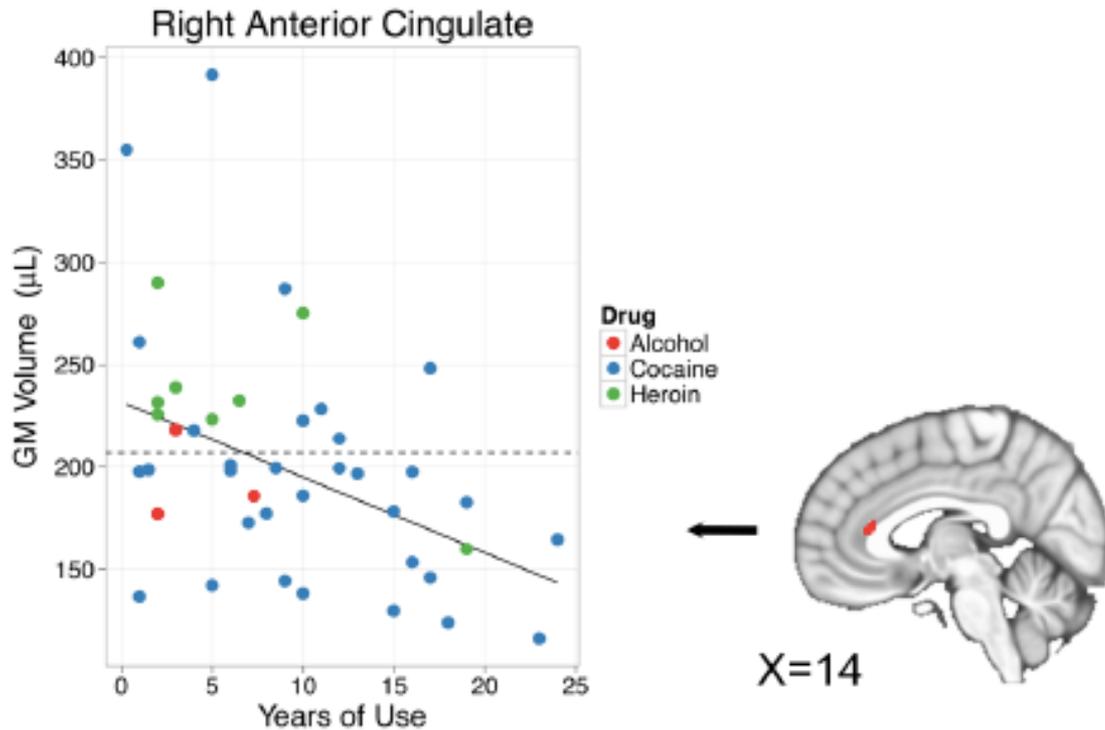


Development = Synaptic growth + synaptic pruning



- Synaptic growth → flexibility, novelty, increasing range of knowledge and skills
 - Synaptic pruning → consolidation, efficiency, habit formation

If this thinning is viewed as synaptic pruning....



...then we should not be surprised by further synaptic alteration!

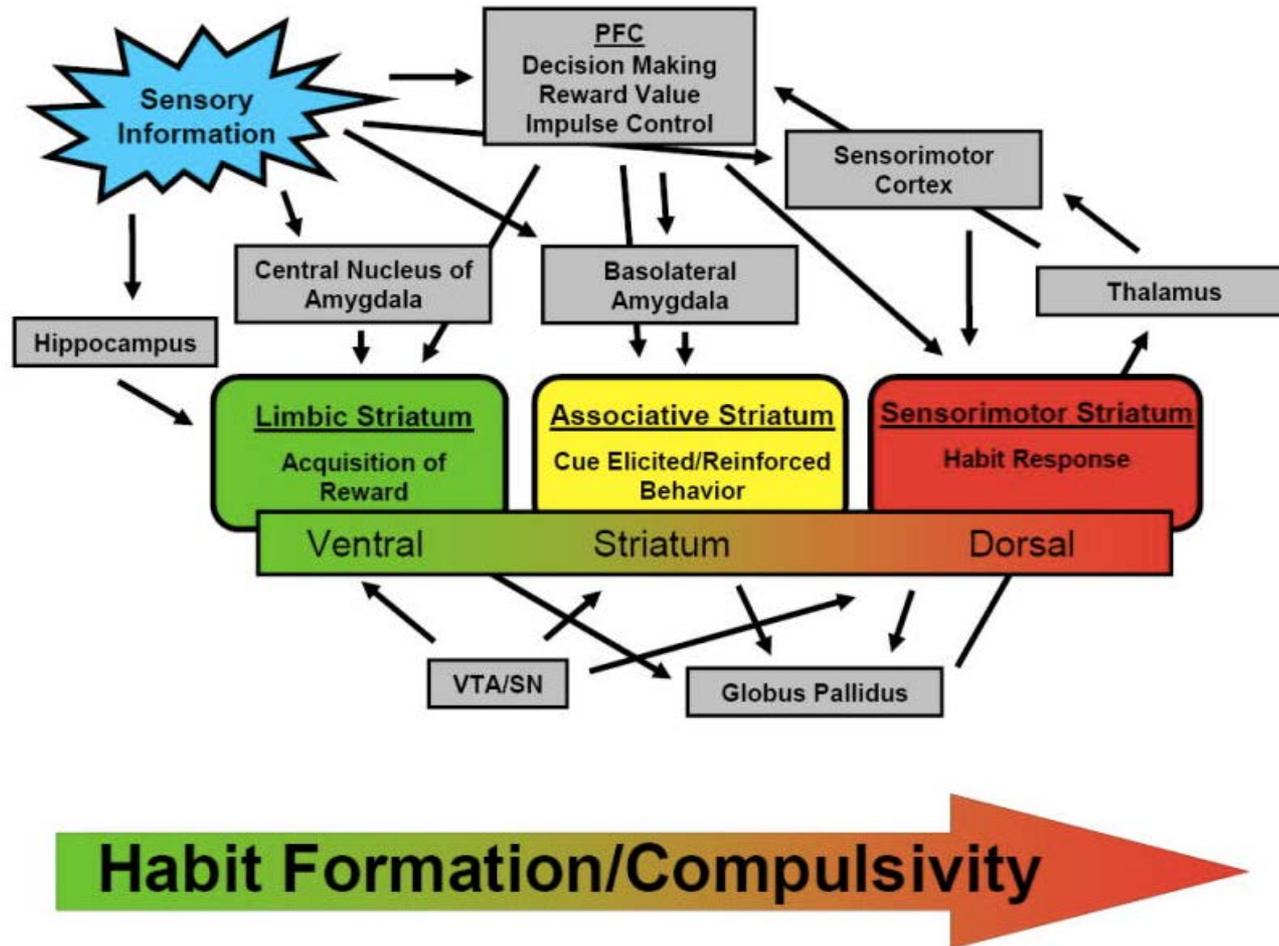
Since pruning makes the brain more efficient...

