

# A NEUROBIOGRAPHY OF ADDICTION

Linking memoir and brain science to  
explain the inexplicable

*Marc D. Lewis*

Public lecture given at the main auditorium of  
The Centre for Addiction and Mental Health  
(250 College Street, Toronto)  
On March 27, 2012  
Slated be aired on *Big Ideas* (TVO), May 26-27th, 2012

## Addiction is very hard to understand

It's inexplicable that people keep taking things intended to make  
them feel better that *consistently* make them feel worse...  
...and that they can't seem to stop!

- But how should we talk about it?
- How should we feel about it?
- How can we come to understand it?

Neuroscience has a lot to offer the study of addiction.

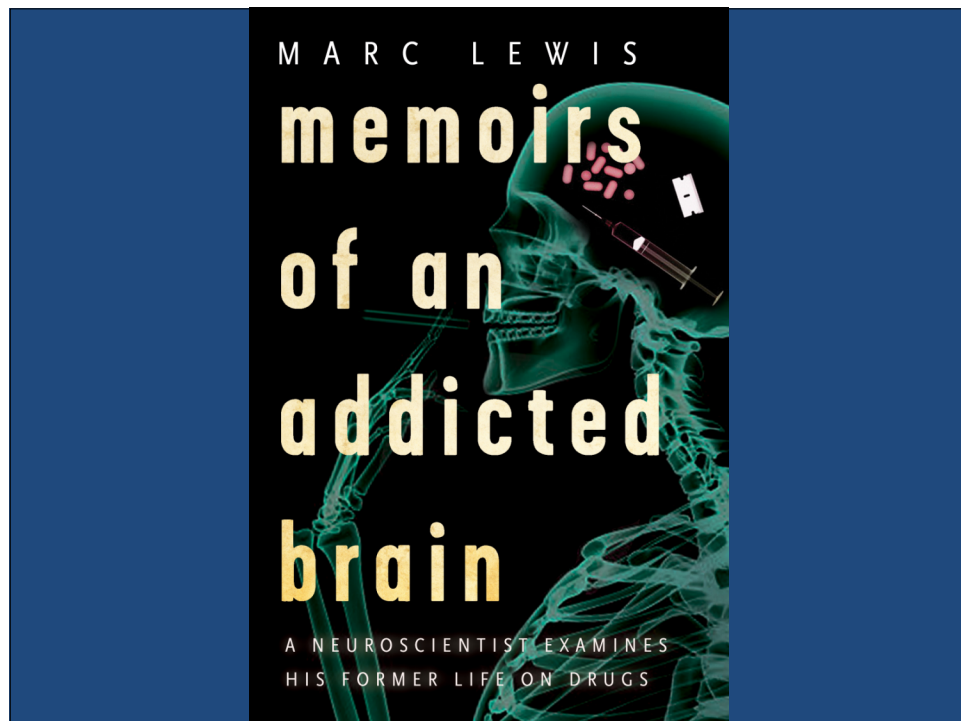
But neuroscience needs to make contact with subjective experience, in order to make its fullest contribution.

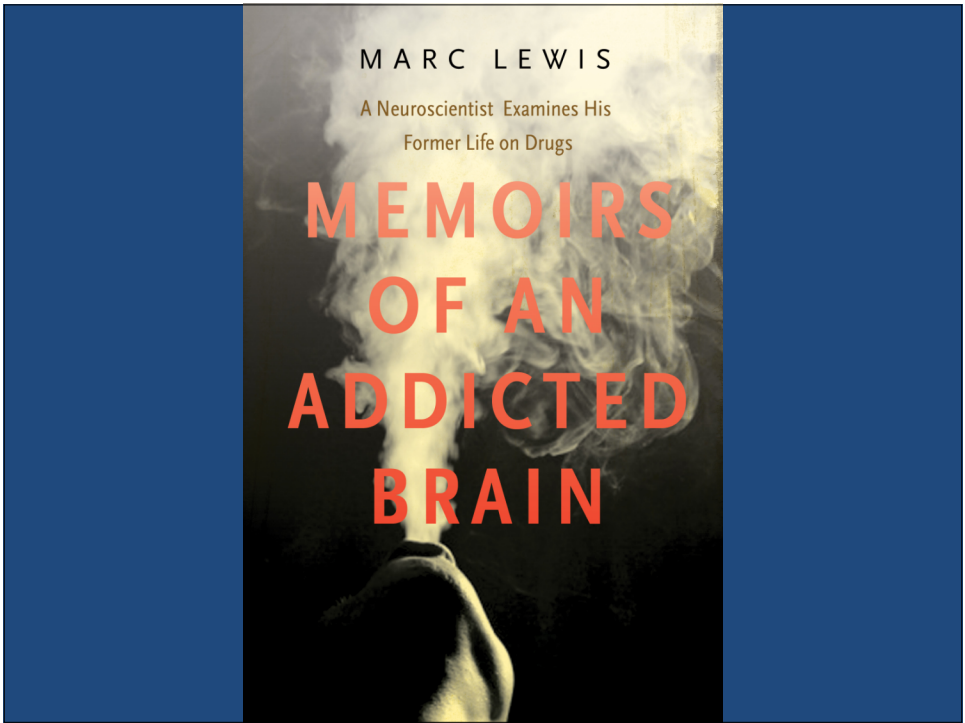
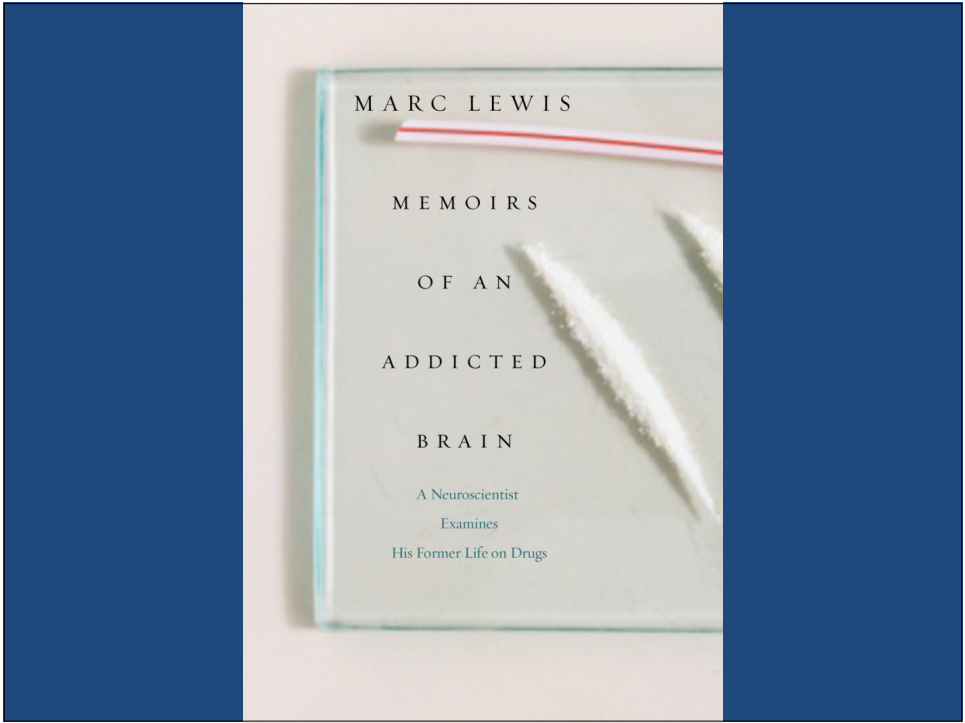
## Interview of Charles Fernyhough by Jonah Lehrer

