The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Psychological and Evolutionary Roots of Resource Overconsumption Revisited

Posted by nate hagens on June 25, 2009 - 8:15am

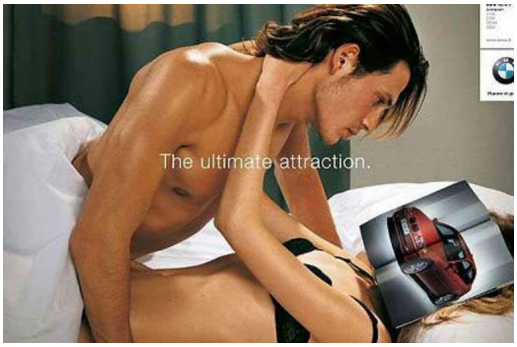
This post examines our own history on the planet, outlines how the ancient-derived reward pathways of our brain are easily hijacked by modern stimuli, and concludes that in very real ways, we have become addicted to the 'consumptive behaviors' linked to oil.

Gold Plated Porsche

*Editor's note: I have learned a great deal more on the twin drivers of consumption - **relative status and habituation/addiction** since what follows was first written. However, despite best intentions, I am personally even more habituated to stimulation offered in modern American culture and my life still has about the same physical dependence on oil's emergent properties as it did back then. On the bright side however, I have continued my decade long shift of 'competition for status' away from pecuniary metrics...*

WHY ARE WE ADDICTED TO OIL?

> "Selfish behaviors are reward driven and innate, wired deeply into the survival mechanisms of the primitive brain, and when consistently reinforced, they will run away to greed, with its associated craving for money, food, or power. On the other hand, the self restraint and the empathy for others that are so important in fostering physical and mental health are learned behaviors – largely functions of the new human cortex and thus culturally dependent. These social behaviors are fragile and learned by imitations much as we learn language". Dr. Peter Whybrow - "American Mania"



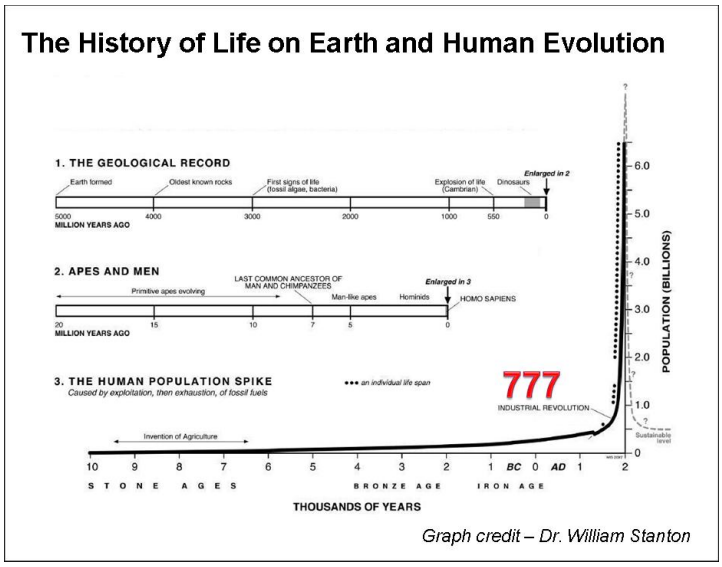
An advertisement for BMW cars -and freedom, and power, and sex, and status.... (Click to enlarge)

INTRODUCTION

The majority of Peak Oil writing and discussion centers around the upcoming date of an all liquids peak and how steep the subsequent decline rate might be. There's also active debate on how to best replace the coming shortfall in fossil energy with renewable flows. Fewer discussions are about relocalizing a global economy dependent on cheap transportation fuels, and how best to structure a world with lower density energy. Yet fewer still delve into who we are, how we got here, and what and why we use energy, and seemingly want more of it every year. Essentially, most of our energy conversations, at conferences, schools, institutions, and the blogosphere, focus on the **means**, and not the **ends**. The *ends* have generally remained unquestioned. There seems to be an implicit assumption that worldwide energy demand will continue to grow something akin to a natural law, and that solutions should focus on ways to increase supply and/or efficiency of energy. But in an economic system based on self-interest on a finite planet, the true drivers of demand will need to be better understood beyond the microeconomic mantra "price will change behavior".

This post examines our own history on the planet, outlines how the ancient-derived reward pathways of our brain are easily hijacked by modern stimuli, and concludes that in very real ways, we have become addicted to the 'consumptive behaviors' linked to oil. "Traditional" drug abuse happens because natural selection has shaped behavior regulation mechanisms that function via chemical transmitters. Just as an addict becomes habituated to cocaine, heroin or alcohol, the 'normal person' possesses neural architecture to become habituated via a positive feedback loop to the 'chemical sensations' we receive from shopping, keeping up with the joneses (conspicuous consumption), pursuing more stock options and profits, and myriad other stimulating activities that a large social energy surplus provides. In order to overcome addictions, it is usually not enough to argue about which year the drug supply is going to begin its decline. It's a better path to understand the addiction, admit it before one hits rock bottom, and either begin the cold turkey process or become addicted to something else.

HUMAN HISTORY AND EVOLUTION



Timeline of human evolution - Source: Dr. William Stanton (Click to enlarge)

To understand how and why our demand for oil and energy services has continually increased, and what behavioral constraints we might encounter if an energy decline occurs, it will be necessary to review 'some' evolutionary history. For those familiar with biology it will be a quick refresher - for those not, it shouldn't be too painful, (but maybe a little).

All life on earth originated from the same single celled organisms. We are used to thinking in terms of months, years, decades, etc. so it's difficult to grasp millenia let alone millions or billions of years. As can be seen in the above graphic, human history takes up a very small % of the time of life on earth and an even smaller % of the time since Earth was first formed. We share a great deal of our genes with simpler organisms such as mice or wheat, and considerably more with dogs or other primates like chimpanzees. Of the genes actually used, or 'conserved', we share more – over 60% with fruit flies and over 96% with chimpanzees. We are all kin, somehow traceable back

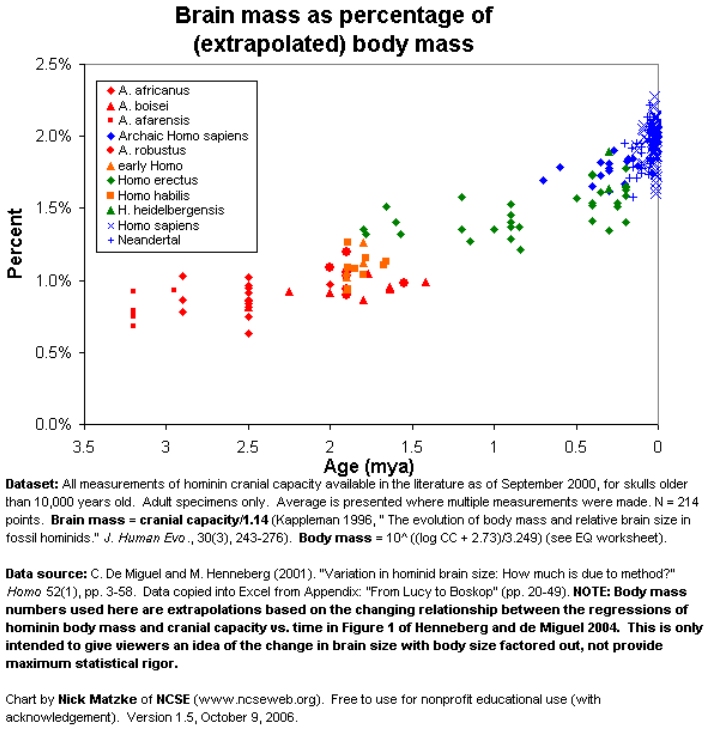
several billion years to the origin of life on earth. I am not only related to my colleague Euan Mearns, but to a lesser extent his dogs, and still lesser extent, the plants in his yard.

Charles Darwin's maxim of evolution: "Multiply, vary, let the strongest live and the weakest die" has gradually, but definitively shaped who we have become as humans today. This theme has been expanded by modern biological research to focus less on 'the strongest' in the physical sense, and more on the concept of 'relative fitness' (or inclusive fitness), that those adaptations that are successful in propelling genes, or suites of genes, into the next generation will have outcompeted those that were deleterious or did not keep up with environmental change. Evolution does not have 'purpose', it just combines time (a great deal of it) with the substrate of life and hones and culls as eons pass. A male spider is sometimes consumed by the female after they have sex. This obviously is a bummer for the male spider, but can be explained by evolution if the nutrition provided for his offspring (carrying his genes) outweighs the sum of his future mating opportunities. Thus the spider, when presented with a 'hot female spider' is not 'calculating' the odds of being eaten vs. how many nutrients are in his body, but performing a behavior that was successful for his ancestors, and therefore chemically 'felt right'. (spiders share many of the same neurotransmitters as humans, e.g. serotonin and dopamine). All of life has arrived in 2008 by some path like this, including and especially human beings.