- ...the addict's brain learns to *efficiently* identify and aim behaviour toward habitual rewards
- I think it's exactly the same for gamblers
- So, addiction (including gambling) is a highly efficient mode of pursuing probable rewards
- This can help rebalance the “blunting” consequence of too much stimulation (reduced dopamine transmission)

Another big challenge for the disease model of addiction:

Behavioural addictions look very similar to substance addictions
in the brain and in “real life”

Figure 1

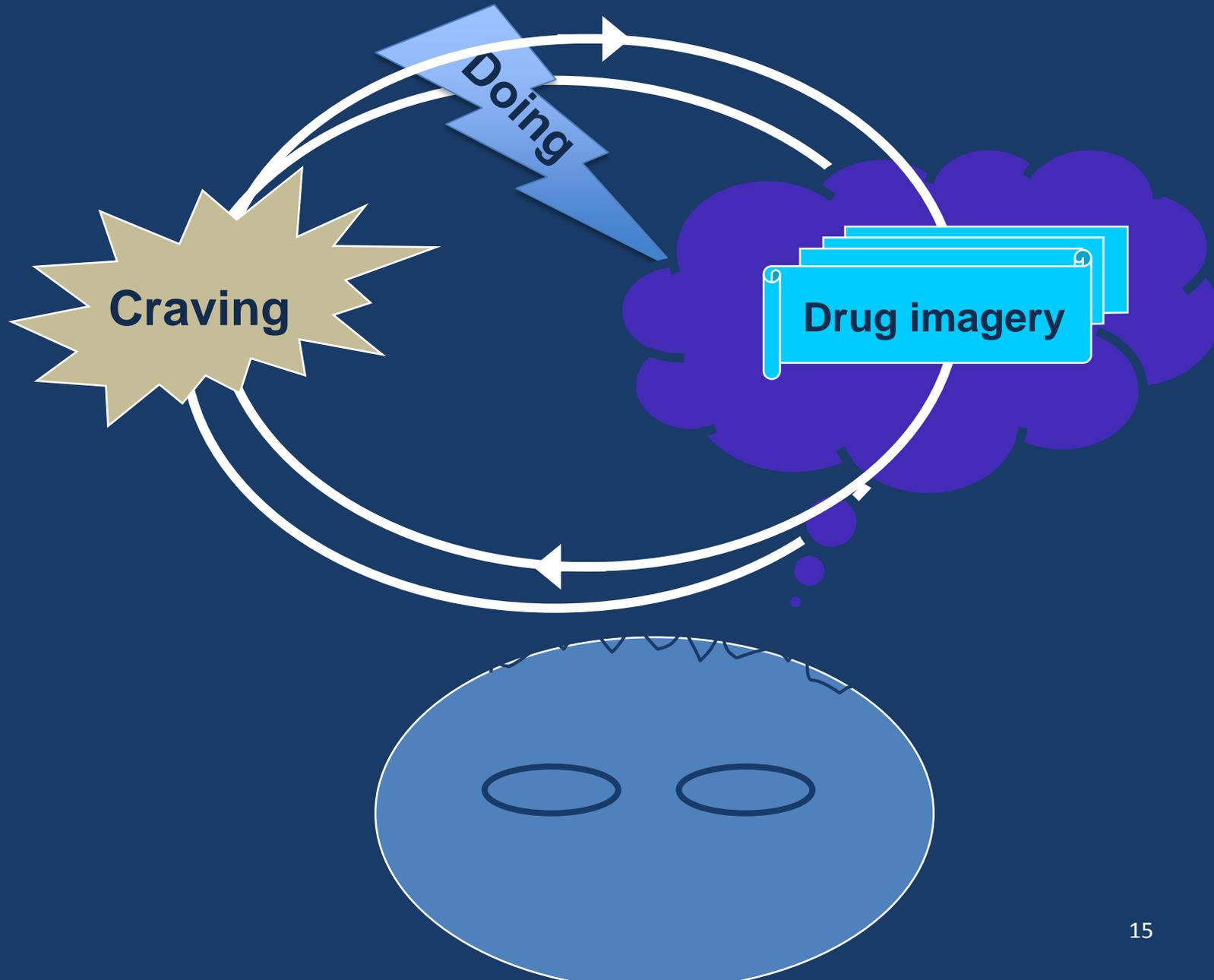


From Brewer & Potenza (2008). The neurobiology and genetics of impulse control disorders: Relationships to drug addictions, *Biochemical Pharmacology*, vol 75.

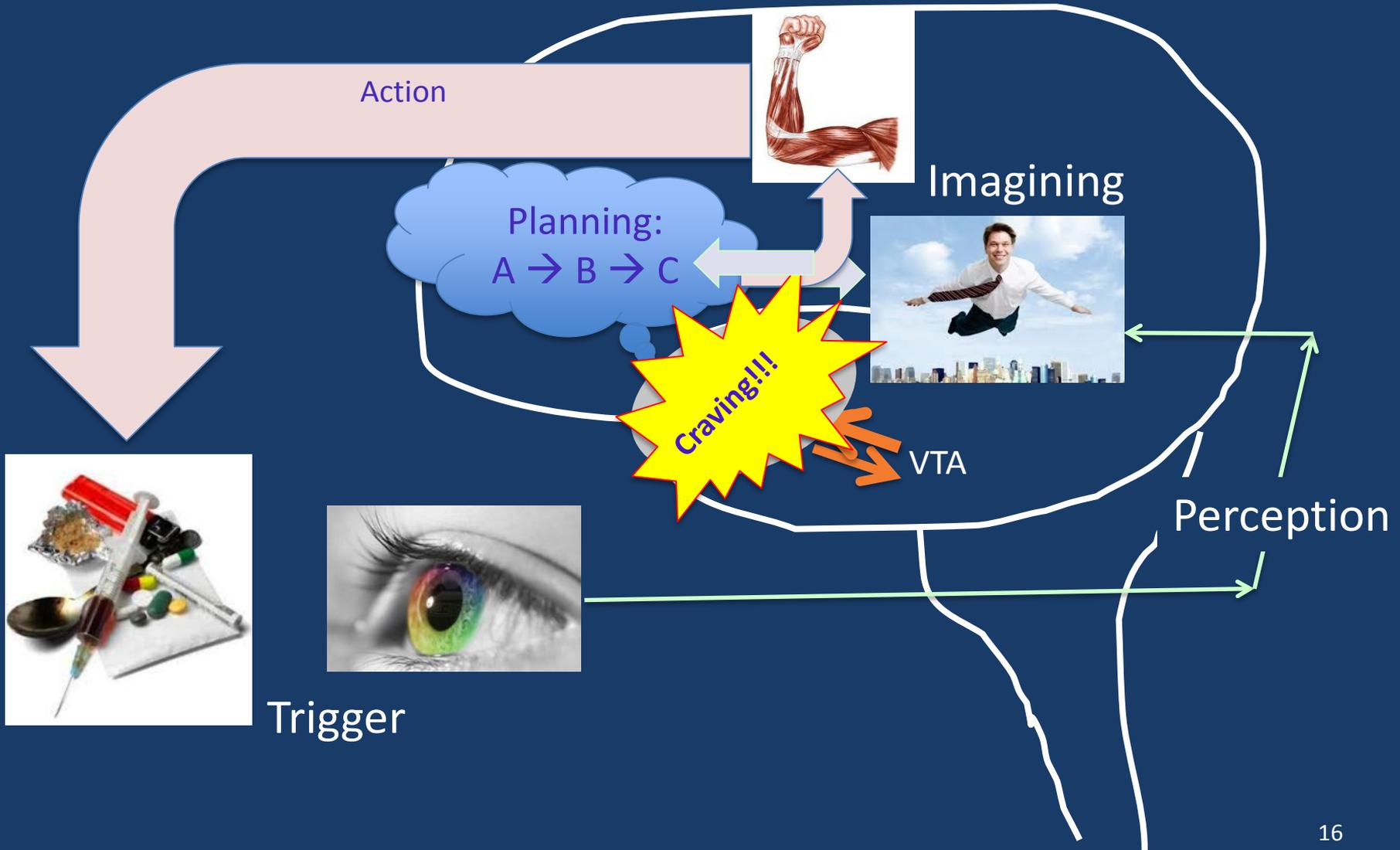
So why is it so hard to stop?