- I'm trying to say something about how we as a species consume the science, rather than about the science itself. Neuroscientific research will stand or fall on the age-old criteria of testability, replicability, methodological rigour, conceptual coherence, and so on. With this project, I'm more interested in what the person in the street takes from the science.
- I think it's true that fiction ... can reveal nuances that we could never get a handle on in the lab. One of the frustrations of doing cognitive science is that you are constantly having to factor out messy human complexities so that you can get meaningful findings.

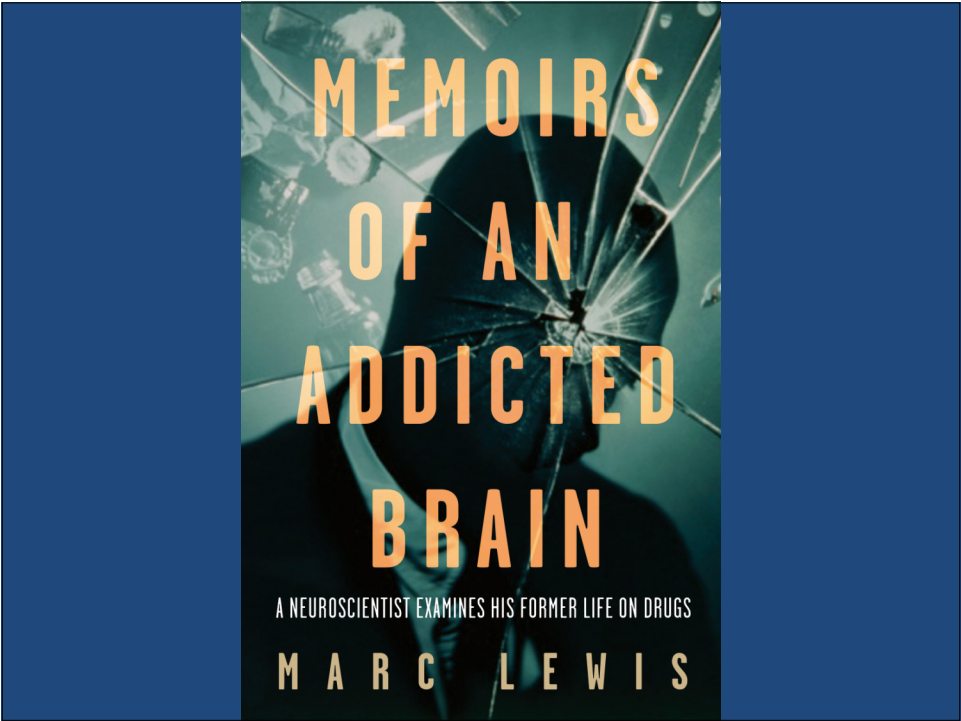
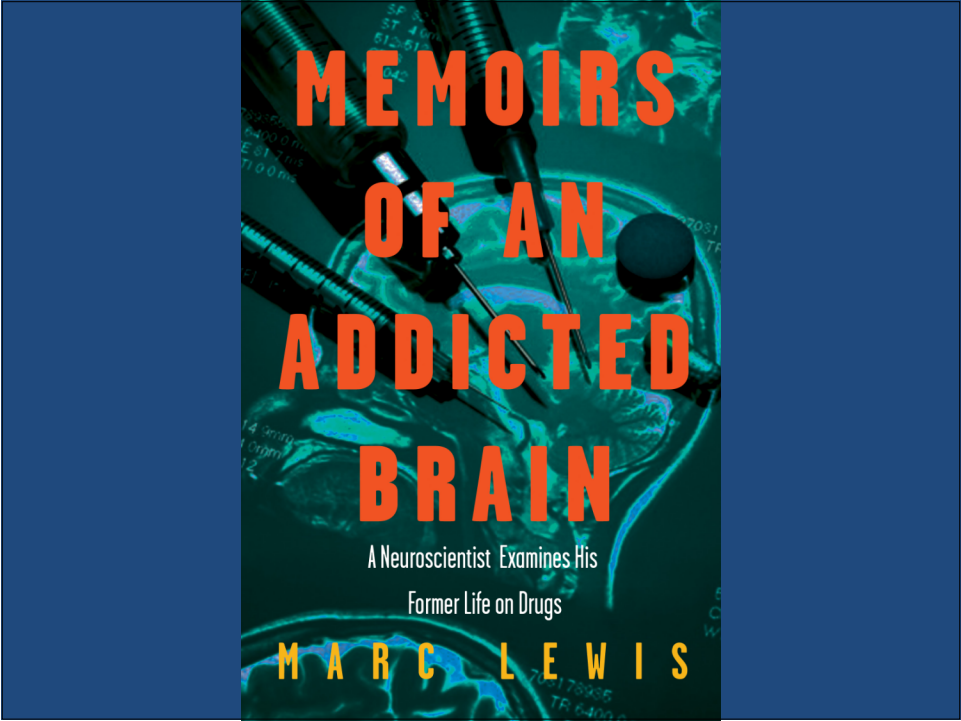
Following are attempts by artists at Random House Canada to come up with a suitable cover!