Fossil hominid skulls - Image Copyright Smithsonian Institute
A more detailed description Doug Theobold, Phd (Click to enlarge)

* (A) Pan troglodytes, chimpanzee, modern
* (B) Australopithecus africanus, STS 5, 2.6 My
* (C) Australopithecus africanus, STS 71, 2.5 My
* (D) Homo habilis, KNM-ER 1813, 1.9 My
* (E) Homo habilis, OH24, 1.8 My
* (F) Homo rudolfensis, KNM-ER 1470, 1.8 My
* (G) Homo erectus, Dmanisi cranium D2700, 1.75 My
* (H) Homo ergaster (early H. erectus), KNM-ER 3733, 1.75 My
* (I) Homo heidelbergensis, "Rhodesia man," 300,000 - 125,000 y
* (J) Homo sapiens neanderthalensis, La Ferrassie 1, 70,000 y
* (K) Homo sapiens neanderthalensis, La Chappelle-aux-Saints, 60,000 y
* (L) Homo sapiens neanderthalensis, Le Moustier, 45,000 y
* (M) Homo sapiens sapiens, Cro-Magnon I, 30,000 y
* (N) Homo sapiens sapiens, modern

Man split off from the rest of the apes about 5-6 million years ago (my). It is estimated that our earliest hominid ancestors, the australopithecenes were the first to walk upright. Can you imagine the excitement and attraction to the first few pairs of these creatures that started walking on two legs instead of four? Must have been like having the shiniest muscle car on the block!
Tens of thousands of generations of various stages of human ancestry passed in Africa, the big cats and environmental hazards keeping hominids close to or under local carrying capacities, with no real need to migrate. Genetic analysis shows that the intelligence that distinguishes us as homo sapiens is of comparatively recent origin-emerging perhaps a mere 200,000 years ago, compared to the millions of years that the hominid line has been in evolution. Wildly oscillating climate and the introduction of language were likely strong influences on the increase in hominid brain size during the past 1 million years.



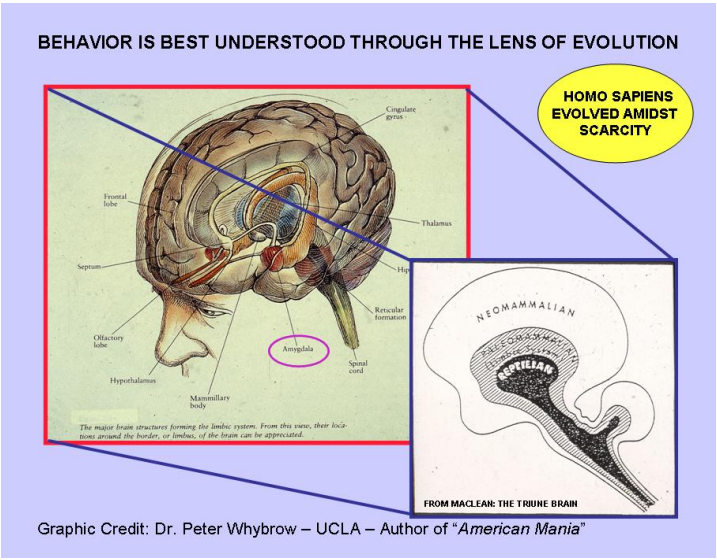
Dataset: All measurements of hominin cranial capacity available in the literature as of September 2000, for skulls older than 10,000 years old. Adult specimens only. Average is presented where multiple measurements were made. N = 214 points. **Brain mass = cranial capacity/1.14** (Kappleman 1996, " The evolution of body mass and relative brain size in fossil hominids." *J. Human Evo.*, 30(3), 243-276). **Body mass** = 10^ ((log CC + 2.73)/3.249) (see EQ worksheet).

Data source: C. De Miguel and M. Henneberg (2001). "Variation in hominid brain size: How much is due to method?" *Homo* 52(1), pp. 3-58. Data copied into Excel from Appendix: "From Lucy to Boskop" (pp. 20-49). **NOTE: Body mass numbers used here are extrapolations based on the changing relationship between the regressions of hominin body mass and cranial capacity vs. time in Figure 1 of Henneberg and de Miguel 2004. This is only intended to give viewers an idea of the change in brain size with body size factored out, not provide maximum statistical rigor.**

Chart by **Nick Matzke** of **NCSE** (www.ncseweb.org). Free to use for nonprofit educational use (with acknowledgement). Version 1.5, October 9, 2006.

History of human brain volume (Click to enlarge)

Modern humans ultimately emerged around 125,000 years ago and remained in small hunter gatherer tribes until the invention of agriculture around 12,000 years ago. It was not until we started 'spending' our 'ancient sunlight' bank account in the late 1700s that our population began its moonshot trajectory. The average American today uses around 60 barrel of oil equivalents of primary energy each year- depending on the assumptions this represents hundreds of annual energy 'slaves', for each one of us.



The Triune Brain (Mclean) viewed through the lens of natural selection (Click to enlarge)

NATURAL SELECTION AND ITS IMPACT ON THE MODERN BRAIN AND BEHAVIOUR

I have (briefly) gone through evolution of the triune brain several times on TOD before. The various layers and mechanisms of our brain were built on top of eachother, via millions and millions of iterations, keeping intact what 'worked' and adding on what changes and mutations

helped the pre-human, pre-mammal organism incrementally advance. Brain structures that functioned poorly in those ancient environments are no longer around. Gradually, organisms became more complex and the human neocortex developed on top of, and in complex synergy with, the older brain structures of the limbic system and the primitive reptilian core. We are, all of us, descended from the best of the best at surviving and procreating, which in the environment of privation and danger where we endured the most 'iterations' of our evolution, meant acquiring necessary resources, achieving status, and possessing brains finely tuned to natural dangers and opportunities. In our modern environment, it is the combination of *pursuit of social status* and the plethora of *fun, exciting/novel activities* that underlies our large appetite for oil.

STATUS

Status has historically been a signaling mechanism that minimized the costs of competition, whether for reproductive opportunities, or for material resources. If you place 10 chickens in an enclosure there will ensue a series of fights until a pecking order is established. Each bird quicly learns who it can and cannot beat and a status hierarchy is created, thus making future fights (and wastes of energy) less common. Physical competition is costly behavior which requires energy and entails risk of injury. Status is a way to determine who one can profitably challenge and who one cannot. In our ancestral environment, those men (and women) that successfully moved up the social hierarchy ladder, 'improved' their mating and resource prospects. The ones at the bottom of the status rung did not mate at all. In modern humans, status is defined by what *culture* dictates – popularity, physical looks, wealth, fast cars, political connections, etc.

Biologists have shown that historically, the primary way to reliably demonstrate one's 'quality' during courtship is to display a high-cost signal - e.g. a heavy and colorful peacock's tail, an energy expending bird-song concert, or a $100,000 sports car. Only these costly "handicap" signals are evolutionarily stable indicators of their producer's quality, because cheap signals are too easy for low-quality imitators to fake (Zahavi and Zahavi, 1997). In this sense 'waste' has been evolutionarily selected for! Think of the 3 drawbacks to a male peacock of growing such a hugely ornate tail: 1)the energy, vitamins and minerals needed to go into the creation of the tail could have been used for other survival/reproductive needs, 2)the tail makes it more likely to be spotted by a predator, 3)if spotted, the tail makes it less likely to get away from a predator. All three of these negative fitness hits MUST have been outweighed by the drab female peahen's preference for males with larger more ornate tails. This is all outlined by the evolutionary theory of sexual selection (please read the wiki intro if this is a new concept to you).

It follows that the larger a cultures energy subsidy, the more opportunity there is for 'status badges' to separate from traits actually correlated with basic needs (e.g. strength, intelligence, adaptability, stamina, etc.) In many societies, achieving cultural success appears to lead to biological (genetic) success. Though 'what' defines status may be culturally derived, status hierarchies themselves are part of our evolved nature. Our ancestors at the bottom of the mating pecking order, ceteris paribus, are not our ancestors, and many of our ancestors had orders of

magnitude more descendants than others. For example, scientists recently discovered an odd geographical preponderance for a particular Y chromosome which turns out to be originally descended from Ghengis Khan. Given the 16 million odd male descendants alive today with this Y marker, Mr. Khan had 800,000 times the reproductive success than the average male alive on the planet during 1200 AD.