1. Strong attraction → repetition → deep learning
2. Getting trapped by “now appeal”
3. Ego fatigue: the loss of self-control
4. Addiction feeds into *personality development*

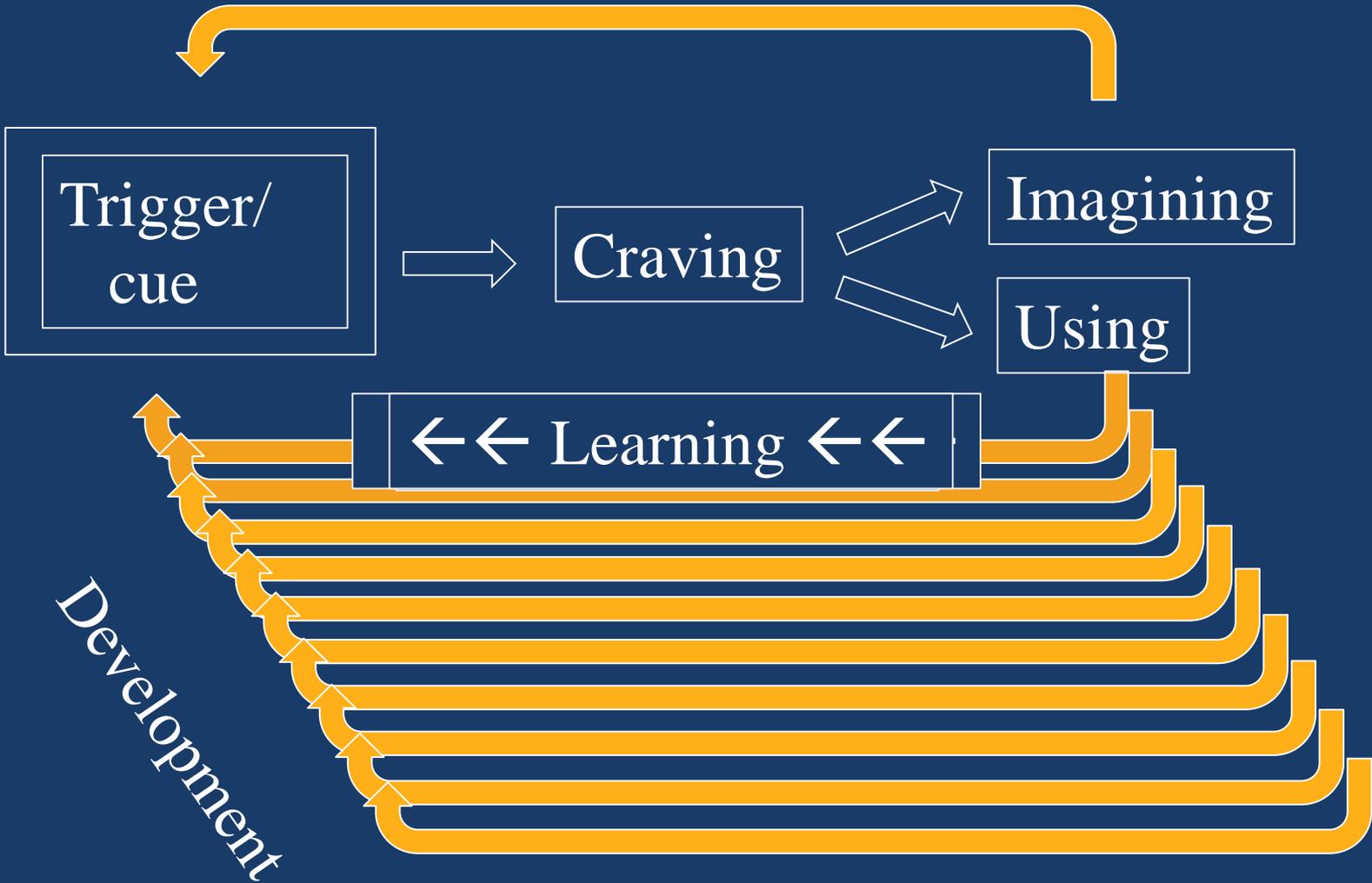
1. The classic feedback cycle in addiction



Cycle of brain activation



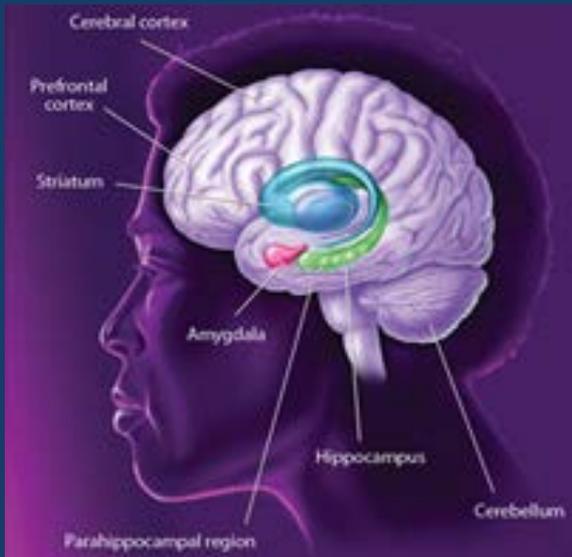
Intensification



Sensitization

2. Now Appeal

The circuitry of desire

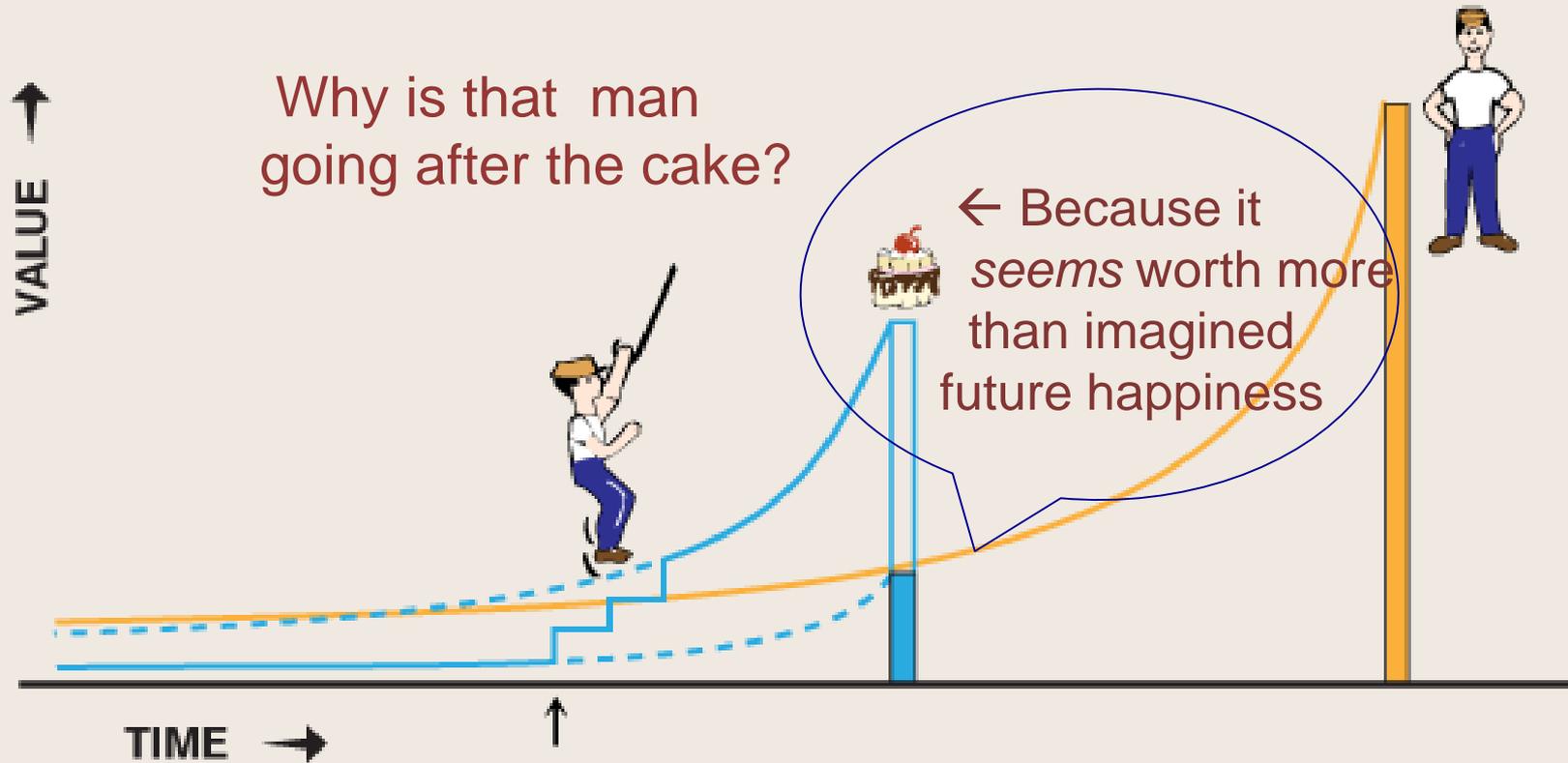


Dopamine focuses attention on the immediate goal....