- I include these for comic relief, and because they help show what a mind-bending synthesis this proved to be, and not only for me!
- In other words, the book seemed to be in a category of its own





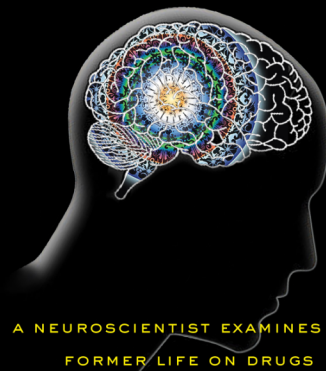




We finally came up with this...

In Canada....

*Memoirs of an*  
**ADDICTED  
BRAIN**

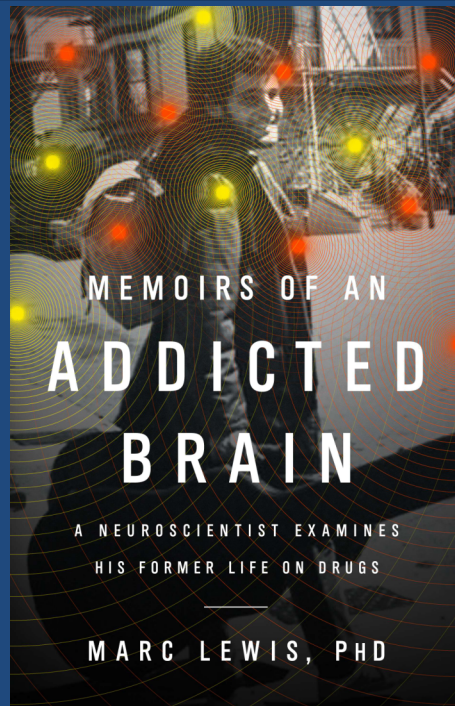


A NEUROSCIENTIST EXAMINES HIS  
FORMER LIFE ON DRUGS

MARC LEWIS, PhD

In the USA....

(published by  
*PublicAffairs*,  
a division of  
*Perseus Books*)



### First excerpt read aloud:

What's a brain to do when its blanket of serotonin is suddenly pulled away, and the impossibly bracing wind of raw sensation bathes its every surface? That brain finds itself attending to everything. Not just what's important, or novel, or meaningful, or expectable, but the tiniest fragments of thought and perception. It is now filled to bursting with images, with information inflow, with detailed inscriptions of a world that was never perceived before. A world that might never have been perceived with the dark glasses of serotonin firmly in place, protecting its tender pathways.

My brain is reeling without control, without a clue as to how to proceed. I am both preoccupied and overwhelmed with each mushrooming nuance of awareness, propelled without direction by visual displays both frightening and beautiful, by a blizzard of wayward thoughts, and by the unexpected force of my emotions.

I stand up, swaying, and make for the door.

"Where are you going?" asks Thomas, alarmed.

"Don't know. For a walk. Need air." He stares at me for a moment—rising up, swelling—before I bolt out the door and down the stairs, panicked by now, into a foyer that looks twisted and fake, like a cheap prop, but with walls that pour brilliant yellow light into my retinas.