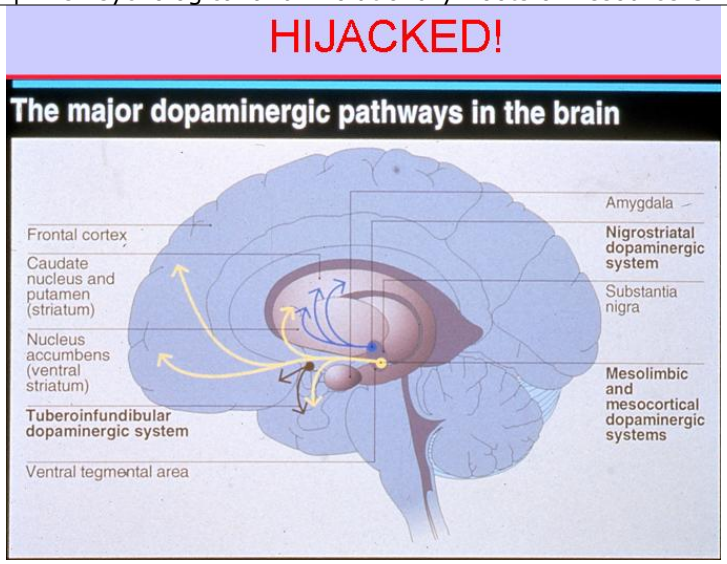
NOVELTY

The brain utilizes about 40% of all available genes and consumes over 20% of our caloric intake. When it comes to self preservation, nature is especially parsimonious in shaping the brains survival systems to become incredibly efficient. Incremental biases in how our brains recognize, process, and react to the world around us either contributed to our survival and thus were carried forward, or died out. Of major importance in the millions of years of hominid adaptation was the concept of 'salience', which is related to curiosity, novelty and reward seeking. Salience is noticing what is important, or different; what contrasts from the usual. All of the various precursor hominid species to modern man evolved under conditions of privation and scarcity, at least until 20-30,000 years ago, (which is too short of time to meaningfully impact millions of years of neural sculpture).

Salience recognition is part of the mesolimbic dopamine reward pathway. This system of neurons is integral to survival efficiency, helping us to instantly decide what in the environment should command our attention. Historically, immediate feedback on what is 'new' was critical in avoiding danger as well as procuring food. Because most of what happens around us each day is predictable, processing every detail of a familiar habitat wastes brain energy. It also would slow down our mental computer so as to become a deadly distraction. Thus our ancestors living on the African savanna paid little attention to the stable mountains on the horizon but were alert to any change or movement in the bush, on the plains, or at the riverbank. Those more able to detect and quickly process 'novel cues' were more likely to survive and pass on their genes. Indeed, modern experimental removal of dopamine receptor genes in animals causes them to reduce exploratory behavior, a key variable related to inclusive fitness in animal biology. Novelty also played a role in mating selection itself as well. Perceptual biases (e.g. greater responsiveness to large, bright, high-contrast, loud, rhythmic, or novel stimuli) can influence the direction of sexual selection and the details of courtship displays (e.g. Endler, 1992; Ryan & Keddy-Hector, 1992). Small differences between species in these perceptual biases could lead to large differences in the courtship displays they evolved.

We are instinctually geared for individual survival - being both reward driven, and curious. It was these two core traits which the father of economics himself, Adam Smith, predicted would be the drivers of world economic growth in *"Wealth of Nations"*. According to Smith, uniting the twin economic engines of self-interest (which he termed self-love) and curiosity was *ambition* – "the competitive human drive for social betterment". Charles Darwin, about 70 years later after reading Adam Smiths *"Theory of Moral Sentiments"* recognized the parallel between the **pursuit of wealth creation** and the **competition for resources** that occurred among species. More recently, books by Peter Whybrow "(American Mania)"and Michael Shermer (The Mind of the Market: Compassionate Apes, Competitive Humans, and other Tales from Evolutionary Economics) have suggested that our market system of allocating resources and 'status' has been the natural social culmination for an intelligent species finding an abundance of resources.

But, as we shall soon see, the revered Scottish philosopher could not have envisioned heli-skiing, Starbucks, corporate jets, 500 foot yachts, and many other stimulating and pleasurable objects that his modern descendants compete for and so easily become acclimated to. (I doubt he ever conceived of Peak Oil either).



The major brain dopamine pathways (Thanks to Dr. Peter Whybrow) (Click to enlarge)

THE MODERN MESOLIMBIC DOPAMINERGIC REWARD SYSTEM

> "Americans find prosperity almost everywhere, but not happiness. For them desire for wellbeing has become a restless burning passion which increases with satisfaction. To start with emigration was a necessity for them: now it is a sort of gamble, and they enjoy the sensations as much as the profit." Alexis DeTocqueville, *Democracy in America* ***1831***

An explosion of neuroscience and brain imaging research tells us that drugs of abuse activate the brain's mesolimbic dopamine reward system, the neural network that regulates our ability to feel pleasure and be motivated for "more". When we have a great experience – a glance from a pretty girl, a lovemaking romp in the woods, a plate of fresh sushi, hitting 777 on a $5 machine, catching a lunker pike, watching a sunset, hearing a great guitar riff etc. – our brain experiences a surge in the level of the neurotransmitter dopamine. We feel positively charged, warm, 'in the zone' and happy. After a while, the dopamine gets flushed out of our system and returns to it's baseline level. We go about our lives, looking forward to the next pleasurable experience. But the experience has been logged onto our brains limbic system, which in addition to being the center of pleasure and emotion, holds our memory and motivation circuitry. We now begin to look forward to repeat performances. This desire has it's beginnings outside of conscious awareness. Recent brain imaging research shows that drug and sexual cues as brief as 33 milliseconds can activate the dopamine circuitry, even if a person is not conscious of the cues. Maybe that's why they hide artistically shaped sexual images in advertisements for whiskey and such.

Historically, this entire system evolved from the biological imperative of survival. Food meant survival, sex meant survival (of genes or suites of genes), and additional stockpiles of both provided success relative to others, both within and between species. There was a discrete payoff from waiting hours for some movement in the brush that signaled 'food', or the sound of a particular bird that circled a tree with a beehive full of honey,etc. Our pattern recognition system on the Pleistocene would have been a grab-bag of various environmental stimuli that 'excited' our brains towards action that correlated with resources (typically food). In sum, the brain's reward pathway records both the actual experience of pleasure as well as ensures that the behaviors that led to it are remembered and repeated. Irrespective of whether they are 'good' for the organism in the current context– they 'feel' good, which is the mechanism our brain has left us as a heritage of natural selection.

THE (VERY IMPORTANT) MECHANISM OF HABITUATION

HELLO

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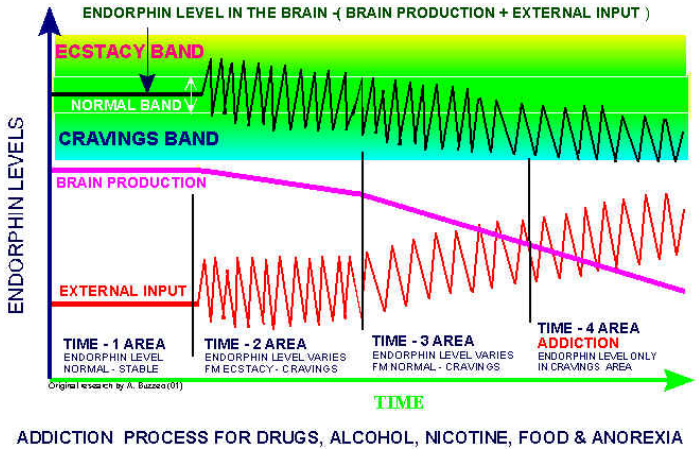
YOU MIGHT EVEN BE A WINNER!!!

Rescorla Wagner Learning Function (Click to enlarge)

Habituation (and subsequent substance abuse and addiction) originates in the mechansims of how we learn. Dopamine responses comply with basic assumptions of formal learning theory. Learning depends crucially on the discrepancy between the prediction and occurrence of a reward. The importance of such prediction errors is derived from Kamin's blocking effect (1969) which postulates that a reward that is fully predicted does not contribute to the learning of a stimulus or action, even when it has been repeatedly paired with the stimulus or action. This is conceptualized in the Rescorla-Wagner learning rules, according to which *learning advances only to the extent to which a reinforcer is unpredicted and slows progressively as the reinforcer becomes more predicted.*

Dopamine activation has been linked with addictive, impulsive activity in numerous species. Dopamine is released within the brain not only to stimuli an organism finds rewarding but also to those events which *predict* rewards. It has long been known that two groups of neurons, in the ventral tegmental and the substantia nigra pars compacta areas, and the dopamine they release, are critical for reinforcing certain kinds of behavior (Dayan and Montague, 1997; Glimcher, Dorris and Bayer, 2005; Schultz, 2002). Wolfram Schultz measured the activity of these dopamine neurons while thirsty monkeys waited for a tone which was followed by a squirt of fruit juice into their mouths. After a regimen of fixed, steady amounts of juice, the volume of juice was doubled without warning. The rate of neuron firing went from about 3 per second to 80 per second. But after several trials, as this new magnitude of reward was 'habituated to', the firing rate returned to the baseline rate of 3 firings per second. The monkeys had habituated to what was coming. The opposite happened when the reward was reduced without warning. The firing rate dropped dramatically, but then returned to the baseline rate of 3 firings per second. (Gowdy 2007)