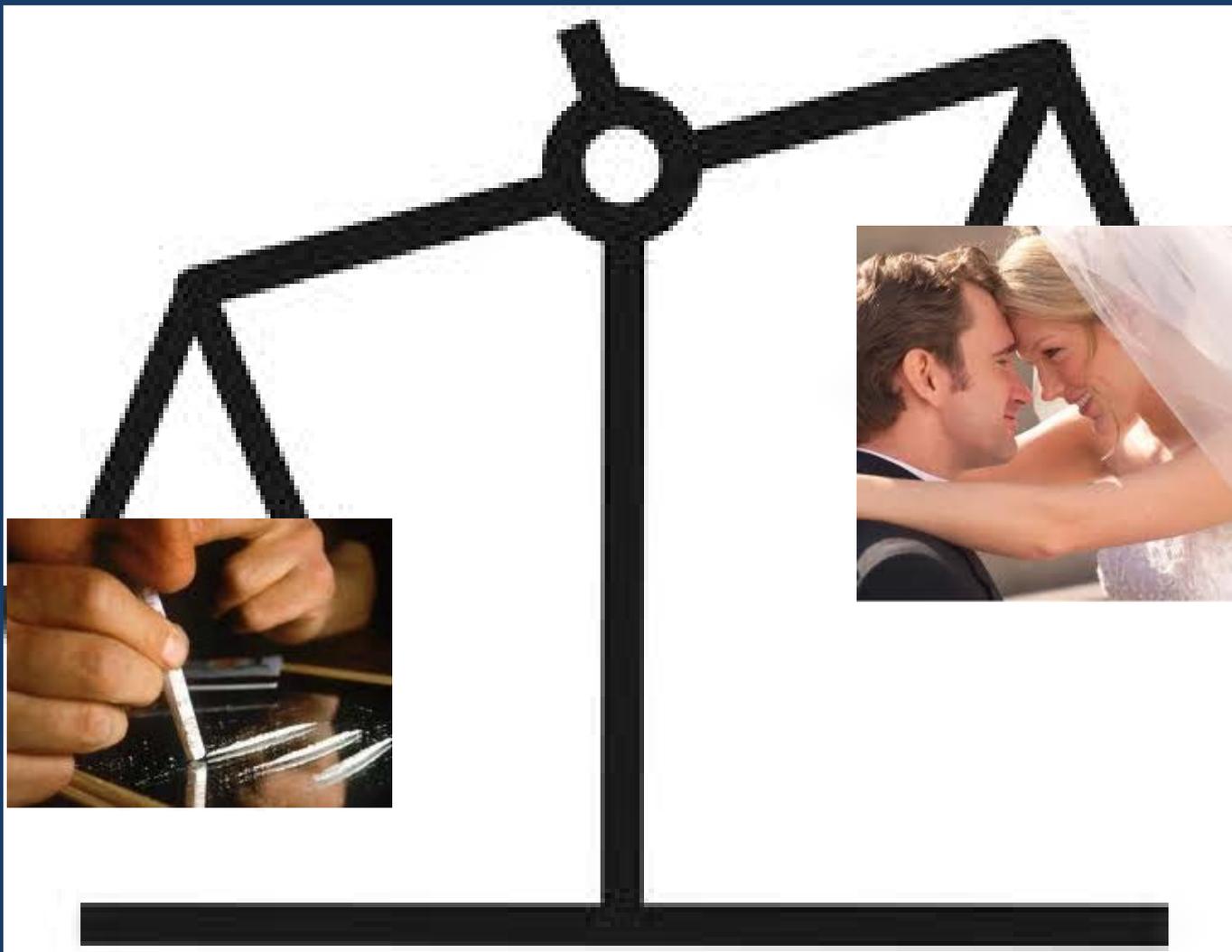
→ → **craving**



Craving → delay discounting = “now appeal”



...dopamine is *tuned* to the cake.

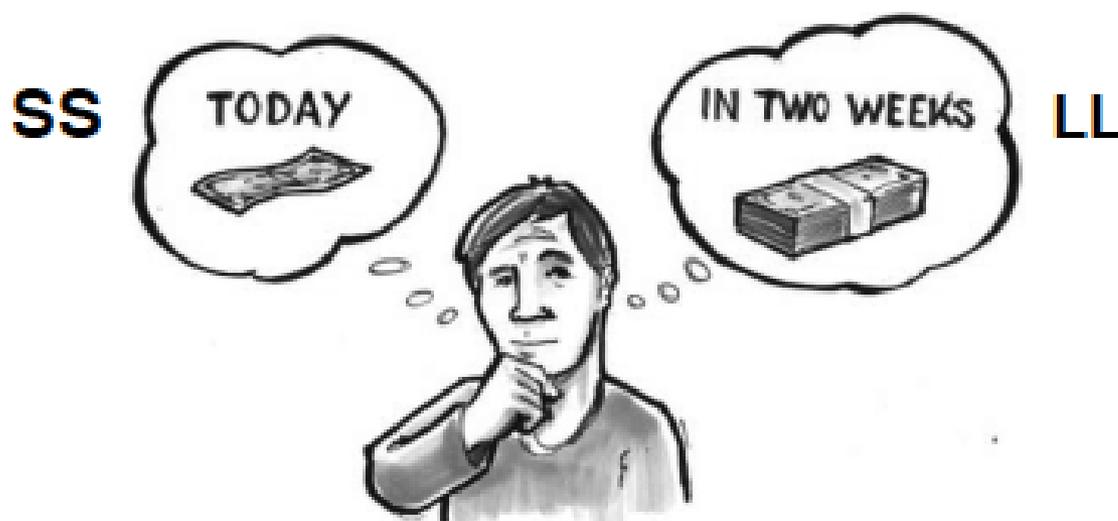


...outweighs the imagined future!

Money as intertemporal rewards

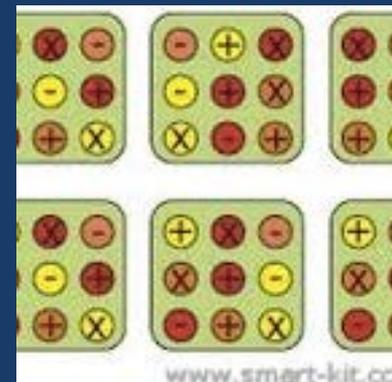
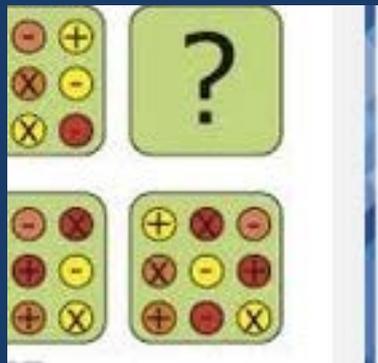
Marshmallow choices might not work equally well for all age groups...

- Choices between monetary outcomes
 - a smaller-sooner monetary reward (SS) versus
 - a larger-later monetary reward (LL)



3. Ego fatigue

Hungry?