## Definitions of addiction

- Disease model
- Choice model
- Genetic disorder, which gets triggered by life events
- Traumatic life events, which require self-medicating
  
- *None of these models is fully adequate*
- *These models tend to clash...they are not compatible*
- *None of these models fit very well with **my experience** of being an addict.*

## These models...

- ...derive from:
  - Psychology
  - Psychiatry
  - Genetics
  - Prevention science
  - Intervention science
  - Sociological perspectives

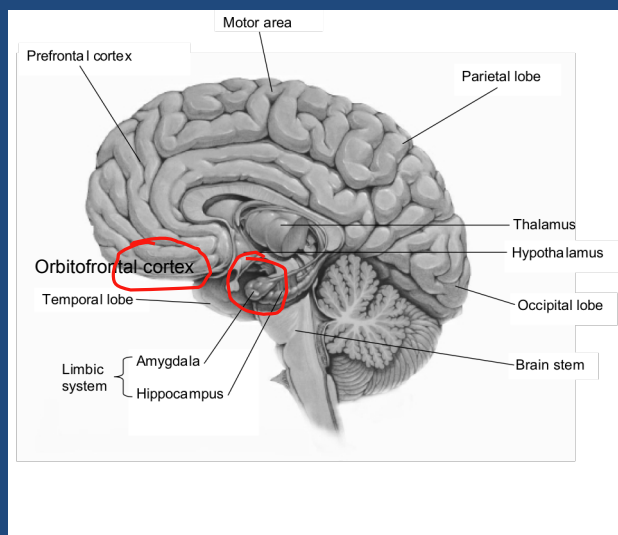
But the explosion of neuroscience research pushes us toward new models -- new definitions.

Integrating neuroscience with subjective experience may be a “road test” for how well these models work!

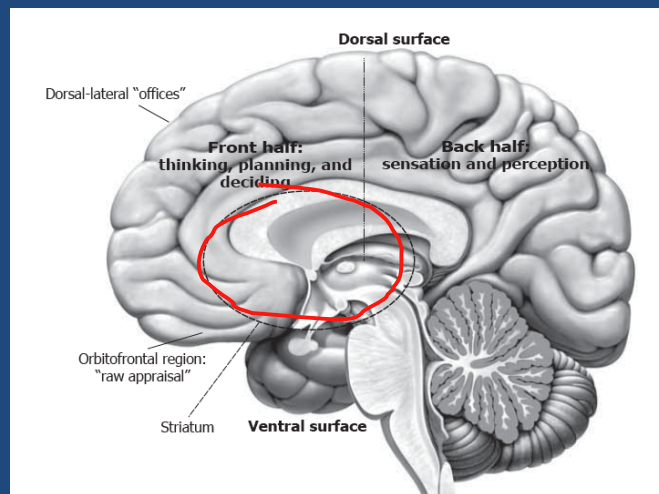
## A condensed autobiography

15-17 years	Anxiety and depression at boarding school; experimented with alcohol, dextromethorphan cough medicine, pot
17-18 years	Arrived at Berkeley: introduction to psychedelics (LSD, mescaline, etc.), loneliness, violence, police
18-19 years	First experiences with heroin, a “red badge of courage”
19-20 years	Lived in Malaysia, traveled throughout Asia, taking methamphetamine, heroin and then opium
21-25 years	Lived in Berkeley: sporadic use of heroin and cocaine
26-28 years	Bad first marriage, began graduate school in psychology; began stealing to obtain drugs; <i>personality disorder</i>
28 years	Arrested, convicted, kicked out of graduate school
28-30 years	Continued thefts, sporadic severe depression, dissociation and self-destructive acts, repeated attempts to quit
30-31 years	Quit for good

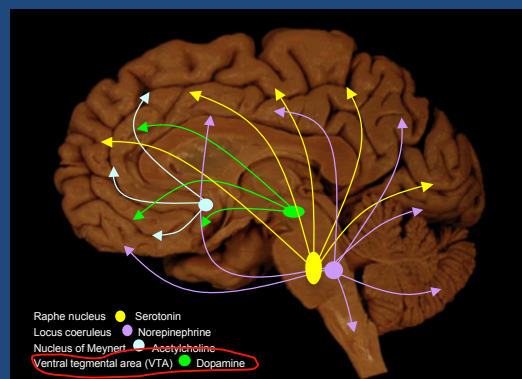
## Key regions in emotion and interpretation



## The *ventral striatum* and goal pursuit



## Neuromodulator release to multiple regions



### *My model -- Part 1.*

Addiction happens gradually...  
(it is a developmental process)

### Addiction as accelerated learning

- All learning modifies cortical synapses
- All learning is driven by emotions
- Emotions such as **Desire**
- Desire is mediated by **dopamine** release in the ventral striatum
- Dopamine powers goal-seeking (in the v. striatum) and fuels synaptic connections in the OFC (and other regions)
- And those synaptic connections release more dopamine...whenever cues (associations) to the drug or drink are perceived or remembered

- Addiction is “corrupted” learning, energized by excessive dopamine, repeatedly, in response to an ever-narrowing range of cues