The first time we experience a drug or alcohol high, the amount of chemical we ingest often exceeds by an order of magnitude the levels of naturally occurring neurotransmitters in our bodies. No matter how brief, that experience is stored in our neural homes for motivation and memory - the amygdyla and hippocampus. Getting drunk with your friends, getting high on a ski-lift, removing the undergarments of a member of the opposite sex for the first time –all initially flood the brain with dopamine alongside a picture memory of the event linked to the bodys pleasurable response to it. As such we look forward to doing it again, because we want to repeat that 'feeling'. But in a modern stimuli-laden culture, this process is easily hijacked. After each upward spike, dopamine levels again recede, eventually to below the baseline. The following spike doesn't go quite as high as the one before it. Over time, the rush becomes smaller, and the crash that follows becomes steeper. The brain has been fooled into 'thinking' that achieving that high is equivalent to survival (even more so than with food or sex which actually *do* contribute to survival) and the 'consume' light remains on all the time. Eventually, the brain is forced to turn on a self defense mechanism, reducing the production of dopamine altogether – thus weakening the pleasure circuits' intended function. At this point, an 'addicted' person is compelled to use the substance not to get high, but just to feel normal – since ones own body is producing little or no enodgenous dopamine response. Such a person has reached a state of anhedonia, or inability to feel pleasure via normal experiences. Furthermore, being addicted raises the risk of having depression; being depressed increases the risk of self-medicating, which then leads to addiction, etc. via positive feedback loops.



Habituation and eventual addiction to a substance (the graph indicates endorphins, which relate to opiates, but similar patterns exist for dopamine) (Click to enlarge)

Essentially, when exposed to novel stimuli, high levels of curiosity (dopamine) are generated, but it is the *unexpected reward* that causes their activation. If I order a fantastic array of sushi and the waiter brings me my check along with a breath mint, I am going to have a plunge in dopamine levels which will create an immediate craving for food. It is this interplay between expected reward and reality that underlies much of our behavioral reactions. Ultimately, repeated use of a dopamine generating 'activity' causes tolerance. Withdrawal results in lower levels of dopamine and continuous use is required to keep dopamine at normal levels, and even higher doses to get the 'high' levels of initial use. (1)

Taking this further, the Rescorla-Wagner learning function 'shape' seems to be common in life - kind of like the 80/20 rule. Here we see it with happiness and GDP. There is something important here....

ON GENES AND CULTURE

> "Most of these people in the nations of the United States are extremely eager in the pursuit of immediate material pleasures and are always discontented with the position they occupy. They think about nothing but ways of changing their lot and bettering it...An American will build a house in which to pass his old age and sell it before the roof is on. He will plant a garden and rent it just as the trees are coming into bear. He will take up a profession and leave it, settle in one place and soon go of elsewhere with his changing desire. Yet at the end of the year crammed with work he has little spare leisure. His restless curiosity goes with him traveling up and down the vast territories of the United States." Alexis DeTocqueville, *Democracy in America* **1831!**

All humans share the same general neurocircuitry that can be hijacked by access to intense and pleasurable stimuli. But some are more at risk than others, both genetically, and as is increasingly apparent in the fast paced OECD world, by culture. Just having a genetic predisposition to a certain condition doesn't assure that the condition will happen. In order to 'switch on', certain genes must interact with or be triggered by environmental factors. If that doesn't happen, the addiction will not occur. Temperament and character are the 2 key components that comprise individual personality. Their distinction is inherent when we separate instinct and inborn habits from free will and what we learn. '**Character**' emerges over time through self-awareness - it is learned behavior shaped largely by the family and the culture we grow up in. "**Temperament**' on the other hand, is an inborn pattern of emotional style that starts to unfold in childhood and persists into adult life. Temperament is strongly heritable, accounting for approximately 40% of behavioral variance in twin studies.

Professor Robert Cloninger has developed a system of evaluating human temperament and character and their variations. Utilizing a large database from over two decades of research, Cloninger has integrated objective psychological testing of individuals with the growing knowledge of the brains anatomy and chemical messenger systems. His research confirms that patterns of temperament are heritable, but further suggests that different personality patterns reflect variation in the genetic programming of neurochemical communication. The common behavioral patterns of temperament appear to reflect the balance of activity among the dopamine, norepenephrine and serotonin systems (the 3 information superhighways linking the ancient brain stem to the neocortex). His research has identified behavioral clusters that describe 4 major temperament styles -the poles of which are 'harm avoidance' (shy) and 'novelty seeking' (bold).

Cloninger's analysis integrates common patterns in which we interact with others and how we respond to social challenges. Briefly, individuals with harm avoidance temperament are generally shy and anxious in the face of social competition. (Research in humans and other primates suggest this pattern is associated with a dominance of serotonin in the brain messenger systems). On the other hand the temperament clusters of reward dependence, persistence, and novelty seeking – the 3 behaviors that overlap with curiosity – are linked to the activity of the brains reward system as well as to the dopamine and norepenephrine superhighways. When we are 'curious' and try some new snack, play a new video game, write a good rebuttal to a Stuart Staniford post, or meet somebody we really like, it is our dopamine reward pathways that are activated, reminding us to repeat the experience. This pleasurable reinforcement begins a positive feedback loop – a reward and an individuals response to and dependence on that reward is a large part of what defines ones type of temperament.

Individuals who are fascinated by novelty and risk are less anxious and fearful when confronted with uncertainty or danger. On the flip side, they are also easily bored, (for example by reading long oildrum posts with low 'graphic/text' ratios). The association of exploratory behavior across species (genetic 'conservation') with the D4 dopamine receptor complex suggests that this circuitry has played an important role in mammalian adaptation to changing environments

throughout evolution. It is this novelty seeking temperament that is important in understanding exploratory (migratory?) behavior. This temperament style appears to reflect genetic differences in the dopamine reward system of the brain. Those scoring high on this scale are bold and curious individuals, who enjoy exploration and challenge and are risk takers with thick skins in social situations.

CURIOUS GEORGE DISCOVERS AMERICA

> "In Europe, we habitually regard a restless spirit, a moderate desire for wealth and an extreme love of independence as great social dangers, but precisely these things assure a long and peaceful future in the American republics" - Alexis DeTocqueville "Democracy in America" **1831**(this guy was a freakin' prophet!)

> "America was set apart in a special way. It was put here between the oceans to be found by a certain kind of people. A beacon of hope to the rest of the world" Ronald Reagan – *A Time for Choosing* 1984

> An invasive species will be defined as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" - *Executive Order 13112* signed by Bill Clinton in February 1999

The fact that patterns of temperament are strongly heritable has obvious implications for understanding the restless curiousity and risk taking that is so characteristic in American culture. 98% of all humans who have ever lived on the planet never moved from their birthplace.(9) Beginning in Africa, as few as 500 humans migrated northward into Europe and Asia, which began the population seeding of the rest of the world around 120,000 years ago. Fast forward to the 17th-19th centuries, a relatively empty America was rumoured to be a land of opportunity and full of resources. Typical migrants to our shores were self-selected and for a variety of individual reasons, *chose* to come here (with the exception of slaves). Whether it was to escape oppression, to better ones-self and family with the promise of riches, or to quest for new lands and experiences, America has become a melting pot of immigrants in the past few centuries. If only 2% of the worlds population is migrant, then it logically follows that Americans, in their risk to start life anew are a self selected subgroup of that émigré population. At the time of its first Census in 1790, the United States was home to a population of just over 4 million people. Today, 98%+ of our 300 million residents were either born elsewhere and migrated here or born into families that migrated to the United States in the last three centuries. (The other 2% being Native Americans). This phenomenon is not confined to first generation migrants – over 20% of Americans change their residence every year and this trend has been in place since the 1950s.(1)

There has been considerable genetic testing on a suite of alleles accompanying the D dopamine receptor, which in some tests showed a high correlation with novelty/impulsivity, especially at the DRD4 polymorphism. Lack of funding (and perhaps lack of political correctness) has precluded the obvious hypothesis tests to see if Americans really are more 'genetically' wired for novelty/impulsivity. Though the brain sciences have made major advances in the past decade, they are still in their infancy in what they might accomplish. Parsing behaviors down to one particular allele, though possible, doesn't seem too likely. However, the premise that Americans are genetically/culturally more prone to risk taking, impulsivity, novelty-seeking, and therefore addiction, is the main theme of the excellent book "American Mania" (a book which I've heavily borrowed from in this post) by Dr. Peter Whybrow, who heads up the Semel Neuroscience Institute at the UCLA Medical School. I find this thesis, especially given my personal history on Wall Street and interaction with people around the world, a compelling one.