Cues, cues, cues



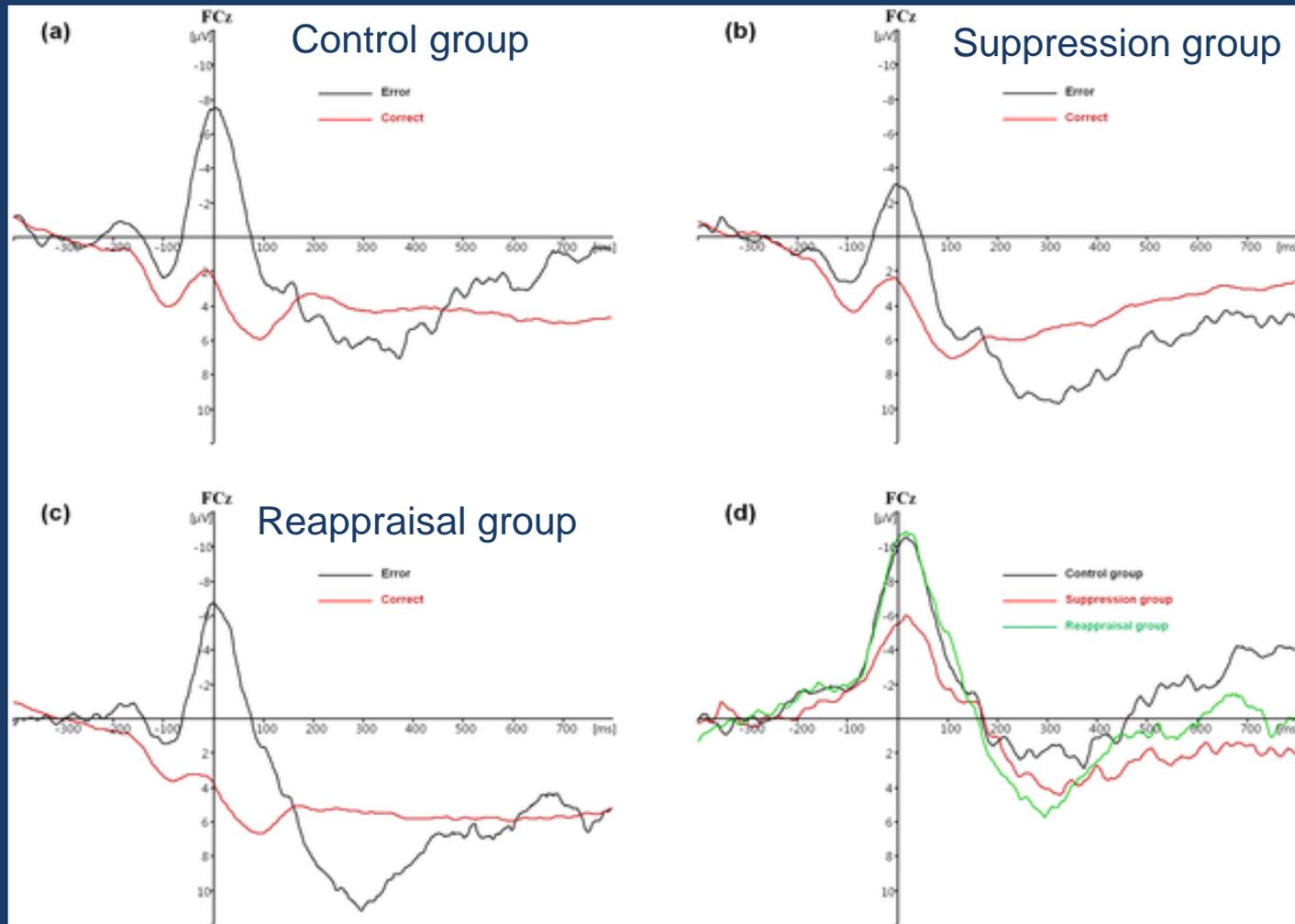
The War on Drugs...



Just say “no”?

- A study showing the value of “*just saying No*”
- Participants watch terribly sad movie clip
- Group 1 told suppress emotions and expressions
- Group 2 told to “think about the film objectively and analytically...”
- i.e., *reappraisal*

“...subjects in the emotion-suppression group exhibited reduced ERN amplitudes when making errors on the Stroop task.”



Wang Y, Yang L, Wang Y (2014) Suppression (but Not Reappraisal) Impairs Subsequent Error Detection: An ERP Study of Emotion Regulation's Resource-Depleting Effect. PLoS ONE 9(4).

Now, gambling is clearly a behavioural addiction...

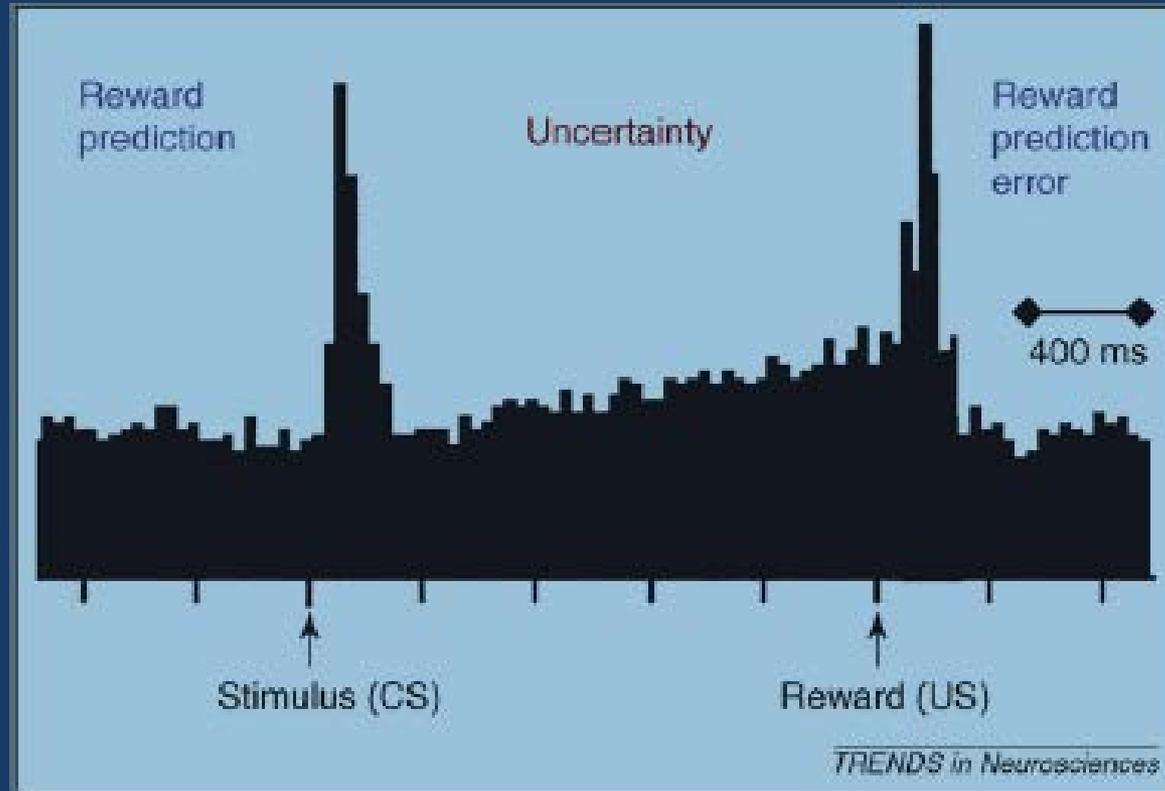
...but it may be particularly insidious

Here's why...