Craving  $\longleftrightarrow$  synaptic growth

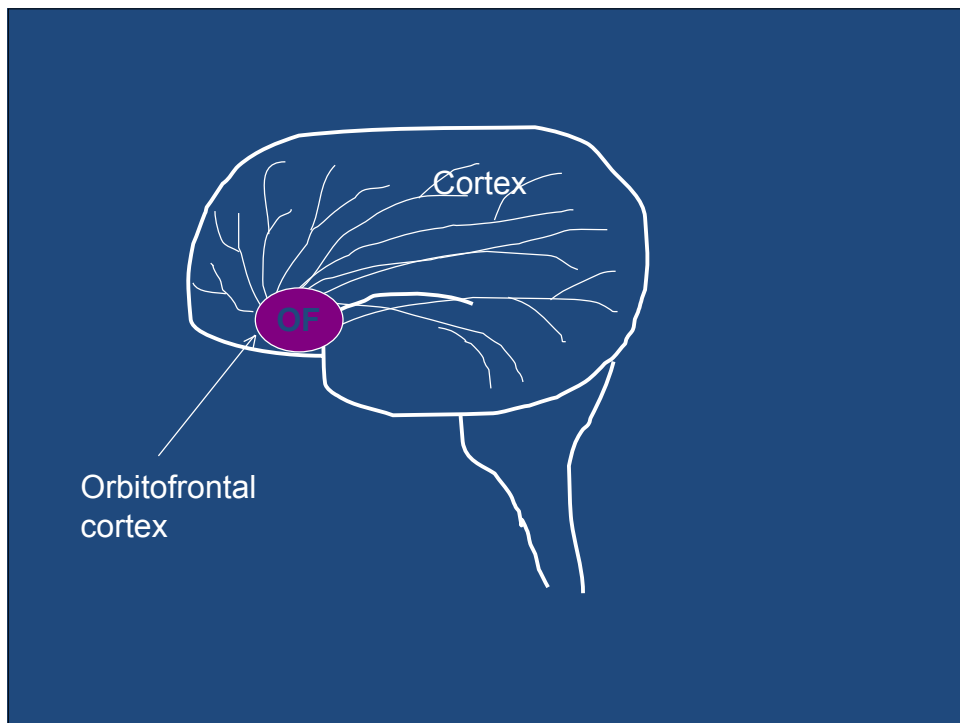
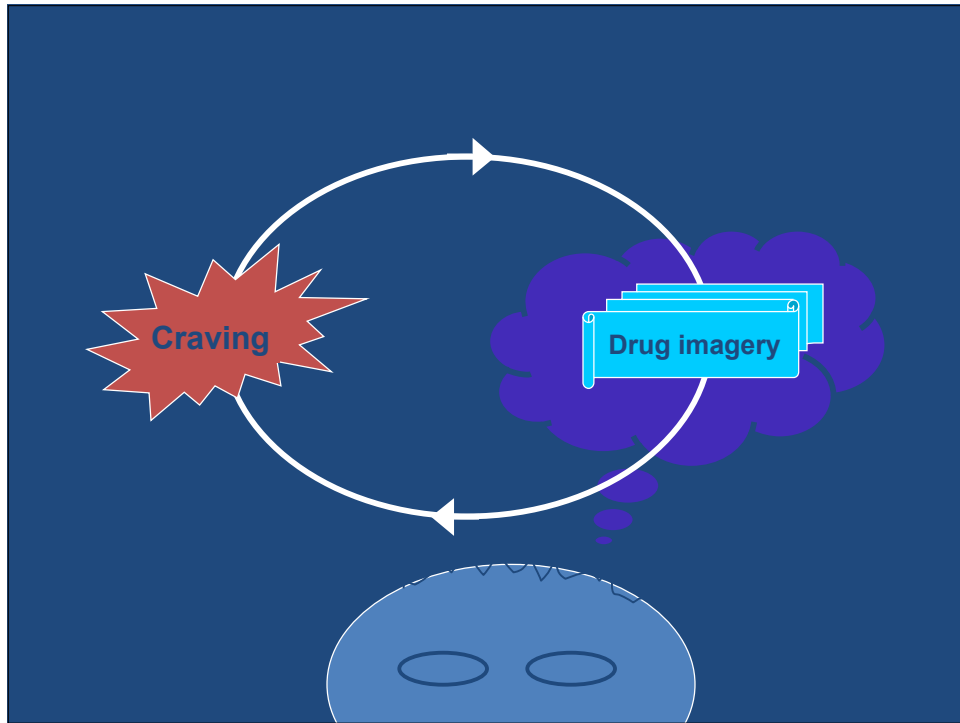