AMERICA AND ADDICTION

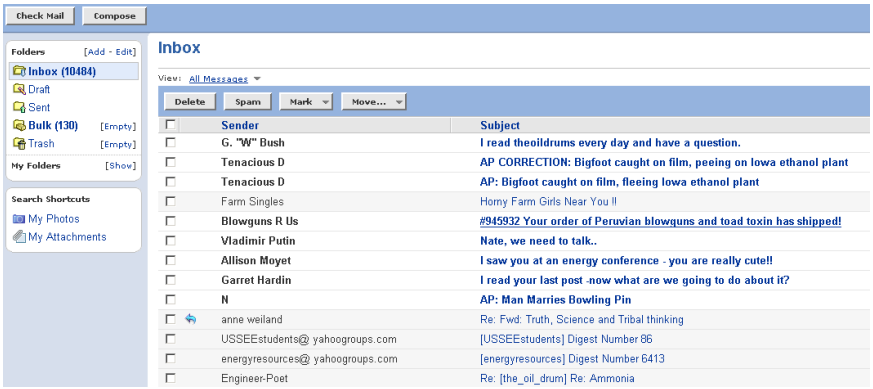
Americas Addictions - Time Magazine July 2007(Click to enlarge)

It would be pretty hard to be addicted directly to oil. Its toxic, slimy and tastes really bad. But it can be quite possible to become addicted to the energy services that oil provides. Within a frenetic culture of 'more', it is no wonder we have so many addicts. By instinct we are geared for individual survival-curious, reward-driven and self-absorbed – modern technology has now become a vector for these cravings. Material wealth and the abundant choices available in contemporary US society are unique in human (or animal) experience – never before in the history of our species have so many enjoyed (used?) so much. High density energy and human ingenuity have removed the natural constraints on our behavior of distance, time, oceans and mountains. For now, these phenomenon are largely constrained to developed nations - people living in a hut in Botswana or a yurt in Mongolia cannot easily be exposed to the 'hijacking stimuli' of an average westerner, especially one living in a big city in the United States, like New York, or Los Angeles.

Many activities in an energy rich society unintentionally prey on the difference between expected and unexpected reward. Take fishing for example. If my brother and I are out on a lake fishing and we get a bite -it sends a surge of excitement through our bodies - what kind of fish is it? how big is it? etc. We land an 8 inch perch! Cool. A minute later we catch another 8 inch perch - wow there must be a school! After 45 minutes of catching nothing but 8 inch perch, our brain comes to expect this outcome, and we need something bigger (or at least different) to generate the same level of excitement - so we will likely move to a different part of the lake in search of 'bigger' or 'different' fish. (though my brother claims he would never tire of catching fish no matter the size or species I think he's exaggerating).

But given the above mechanics of the habituation process to 'real' drugs, one can understand how some initially benign activities can morph into things more destructive. Weekly church bingo escalates to $50 blackjack tables; Sports Illustrated swimsuit edition, several years down the road results in monthly delivery (in unmarked brown packaging) of "Jugs" magazine or cybercams locked in on some bedroom in Budapest; youthful rides on a rollercoaster evolves into annual heli-skiing trips, etc. Video game sales just reached $18 billion annually (and are getting more violent by the year - Lord of Rings type stuff is too mild..) Globalization and cheap travel has enabled an explosion of internet matchmaking, where 10s of millions of singles ostensibly seek a mate, but all too often get habituated to the actual 'seeking' process itself (unexpected reward writ large). Many sites now cater to short term encounters (adultfriendfinder has 21 million members). So what started off with a small yearning for flowers and companionship often ends up with exposure to more and more extreme stimuli. Sometimes ignorance really is bliss.

The world wide web is especially capable of hijacking our neural reward pathways. The 24/7 ubiquity and nearly unlimited options for distraction on the internet almost seem to be perfectly designed to hone in on our brains g-spot. Shopping, pornography, gambling, social networking, information searches, etc. easily outcompete the non-virtual, more mundane activities of yesteryear. Though becoming addicted to more 'information' doesn't use a great deal of energy relatively speaking, it, repetitive use can be highly addictive, though psychiatrists in different countries are debating whether it is a 'true' addiction. For better or worse, the first things I do in the morning is a)check what time it is, b)start the coffee machine then c)check my email, to see what 'novelty' might be in my inbox. Bills to pay, and emails from people who are not important or interesting, wait until later in the day, or are forgotten altogether. Then I walk the dog. At least I don't own a television.



Novelty. Novelty. Novelty. Always something new in the inbox... (well, an email from Vladimir Putin would certainly qualify). Don't you just WANT to click on some of these? (Click to enlarge)

As you read this the World Series of Poker is going on in Las Vegas, with upwards of $200,000,000 in total prize money. There has been an explosion of young people playing poker, many of them dropping out of college to do so. Many young players have made millions and gone broke numerous times before their 21st birthday.
With numerous 19-22 year olds making millions per year, this is one modern cultural aspiration that seems to be trumping 'solar installer' or 'micro-hydro engineer'. Once exposed to playing 4-6 high stakes online poker games simultaneously (and winning), planting potatoes or backpacking in Yosemite become the neural equivalent of a baked potato (with nary salt nor butter).

Regarding sex, there are few healthy men on the planet today that in social settings do not respond, outwardly or otherwise, to the attention of a high status, attractive 20-30 something woman. This is *salient* stimuli, irrespective of the mans marital status. But here is one example of where nature and nurture mesh. Despite the fact that 99+% of our history is polygynous, modern culture precludes men from running around pell mell chasing women - we have rules, laws, and institutions such as marriage. Though habituation to various 'things' may at least partially explain the 60%+ divorce rate in modern society. The grass is greener and such...

Seriously, the entire brain and behavior story is far more complex than just one neurotransmitter and its reward pathway. But the pursuit of this particular 'substance' is clearly correlated with anxiety, obesity, and general increasing of conspicuous consumption in our society. (1) That dopamine is directly involved is pretty clear. Parkinsons Disease is a condition where dopamine is lacking in an area of the brain necessary for motor coordination. Here is a fMRI photo of dopamine levels of a Parkinsons patient vs. a control. The Parkinsons drug, Mirapex, increases dopamine levels in that area of the brain, but since pills are not lasers, it also increases dopamine in other areas of the body, including (surprise) the reward pathways. There are numerous lawsuits currently pending by Parkinsons patients who after taking the drug, developed sex, gambling, shopping and overeating compulsions (Journal of Neurology Sep 2005).

Food is also an area that can trick the brain. We evolved in situations where salt and sugar where rare and lacking. When we taste Doritos or Ben and Jerry's Chocolate Fudge Brownie, our reward pathways say 'yes yes - this is good for you!!', at the same time our 'rational' brain reminds us of the science showing obesity comes from eating too much of the wrong type of foods. For most (myself included) my rational brain is batting about .250 or less. Americans lead the world in obesity(Percentage of population with Body Mass Index > 30 SOURCE - OECD FACTBOOK 2005 – ISBN 92-64-01869-7 – © OECD 2005). Since we are exporting our culture (via the market system) to developing countries, it is no surprise that China is following in our footsteps. From 1991 to 2004 the percentage of adults who are overweight or obese in China increased from 12.9% to 27.3%.(8) Furthermore, we can become habituated to repeated presentation of the same food type - we quickly get tired of it and crave something different. We like variety. In food and in other things.

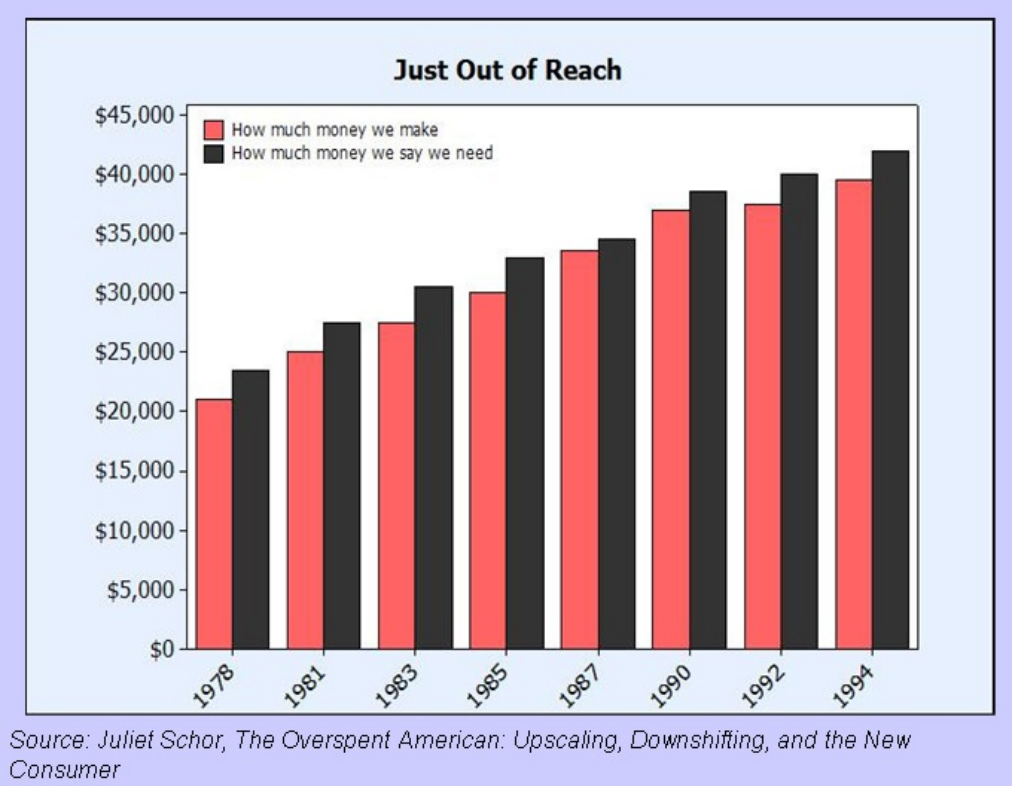
(Side note: recently I've been cooking for myself - I cook too much and share the leftovers with my dog. He now shuns his regular food (unless he's starving). Apparently dogs can experience food habituation as well (which is bad for me - he is now a perpetual beggar).