Dopamine has three jobs

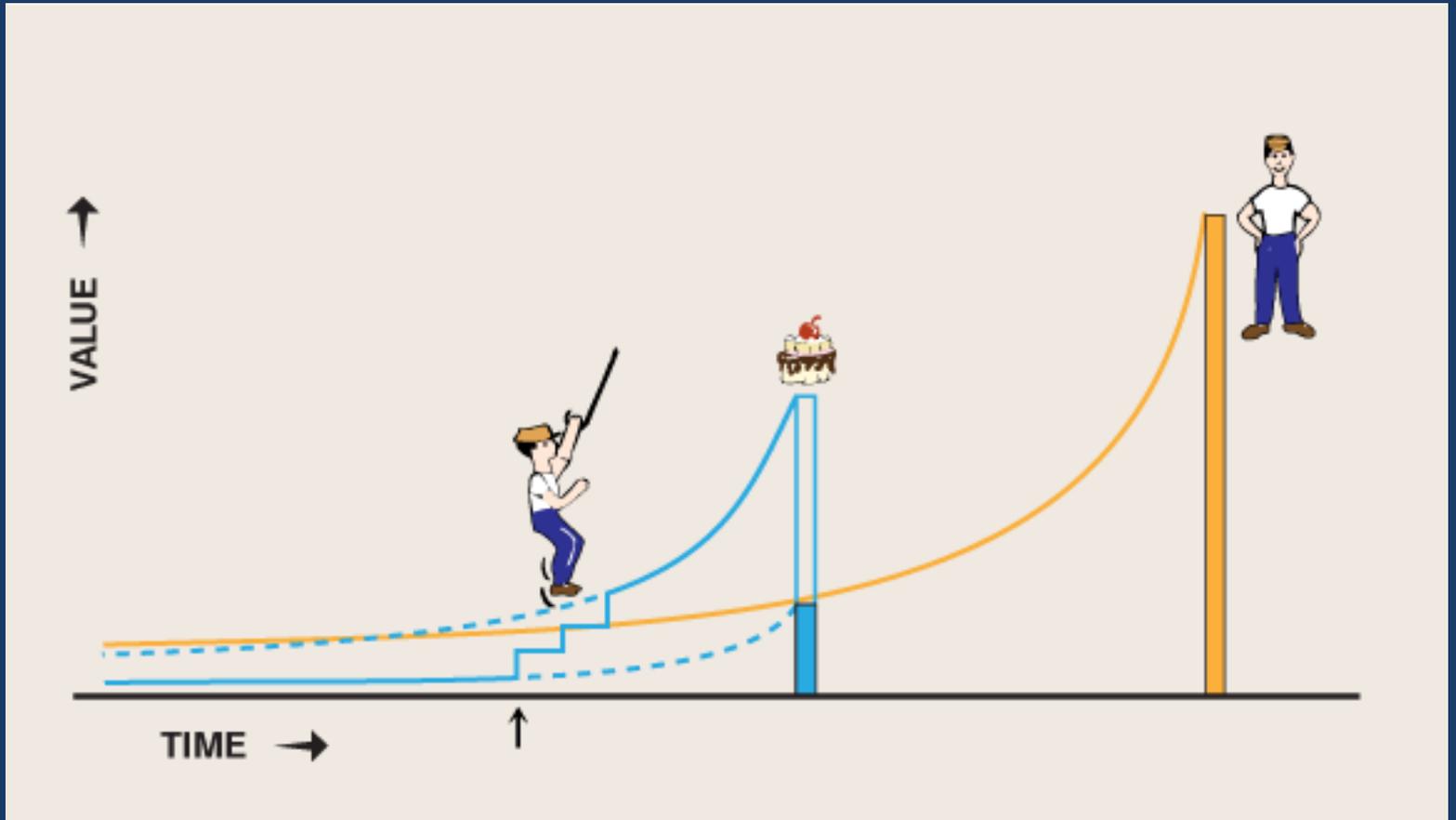
- Reward-predicting stimuli → dopamine rush
- Reward prediction error → dopamine tuning
- Reward uncertainty → ? → ?? → ??? → ????

The three faces of dopamine



From Schultz, 2007. *Trends in Neuroscience*.

Reward prediction -- *The rush: craving and “now appeal” are crucial drivers of gambling addiction*



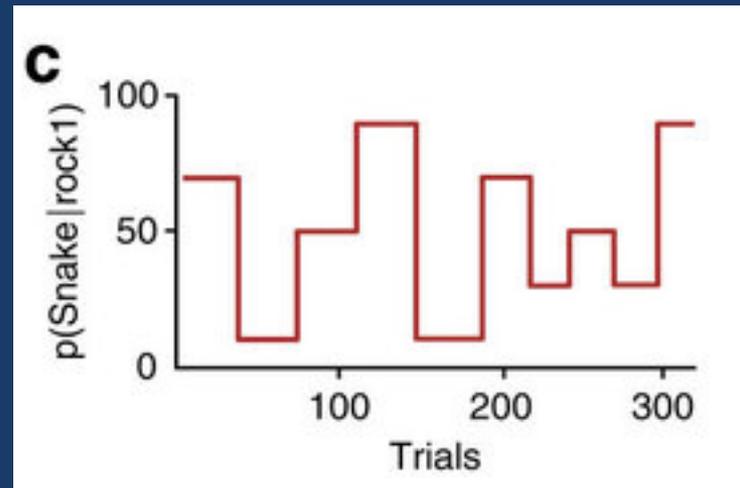
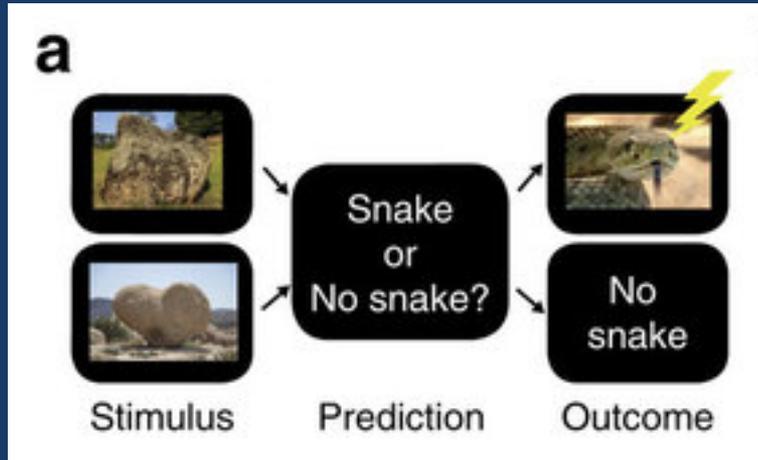
Motivation rises “hyperbolically”

But what about uncertainty?

- One of the main underlying factors to the phenomenon of loss-chasing may relate to the importance of reward uncertainty. Studies have shown that reward uncertainty rather than reward *per se*, will magnify mesolimbic DA, both in monkeys (Fiorillo et al., [2003](#); de Lafuente and Romo, [2011](#)) and healthy human participants (Preuschoff et al., [2006](#)). In PG, accumbens DA is maximal during a gambling task when the probability of winning and losing money is identical—a 50% chance for a two-outcome event representing maximal uncertainty (Linnet et al., [2012](#)).

Anselme et al., 2013. What motivates gambling behavior?
Insight into dopamine's role. *Frontiers in Behavioral Neuroscience*