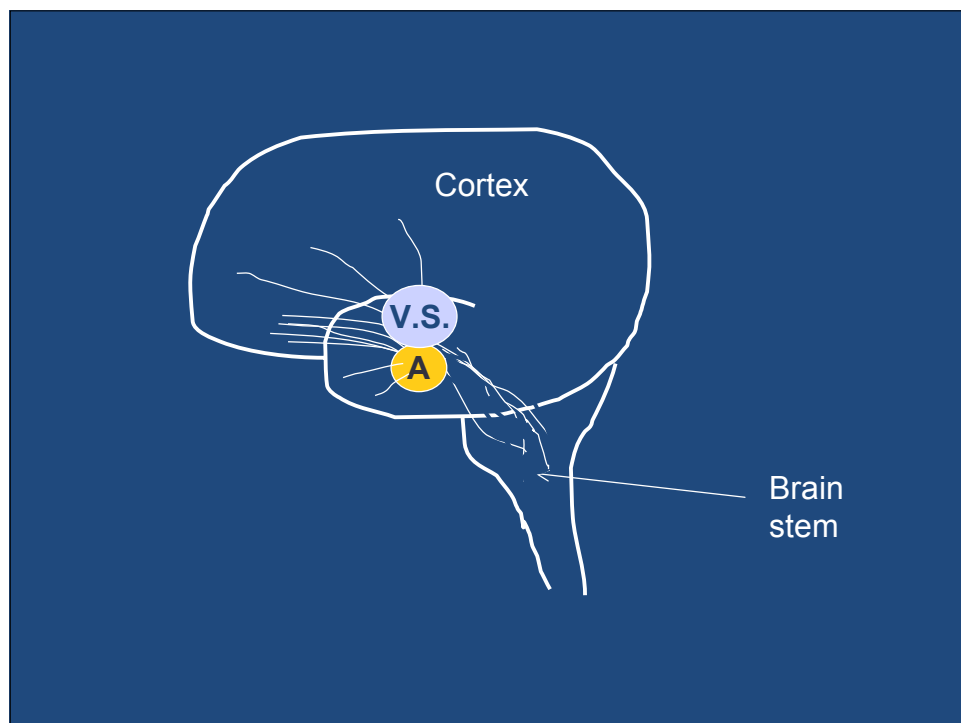
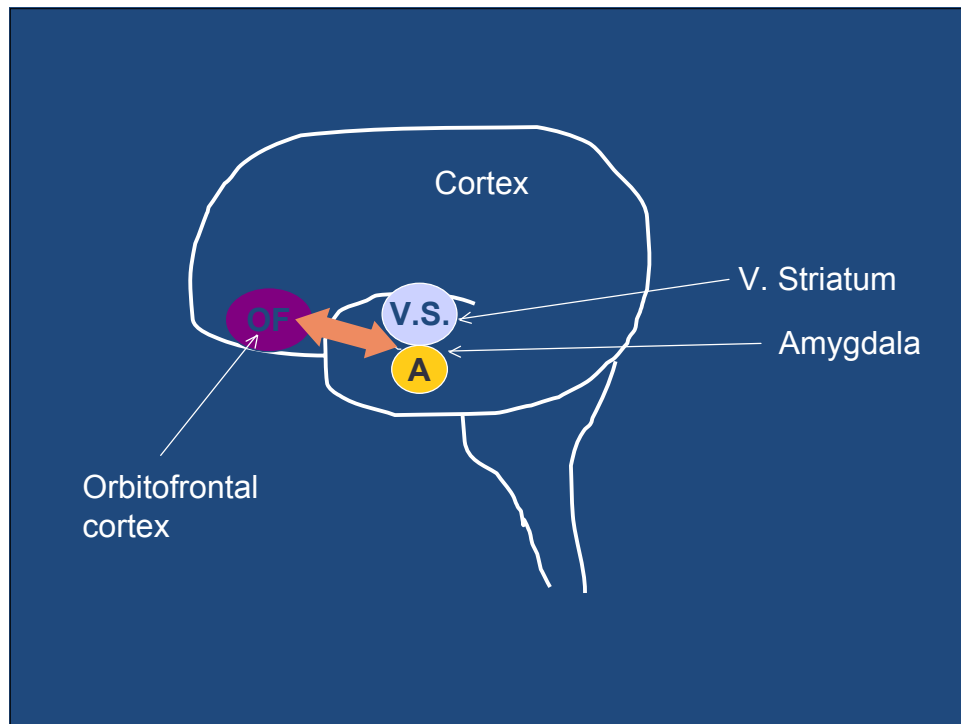
**Increasing proliferation of drug-oriented synaptic networks**  
**Pruning (weakening) of *alternative* goal-oriented networks**

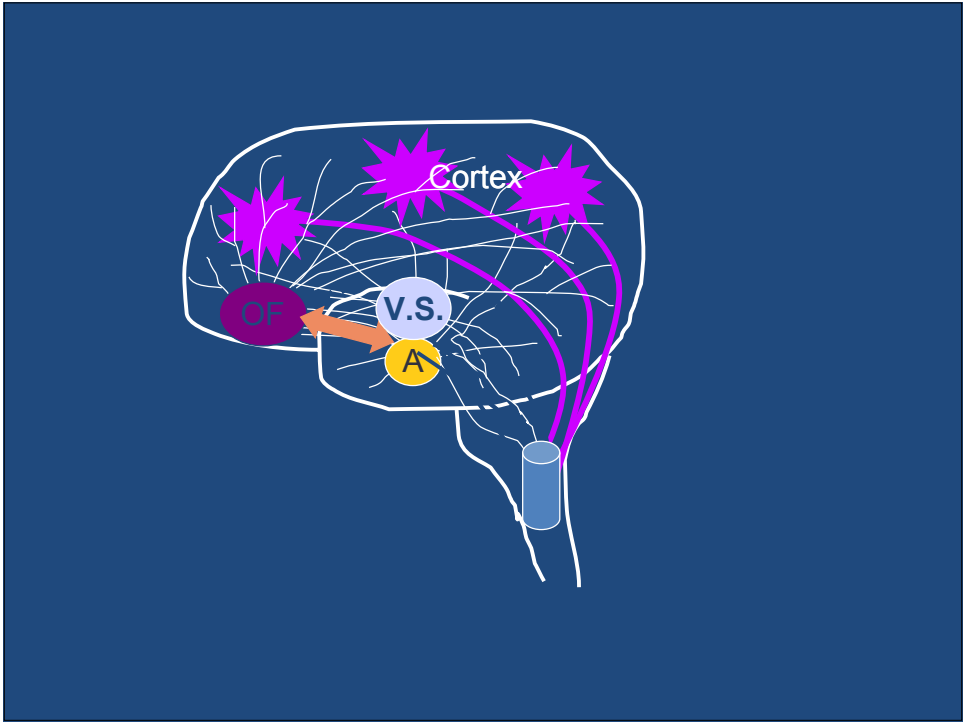
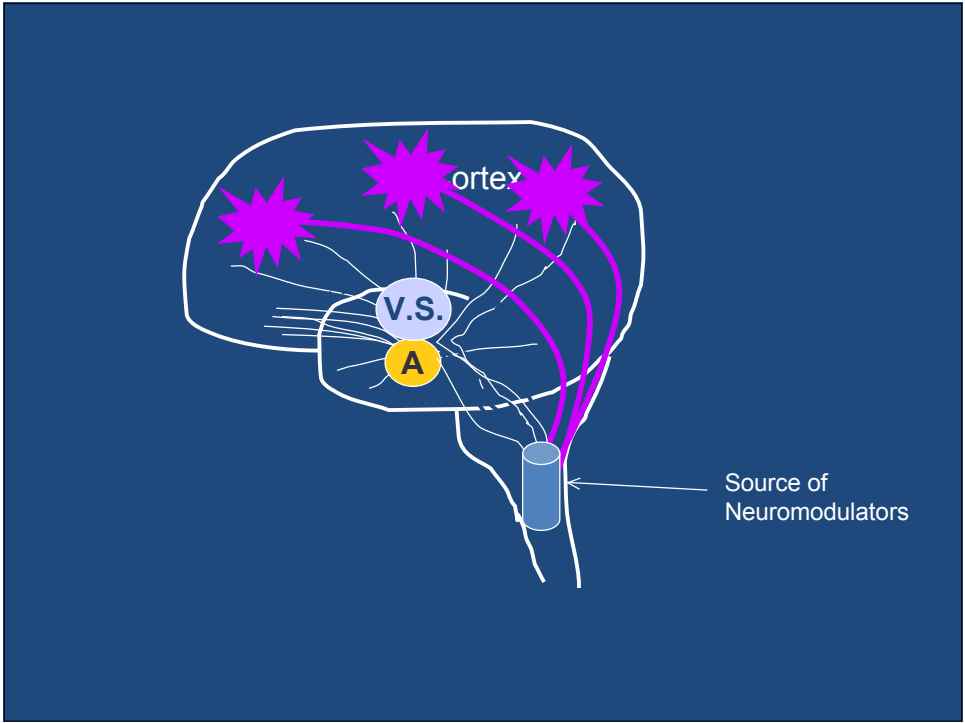
### Second excerpt read aloud:

- The brain changes with addiction. ... changes in dopamine flow, changes in sensitivity to dopamine, changes in other neuromodulators ....changes in the striatum, the amygdala, the hippocampus, and profound changes in the prefrontal cortex, the seat of appraisal, judgment, and consciousness itself. Changes in the brains of lab rats feasting on their daily supply of free narcotics. Changes in the brains of humans, imaged with fMRI or PET scans. Brains of heroin addicts, coke addicts, crack addicts, meth addicts. Who get thirty or forty dollars for their participation, a nice contribution to their day’s income, to help pay for the habit that brought them there. Brains of recovered addicts that still show a sharp spike in activity when pictures of paraphernalia are flashed on a screen. Some of these changes begin much sooner than was previously believed. ....
- We shouldn’t be surprised. Learning to play the piano or violin changes your brain permanently. For example, violin players show increased volume in the part of the motor cortex that controls the left hand. Driving a taxi changes your brain. A famous study using MRI imaging showed that the hippocampus of a typical London cab driver is quite a bit bigger than average. Memory, whether of city streets or positions on the neck of a violin, is the result of learning. And learning increases the number and strength of synapses connecting particular brain cells— .... Long-lasting synaptic alterations make the brain a habit-forming machine.









## *My model -- Part 2.*

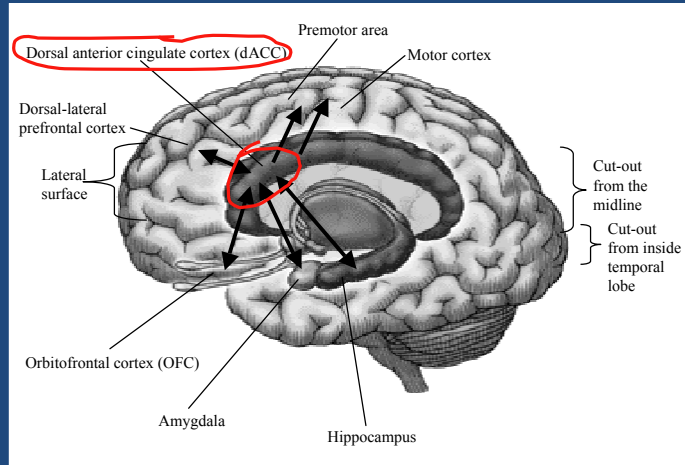
Why do addicts lose self-control, self-awareness, and judgment?

...all at the same time?!

When does the brain lose the capacity for inhibitory control?

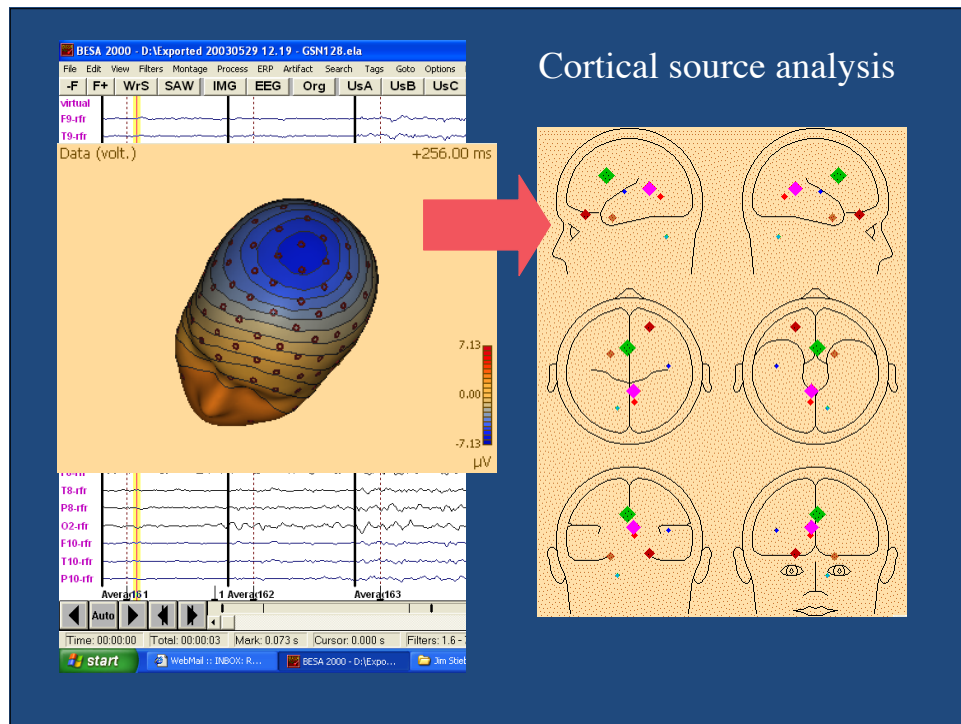
- Inhibitory control can get depleted with excessive demands
- “Ego fatigue” or “ego depletion”
- Ego fatigue is most likely when there is sustained on-line inhibition...