IMPULSIVITY, DISCOUNT RATES, AND PREPARING FOR THE FUTURE

As has been previously written about on theoildrum.com here, the economic term for *impulsivity* is **steep discount rates**, which means we weight the present predominantly more than the

future when making decisions (consciously or otherwise). (I am beginning to think this phenomenon is really the ecological maxim, The Maximum Power Principle, integrated with culture) The discounting model of impulsiveness (Ainslie, 1975) implies that discount rates are positively correlated with impulsivity. On average, heroin addicts' discount rates are over double those of controls. Furthermore, in tests measuring discount rates and preferences among opium addicts, opioid dependent participants discounted delayed monetary rewards significantly more than did non-drug using controls. Also, the opioid-dependent participants discounted **delayed opium significantly more than delayed money**, more evidence that brain chemicals are central to an organisms behavior and money and other abstractions are secondary. Subsequent research has also shown that deprivation of various addictive substances even further steepens a subject's preference for immediate consumption over delayed gratification. This grid summarizes some of the latest research statistics on addiction to various substances that cause us to choose small short term rewards over larger long term rewards. (source - Intertemporal Choice - Chablis et al. -The New Palgrave Dictionary of Economics, 2007). Even if we are not snorting cocaine or binge drinking on a Tuesday night, in a world with so much choice and so many stimulating options vying for our attention, perhaps more and more of us are addicted to...*time*.

THE FALLACY OF REVERSIBILITY A.K.A *"THE RATCHET EFFECT"*



Source - "The Overspent American" - Professor Juliet Schor (Click to enlarge)

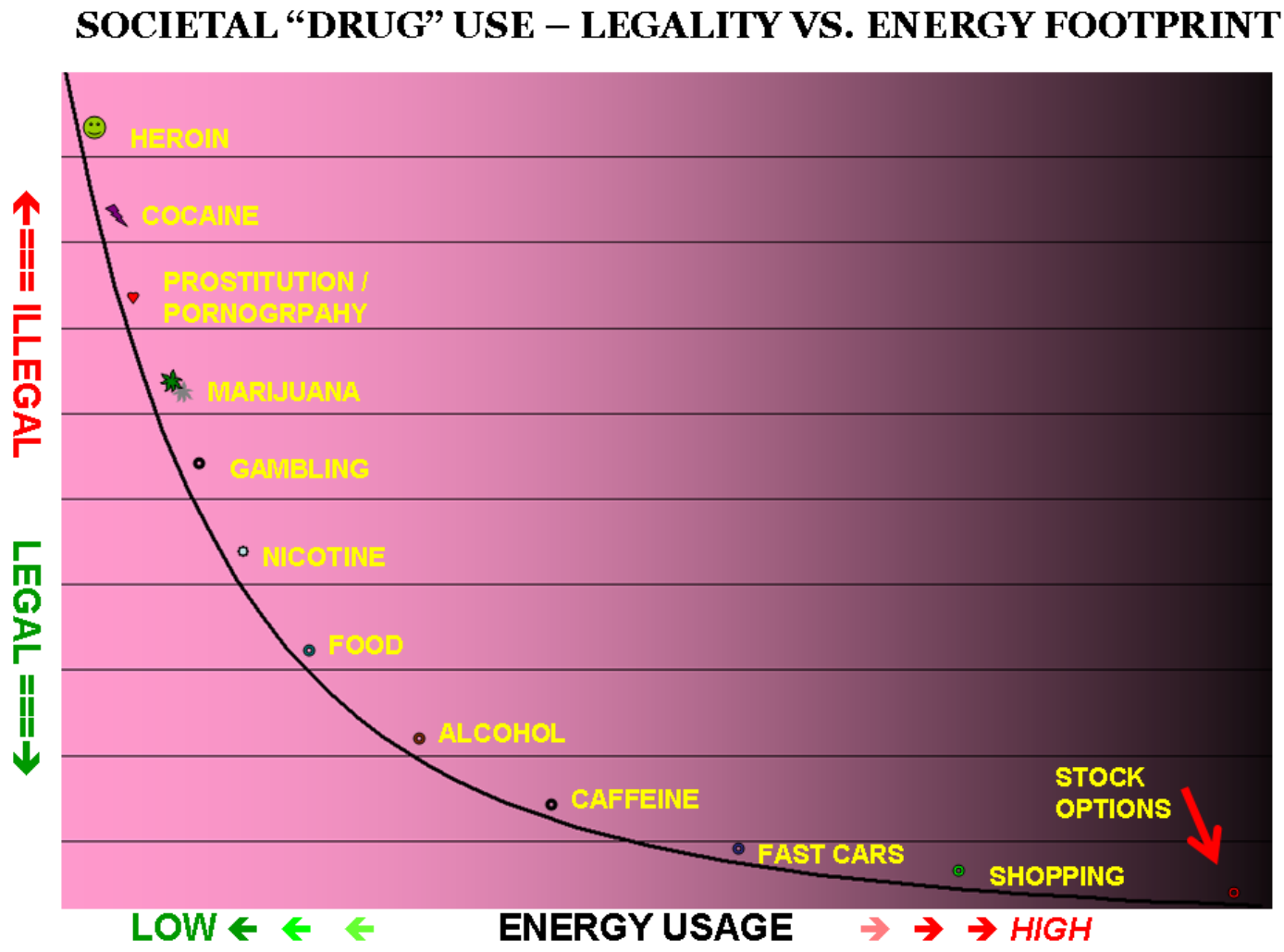
Though we might claim otherwise, we always want more. Many desires have negative feedbacks however. I can only eat about 3 cheeseburgers before my stomach sends a signal to my brain that I am full - if I ate 4 or 5 my stomach and esophogus would eventually fill up so that I couldn't physically eat another one. This is not so with virtual wealth, or many of the "wanting" stimuli promoted in our culture. In ongoing research Professor Juliet Schor of Boston University demonstrates that no matter how much we (the study was on Americans) make, we always say we'd like to make a little more the following year. Similar research, by UCLA economist Richard Easterlin followed a cohort of people over an 16 year period. (he is the eponymous coiner of the "Easterlin Paradox" which points out that average happiness has remained constant over time despite sharp rises in GDP per Capita.) The participants were asked at the onset to list 10 items that they desired. (e.g. sports car, snowmobile, house, private jet, etc.) Over the 16 year study, all age groups tested did acquire some/many of the things they originally desired. But in each case, their **desires increased more than their acquisitions**. This phenomenon is termed the "Hedonic Treadmill". Clearly mansions and sports cars don't inherently elicit lifelong cravings on their own. Culture plays the integral role in linking our neural scaffolding to consumptive pursuits. Modern brain research indicates that we get a higher buzz by pursuing the type of 'status' symbols (in this study, cars) that society attaches value to. In my opinion, this behavior is at the

heart of the Peak Oil problem, and gives me less confidence that we are just going to 'tighten our belts' when the energy situation gets a little tougher and more expensive. That is unless, we change what we want MORE of.

In evolution, (and other fields), this is known as the Ratchet Effect, where once a certain level is reached there is no going backward, at least not all the way. An example of this is obesity - as we get fatter the body creates more adipocytes (adipose tissue). But this system doesn't work in reverse - even though we can lose some of the weight gain, the body can't eliminate these new cells- they are here to stay - thus the ratchet effect. In biology, animals will expend more energy to defend freshly gained territory. In humans, related concepts in economics are the endowment effect and loss aversion - the pain from losing (money) is greater than the pleasure of gaining it.

ARE LEGAL DRUGS "BETTER" OR "WORSE"?