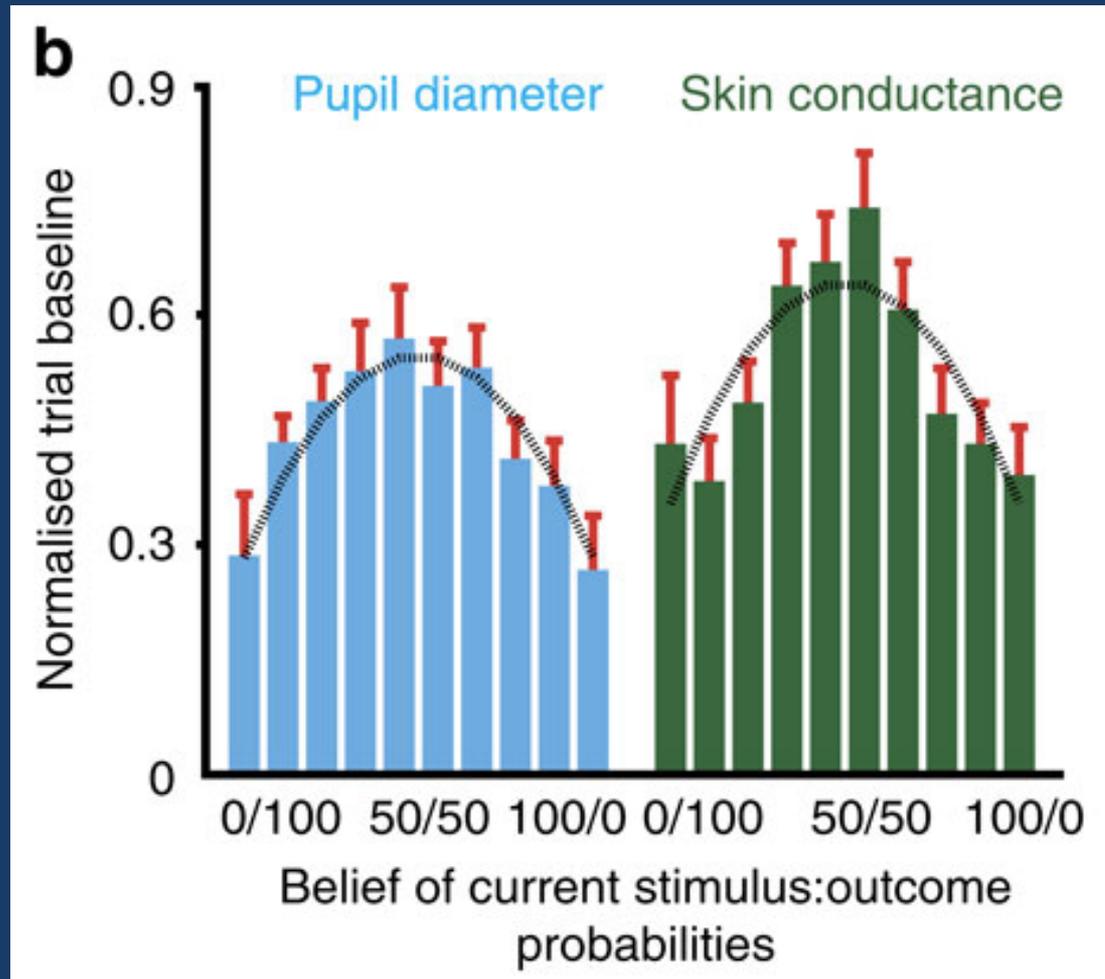
Snakes and shocks study



Designed to track “irreducible uncertainty”surrounding 50% level.

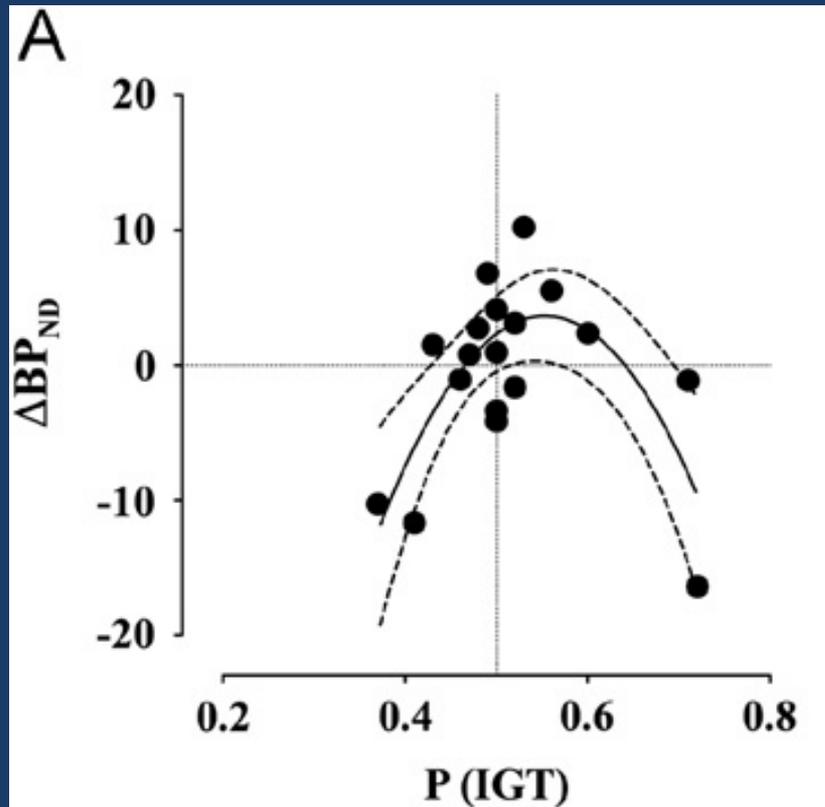
De Berker et al. (2015). *Nature Communications* 7.

Dopamine uptake (in the striatum) peaks with uncertainty



“Irreducible uncertainty best predicted subjective stress responses.”

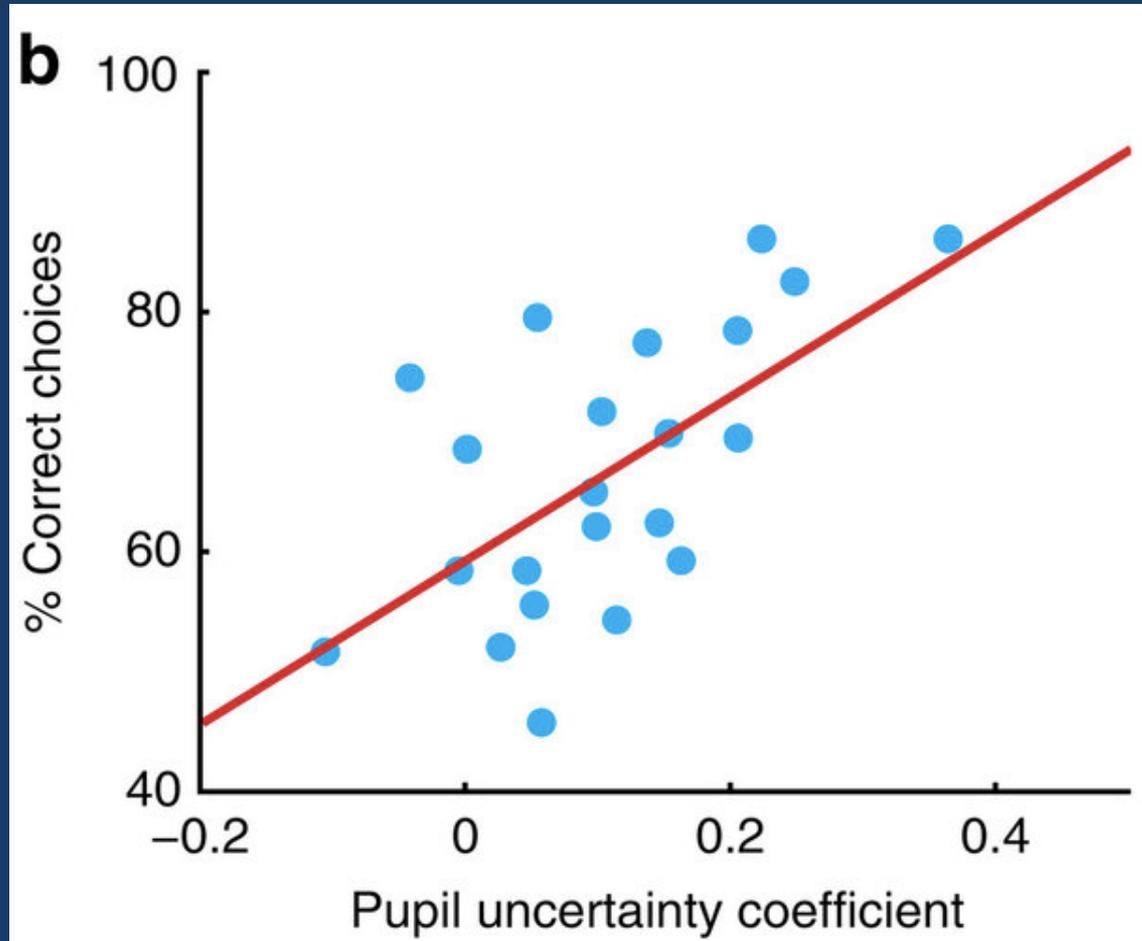
Iowa Gambling Task: variability and dopamine



“The pathological gambling (PG) group shows a significant ($p < 0.002$) quadratic Relationship between [dopamine uptake in striatum] and probability of selecting advantageous decks (P(IGT)). The healthy control group shows no significant quadratic interaction.”