## Neural model

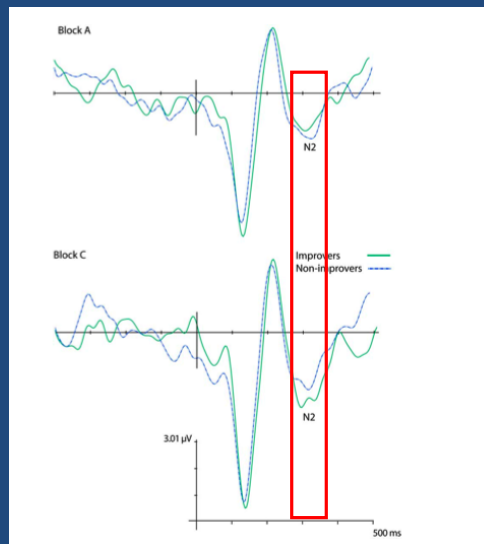


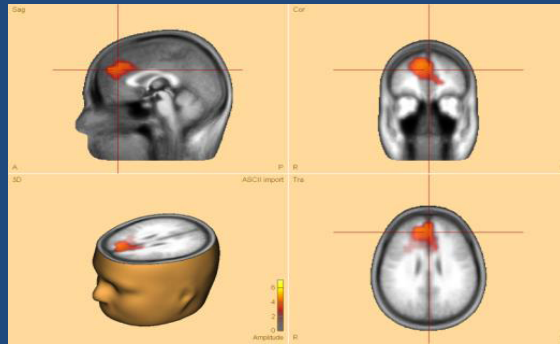
## Measuring brain activity with dense-array EEG nets





- The “inhibitory” N2 occurs when a stimulus requires effortful control, inhibition, or response selection
- Medial-frontal negativities reflect
  - response inhibition
  - self-monitoring
  - conflict-detection
  - selective attention





Reduced activation in the dACC...

...leaves you with a rudderless brain

### *My model -- Part 3.*

#### From loss of self-control to defiance

- To make loss of self-control feel okay, you have to change your goal from *inhibiting impulses* (a losing proposition) to *getting something*
- This might be easier to do if effort and anxiety are replaced by *defiance*....an attitude of F--K YOU!



### Third excerpt read aloud:

The loss of self-control has long been a trademark of addiction. Now scientists have identified the weak link in the neural chain that makes it so. Brains lose control. People lose control. It sounds like another mind-brain parallel. But ...there's a deeper lesson here: the rules of neural conduct, the physical limitations of brain matter itself, provide the cause. The breakdown of human functioning is the consequence. Once again we find that addiction arises from vulnerabilities in the nervous system. And by understanding the limitations of the dACC, we can see why addicts lose so much more than their sobriety. They lose the mental muscle tone for self-direction, for resolve, for strength of character, and for decency itself.

The dACC is smart. The dACC is wise. My dACC is capable of looking past the attractions of the moment and judging the big picture. It wants to—I want to—get home safely, with or without Sharon's blessing. My dACC is my captain, my director, my will. But it's listing, it's sinking, it's going down. Each time the impulse comes up, I can feel the knot slipping. ... After an hour and a half of suppressing my feelings, my control is now flaccid and flawed. ...I can't solve this puzzle anymore. It's too tough. My body arches slightly forward as I come back from the cages. I am eager. I am dropping from the stratosphere of the Young Psychologist, the man with the keys, to the swamplands of unfettered craving. And I feel like it's going to be okay, because it has to be okay, because I can't stop it anymore. And maybe I don't give a shit. Maybe I'll just do what I want. There is a thrill to giving up, a singular joy to giving in, a crass satisfaction to changing state from effortful self-control to *what the hell*. Excitement rises as my ventral striatum lurches into action. The goal *is* attainable. Dopamine surges. It's all yours. To take. Nobody to stop you. Only the rats are here to whisper their disapproval as my hand reaches to the fridge door.

## Recommendations

- 1) Because addiction is self-reinforcing, try to nip it in the bud as early as possible. But once it takes hold, avoid drug-related cues -- this may require a radical shift in environments.
- 2) To minimize ego fatigue, addicts need to get their minds off the thing they crave. They need to get involved in something else!
- 3) Don't be fooled by addicts' bravado and defiance. It's a means for reducing their sense of helplessness. Behind it is a need for help.



## Thanks to...

- Tim Rostron, my editor, at Random House Canada
- Michael Levine, my agent and “coach”
- CAMH for inviting me
- My family in the Netherlands for letting me come