Our gradual acclimation to substances and activities that hijack our reward system is increasingly forcing us (collectively) to live in the moment. Unwinding this cultural behavior may prove to be difficult. The sensations we seek in the modern world are not only available and cheap, but most are legal, and the vast majority are actually promoted by our culture. If the rush is tied to something that society rewards we call it ambition, if its attached to something a little scary, then we label the individual a 'risktaker' and if its tied to something illegal – then they are an 'addict' or substance abuser. So it seems culture has voted on which drugs are 'good' to pursue.



Thought experiment on drugs - legal and illegal vs energy footprint(Click to enlarge)

This is (obviously) a hypothetical chart, so I will follow it with a hypothetical question. What would society look like if Starbucks dispensed marijuana and Home Depots were giant opium dens? Would we be better off, collectively? (Caffeine is akin to horizontal drilling of oil - it

maximizes current production at the cost of higher future depletion).

Drug addiction is defined as "the compulsive seeking and taking of a drug despite adverse consequences". If we substitute the word 'resource' for 'drug', have we meaningfully violated or changed this definition? That should depend on the definition of 'drug' – "a substance that a person chemically comes to rely upon" is standard. Proximally, a drug is a physical substance, but ultimately, it is any activity or substance that generates brain chemicals in a pattern we habituate to. Thus, it is not crude oils intrinsic qualities we crave but the biochemical sensations we have become accustomed to arising from creatively using its embodied energy.

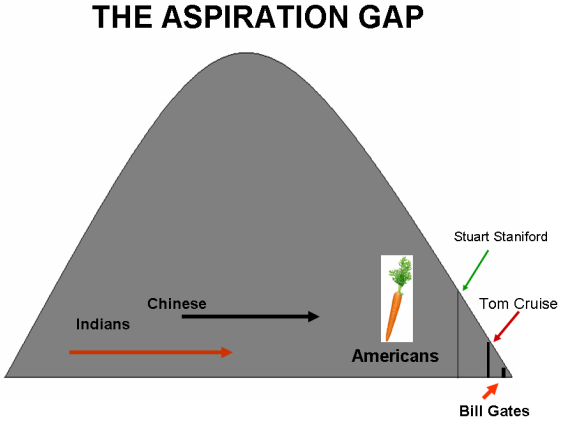
Take stock trading for example. **Neuroscience scans show that stock trading lights up the same brain areas as picking nuts and berries do in other primates, suggestive of what our ancestors must have 'felt' as they tried to increase resources.** In my opinion, there are three (at least) 'objectives' one gets from investing/trading in the market, in varying degrees in different people. Neoclassical economics suggests it is the efficient allocation of capital to the company that rewards the investor for risk. I think people trade for a)money/profit (to compete/move up the mating ladder), b)to be 'right', and c) for the excitement/dopamine of the unexpected nature of market movements. While they are not mutually exclusive, it is not clear to me which objective dominates, especially among people who have already attained infinite wealth (technically their annual expenses divided by the t-bill rate). This I witnessed first hand for many years as my billionaire clients on average were less 'happy' than the $30k a year clerks processing their trades. More exciting lives perhaps, but not happier. The rich wanted 'more' because they were habituated to getting more - it's how they kept score. Unless you inherit it, you don't get to be a billionaire if you are easily satisfied. Old brain - new choices.

Regarding compulsive shopping, if this were a rational process, and our choices were influenced only by need, then brand name t-shirts would sell no better than less expensive shirts of equal quality. The truth is that many shopping decisions are biased by corporate advertising campaigns or distorted by a desire to satisfy some competitive urge or emotional need. Payless Shoe Stores has just set up a website campaign for women who love shoes, etc. If the statistic in www.storyofstuff.com stating that 99% of what we buy ends up as trash within 6 months is correct, then we really have created an entropic machine (I don't know how to check that source - but the video is worth watching). The peak 'brain cocktail' is the moment we decide to buy that new 'item'. After a brief euphoria and a short respite, the clock starts ticking on the next craving.

Not shown on the chart would be many activities falling in the lower left part, both legal and low energy: gardening, reading books, playing games with the family, going for hikes, thinking, sleeping, playing sports, etc. Also not shown might be the hugest dopamine rush of them all - attaining high political office. Unlike heroin and opium which work on opiate receptors and 'satiate' the user, dopamine is a 'wanting' drug. One more orgasm, one more pair of shoes, one more million in the bank, one more social approval, one more check of my email, one more political notch, etc. I wonder what a brain scan of Hillary Clinton during a debate would look like compared to someone on cocaine. I'm guessing pretty similar. (fMRI machines, in order to function, have enormous magnets, and thus only work in lab settings - they cannot be made to be mobile in the forseeable future, but that would be fun)

Also missing on the graphic is violence. Recent research shows that the dopamine we (males) receive from aggression rivals that of food or sex. This is not encouraging.

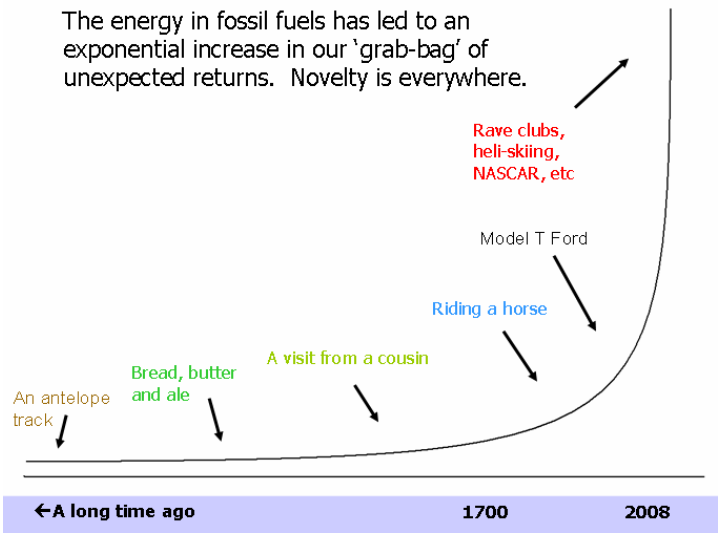
DOPAMINE ON A FULL PLANET



The Global Carrot for 6.6 billion and growing is What and Whom?(Click to enlarge)

So what are the drivers of economic growth and resource depletion? The "aspiration gap" is economic-speak for the relative fitness/status drive towards who/what is at the top of the status hierarchy. Envy is a strong motivator. A friend recounted that when he last visited Madagascar, the 5th poorest nation on earth, the villagers huddled around the one TV in the village watching the nations most popular TV show 'Melrose Place', giving them a window of desire into Hollywood glitz and glamour, and a beacon to dream about and strive for... More recently, a prince in the royal family of U.A.E. paid $14 million for a vanity license plate "1". "I bought it because I want to be the best in the world." said Khouri, whose family made its fortune in real estate. What message do the kids watching TV in U.A.E receive?

The above graphic is a hypothetical normal distribution of world population. Modern developed nations are competing for profits, yet we are doing so smack in the face of declining energy surplus. When a new child is born, it has all the genetic material he will ever have (all his ancestors until that moment have honed his/her neural wiring for fitness maximization - but when he is born, his genes will interact within the environment indicating what to compete for for status, respect, mating prospects, resources etc. From this point forward, the genes are 'fixed' and the infant begins life as an 'adaptation executor'. What will a child born in the 21st century 'learn' to compete for? Historically, we have always pursued social status, though status been measured in dramatically different ways throughout history. Currently, most people pursue money as a short-cut fitness marker, though some compete in other ways - politics, knowledge, etc. Modern fMRIs show artificial cultural objects associated with wealth and social dominance elicit activation in reward-related brain areas (Erk 2002) (in that study, peoples anterior cingulate lit up more (had more neural response) to visual cues of sports cars vs limosines or small cars). Thus, a large looming problem is that the Chinese (and other rapidly developing nations) don't just aspire the wealth of average Americans - they want whole hog to be millionaires. The only way this can happen is that after basic needs are met, the definition of 'millionaires' changes (or I suppose, central banks could dramatically increase the money supply)



A hypothetical human timeline of stimulation opportunities (Click to enlarge)

PEAK OIL AND LEAVING LAS VEGAS

I recently returned from a weekend trip to Las Vegas. On the plane home, full of disconsolate, exhausted zombies, it struck me that Vegas is a microcosm of modern society in several important ways.

1)On the plane ride to Vegas, everyone was giddy, sociable, even manic, anticipating all kinds of unexpected reward in the Babylon of 21st century. Once you get off the plane, its like you are on one extended 72 hour search for unexpected reward. Can't find it here? Let's go there. Craps, horses, poker, women, golf, swimming, booze, craps, massage, sleep, craps, women, sushi over and over. It's society compressed into a weekend.