Linnet et al. (2012) *Psychiatry Research: Neuroimaging*. 204, 55–60.

Does it help?



Snakes and shocks study. $r = 0.62$, $p = 0.0023$

Isn't the pursuit of uncertain rewards sort of noble?

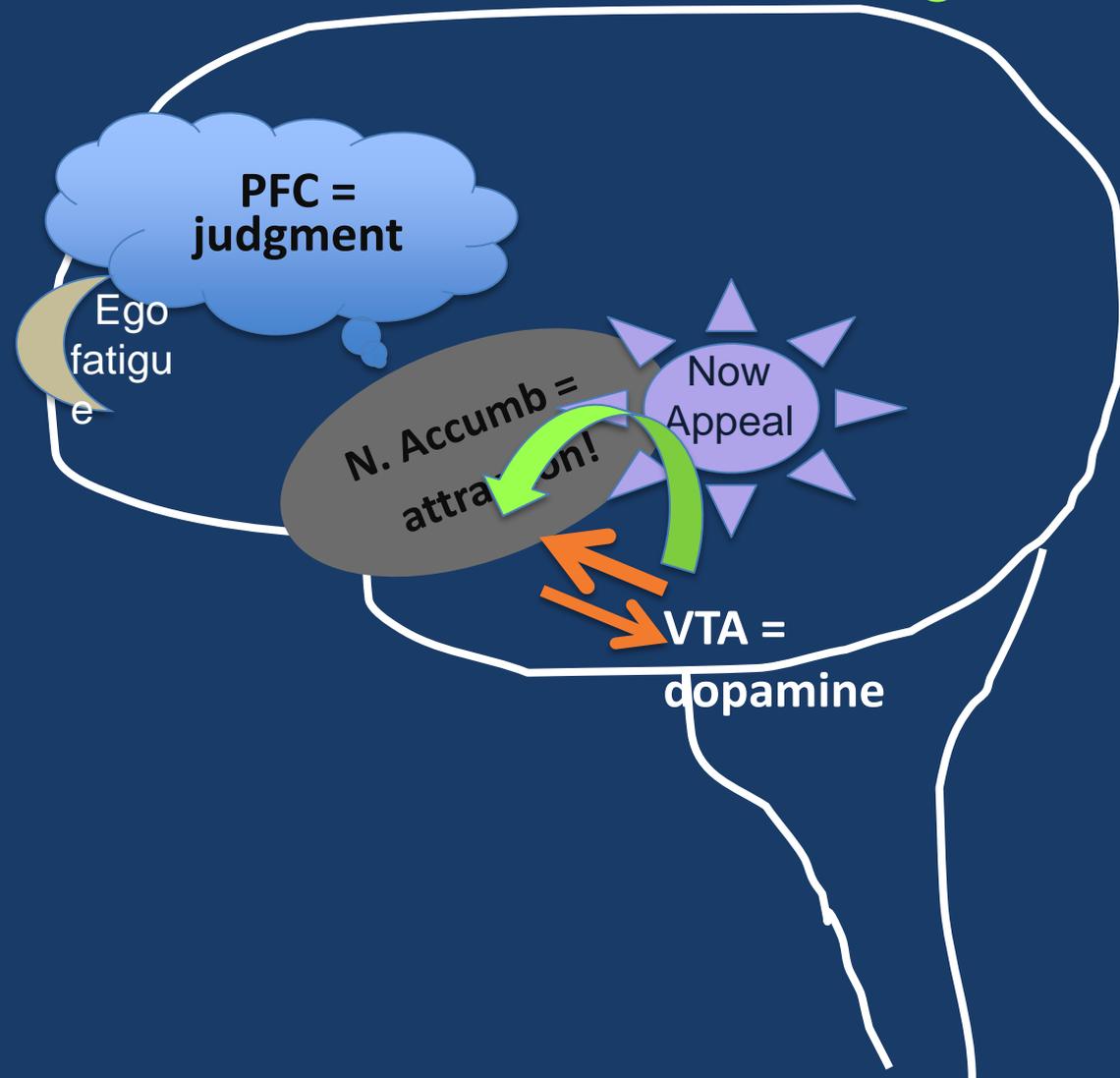
“Who was it said that coincidence was just God's way of remaining anonymous?”

“Who's to say that gamblers don't really understand it better than anyone else? Isn't everything worthwhile a gamble?”

Donna Tartt, *The Goldfinch*

In sum: brain change with addiction

and gambling



The disease model of addiction
isn't just wrong...

It's also harmful!

Why the disease model fails addicts

- The disease model calls for medical treatment
- “Medicalization” makes addicts into *patients*
- Patients don’t feel they have the *power* to change their goals
- Because they’re not formulating those goals
(somebody else is...)

So how do we help addicts feel empowered?

Which is a potent antidote to ego fatigue!

Utilize their desire for other goals

What happens when you give the wheel to your teenage kid?



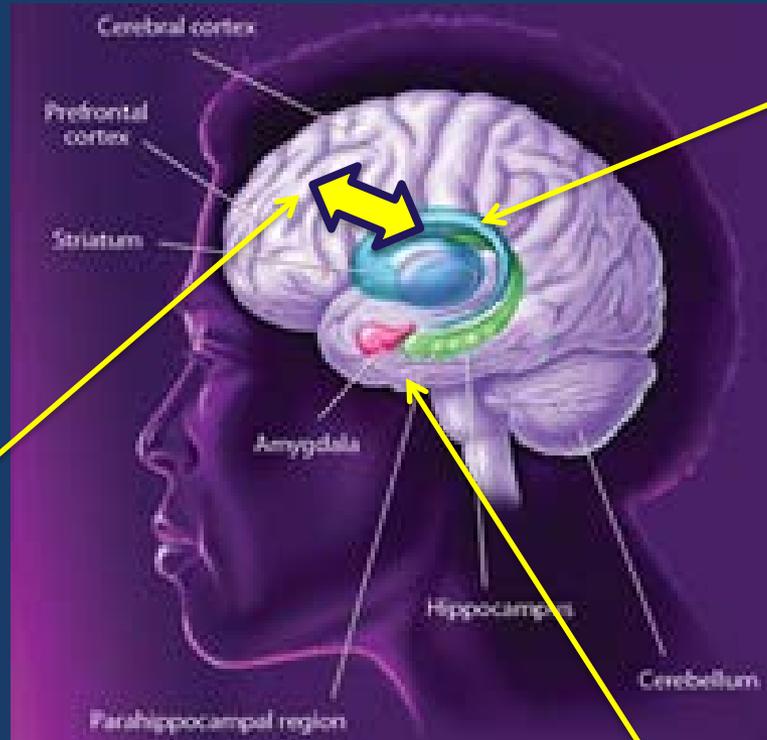
How do we help them envision a future?

Which is a potent antidote to now appeal!

Help them see their life as a narrative
...embedded in a past



Reconnect...



Striatum
The Motivational Engine

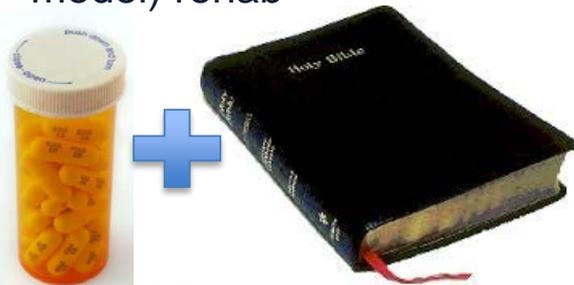
Dorsolateral
prefrontal cortex

The Bridge of the Ship

Midbrain: ventral
tegmental area (VTA)
Dopamine Pump

Treatment works by connecting empowerment to a sense of personal time

Conventional (disease model) rehab



Psychological tools:

- Cognitive behavioral therapy
- Dialectical behavior therapy
- Motivational interviewing
- Mindfulness/meditation
- Contingency management
- Compassion-focused therapy
- Social support/scaffolding



And for best results, link the *neurobiology* of addiction with the *experience* of addiction