2)I probably know more about the issues surrounding Peak Oil than 99% of people on the planet. Yet among the bright lights, freely flowing drinks, friendly company, and non-stop excitement, not only did I forget about our pending date with a global oil peak, but for about a 12 hour period,

under influence from friends, *Peak Oil actually seemed impossible*. There is no way all this glitz and glamour could end - the vitality in the casinos was viral. The availability heuristic, and other psychological phenomenon were very powerful indeed to thus anesthetize a peak oil curmudgeon like myself. (2 hours back at the cabin reading the Drumbeat straightened me right out). My point is that few will believe until events force them too. I've known this for a while, but this little personal vignette sealed the concept.

3)There is a shared mythology in America (and spreading) that we can each enjoy fame and opulence at the top of the social pyramid. Even though everyone (I think) knows the odds are stacked against them - they have hope *they* will be the big winner. 78% of Americans still believe that anybody in America can become rich and live the good life (15). The reality is that the longer one gambles in Vegas, the higher the odds are stacked against you. In our economic system, not everyone can be Donald Trump by definition - there are not enough resources - it's the carrot of potential reward that keeps people working 50 hours a week until they retire at 65. All cannot be first. All cannot be wealthy, which makes capitalism, on a finite resource planet not dissimilar from a Ponzi scheme.

4)Vegas may be a canary in our societal coalmine, as the just-in-time delivery model has to run just right in a desert community importing food, water and energy. Already, there are studies showing there may not be enough water for flat consumption by 2020, let alone enough for planned expansions and a new airport. The Mirage may one day be aptly named.

Given what I've outlined in this post, perhaps the *worst* thing that can happen to a 'new gambler' (or child) is to hit 777 or win big on his/her first experience - its sets up a mental feedback system via the amygdyla and reward pathways that raises expectations in the future, thus making the allure of one armed bandits, etc. difficult to just walk past. A similar setpoint may occur with skiing, buying a new car, making ones first million, or any number of socially sanctioned activities using energy....

"I hate to admit it, but a man with a big carbon footprint makes me hot."

CONCLUSIONS

This essay has explored some of the underlying drivers of resource depletion and human consumption: more humans competing for more stuff that has more novelty. The self-ambition and curiosity that Adam Smith hailed as twin engines of economic growth have been quite effective over the past 200 years. But Adam Smith did caution in "Moral Sentiments" that human envy and a tendency toward compulsions, if left unchecked, could undermine the empathic social relationships that would be essential to his economic model and the successful long term operation of free markets. Smith lived before the creation of the megacorporation, before 24 hour global commerce and before stock options and NASCAR. Amidst so much choice and wealth, we are discovering some uncomfortable facts backed up by modern neurobiology that confirm Adam Smiths fears. In an era of material affluence, when wants have not yet been fully constrained by limited resources, the evidence from our modern American experiment suggests that humans have trouble setting limits on their instinctual cravings. And our rational brains have an equally hard time acknowledging this glaring fact.

This essay has likened the chemical sensations we receive from many socially available stimuli in our fast paced world to the same neural patterns that occur with illicit drugs. "Addiction" can mean many things to many people. I am quite certain a psychiatrist would refuse to diagnose any of us with 'an oil addiction'. But perhaps not an ecologist. The literature from economics as well as psychology and neuroscience suggest that when an addict (broadly defined) is exposed to higher

prices, conventional economic theory will not hold. Since the rational actor model has now been thoroughly disproven so as to almost be an economic footnote, this should not come as a surprise.

In conclusion, dear reader, I have thrown a great deal of information your way. I hope it is clear(er) that we have both biological and cultural constraints on our behavior and that finding the next billion barrels may or may not prove to be a good thing. If you have read this far, I doubt you have serious addiction issues. An addict would likely not have had the patience to read 8,000+ words..;-)

SOME FINAL PHILOSOPHICAL MUSINGS

0. The Human Economy==> We turn natural resources into dollars, and then turn dollars into brain chemicals + waste.

1. If we *do* manage to increase societies aggregate energy gain, this surplus will be split amongst the entrepreneurs and consumers and ripple through the economic system like a deposit in a fractional banking system. More stuff to become habituated to. Thus, What Price Progress?

2. I have come to the conclusion that we cannot change our penchant to want more. We can only change how we define the 'more'. Put aside Peak Oil and Climate Change for the moment. We have it in us to 'nudge' how our brains get 'hijacked'. We can choose to go for a jog/hike instead of sending 10 emails and websurfing, we can choose to have a salad instead of a cheeseburger, we can choose to play a game or read a story with our children instead of making 5 business phone calls, etc. But most of these choices, in my opinion, require prior planning. Because 'at the moment', our brains will fall into the neural grooves that modern culture has worn into them. It takes conscious plans to change these behaviors, and for some this will be harder than for others (for me very hard). But in choosing thusly, we are likely making ourselves as individuals healthier and happier, with the positive externalities of using less energy and slowing and eventually reversing the societal stimulation feedback loop.

3. It sounds corny, but the ratio Dopamine/Entropy may be a better choice to maximize than many economic formulas. The brain is clearly not as simple as just a single one of over 100 neurotransmitters - but in our current cultural runaway feedback, dopamine looms large. However, in addition to maximizing Dopamine/Entopy, we know that we will want MORE (of something) in the future. So we have to build that in to the equation, and only *aspire* to maximize Dopamine/Entropy, e.g. keep the first derivative positive but second derivative negative (or zero). Perhaps maximizing ==>(Unexpected Reward-Expected reward)/Entropy might be a more complex but loftier goal. Food for thought.

4. In the 1970s resource concerns spawned analyses on net energy (Odum), limits to growth(Meadows et al) and criticism of the neoclassical economics model (Georgescu-Roegen, Daly), but the planet was still comparatively empty, and cheap resources still abounded. However, things are really starting to change quickly- the global rich are at least beginning to realize the implications of peak oil, even if they don't believe it is imminent. They will gradually understand that a GINI coefficient rising towards 1.0 and accelerating ecosystem destruction will not leave them or their children much of a place to enjoy their money. This means there is a real possibility of educating local, regional and national leaders (likely via the rich and powerful) towards a different system. It's now in their interests.

5. In my opinion, the United States has a monumental (though long odds) opportunity to shift the worlds carrot away from conspicuous consumption. As ostensible leaders of the free world, we need to set an example that others will follow. The only thing standing in the way is the overwhelming pursuit of profits as our end goal, despite the rationale for the economic system being continually debunked. At a minimum there needs to be government regulation of some areas of the market. Costs that have long been externalized need to be accounted for. Perhaps a system where the market allocates and votes on 'luxury items' while government manages the commons and basic goods? I do admit that Europe is a good deal further than we are on many of these fronts. My fear is that Americans 'ingenuity' will focus entirely on replacing our energy supply with lower EROI renewables, and thus not only miss the larger prize, but win the booby prize. (An upcoming post will be on The Tragedy of the Energy Investing Commons)

6. The planet is finite: there is only so much land, oil, water, dolphins and gold. No matter how efficiently we use our resources, if there are more users competing for more stuff, we will eventually run out of goods. However, information is limitless. We can explore, research, study, and learn as much as we wish. With the caveat that 8 hours of reading be balanced by hearty physical exercise, information is one thing we can compete for that uses few resources. Look at theoildrum.com as one example. Vernadskii dreamt of a system he called "noosphere" – a biosphere driven by human intellect, spirituality, knowledge, and understanding. This has a shot.....(but then, what would we DO with the information...?

7. There is anecdotal evidence that the typical american diet high in processed starches and sugar robs us of our baseline serotonin - the zen master of brain neurotransmitters. Lack of serotonin

makes us more susceptible to cravings/behavioural changes and throws the reward machinery out of whack. Food we buy/eat is available at stores and restaurants because a)it is profitable b)it is convenient and c)it tastes good. I suspect that future changes in diet towards more vegetables and less processed food might improve our collective addictions/impulsivity. However, this is speculation as the data is sparse.

8. If we can be neurally hijacked, what does it suggest about television, advertising, media, etc? The majority of the neuro-economic sources I used in writing this post were a *byproduct* of studies funded by neuromarketing research! How does 'rational utility' function in a society where we are being expertly marketed to pull our evolutionary triggers to funnel the money upwards??

9. In retrospect, this has not been a post about Peak Oil. From the perspective of perpetual wants in an existing system, Peak Oil may only appear to be a crisis, but it **might also be the needed catalyst for change**. We, collectively, are in charge, but need to look at the real big picture, with science, hope and community.

10 The propensity for neural habituation is analog, not digital. Each of us has something akin to an habituation potential 'rating' on a scale of 1-10 (1 being totally non-addictive and 10 being full-on addict -valuing only the next few minutes in their lives over any future rewards/punishments.) The higher the cultural composite sum of these ratings (adding up and averaging a population) the harder it will be to access long term positive decisions. Reducing our addictive behaviours (collectively) will make it easier to face the situations likely during an energy descent.

Footer This amazing photography work artistically frames some of the impacts of the ideas in this essay.)

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(editor's note by PG: This is a slightly revised post adapted from this one which originally ran about a year ago, but it seemed time to bring it back out again. :))