Addiction to drugs, evolution and society: a study on the addiction starting from the evolutionary psychology

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Revista de Humanidades, 26 (2015). p. 129-144. ISSN 1130-5029

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La adicción a las drogas, evolución y sociedad: un estudio sobre la adicción a partir de la psicología evolutiva

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Recibido: 4 de abril de 2015
Aceptado: 6 de mayo de 2015

Abstract

This article aims to analyze the evolutionary foundations of human addiction to psychoactive substances. To this end, we used two recurrent dichotomous hypotheses in evolutionary psychology literature. The first is that natural selection has structured mechanisms of pleasure in our mind that are linked to the maintenance of life and the reproductive success, and in that drugs are a kind of shortcut within these mechanisms, the co-opts so to speak. In this context the addiction would be linked to chemical imbalance in our brain caused by a wear. The other hypothesis is that psychoactive drugs were important for the maintenance of life of our ancestors when going through difficult times or uncertainties. So, if we consider its addictive factor it would be an adaptive consequence of the common use of drugs in the past. Our results show that even that is not possible to define which of the hypotheses is more adherent, both results show that humans are susceptible to addictions.

Keywords: Natural Selection; Evolutionary Psychology; Psychoactive Drugs; Addiction

Resumen

Este artículo tiene como objetivo analizar los fundamentos evolutivos de la adicción humana a las sustancias psicoactivas. Con este fin, hemos utilizado dos hipótesis dicotómicas recurrentes en la literatura de la psicología evolutiva. La primera es que la selección natural ha estructurado mecanismos de placer en nuestra mente que están vinculados con el mantenimiento de la vida y el éxito reproductivo, y donde las drogas son una especie de atajo dentro de estos mecanismos, el co-opta por así decirlo. En este contexto, la adicción estaría vinculada a un desequilibrio químico en

el cerebro causada por un desgaste. La otra hipótesis es que las drogas psicoactivas eran importantes para el mantenimiento de la vida de nuestros antepasados al pasar por momentos difíciles o incertidumbres. Por lo tanto, tenemos en cuenta su factor adictivo, que sería una consecuencia de adaptación de la utilización común de las drogas en el pasado. Nuestros resultados muestran que no es posible definir cuál de las hipótesis es más adherente, ya que ambos resultados muestran que los seres humanos son susceptibles a las adicciones**.**

Palabras clave: Selección natural; Psicología Evolutiva; Drogas psicoactivas; Adicción

Para citar este artículo: Moraes, Thiago Perez Bernardes de; Torrecillas, Geraldo Leopoldo Silva de (2015). Addiction to drugs, evolution and society: a study on the addiction starting from the evolutionary psychology. *Revista de Humanidades*, n. 26, p. 129-144, ISSN 1130-5029 (ISSN-e 2340-8995).

1. INTRODUCTION

The use of psychoactive drugs comes representing a huge public health problem in most countries in the world. In this sense we need to consider the epidemiological weight that drugs represent to society. A relevant path for this purpose is assessing the possible determinants of drug addiction factor.

It is known that it does not seem an easy task to predict human actions. This way a serious epistemological discussion about human behavior is needed. From the perspective of evolutionary psychology, this article aims to offer theoretical and epistemological concepts able to give relevant information for legislators, public officials and private managers, as well as everyone interested in the subject of human nature. We have agreed in advance with the arguments of Pinker (2004), Riddley (2004), and other important evolutionary scientists who argue that despite having become the idea of tabula rasa (blank state) that human behavior is neutral and only influenced by the external environment is somewhat empty and unreal, given the fact of more recent evidence to the contrary produced by behavioral genetics, evolutionary psychology and the other areas[1] of behavior study.

1 Several cognitive scientists have adopted evolutionary approaches to explain the phenomena linked to the specialized areas of the brain. Following that same line of thought, we have the emergence of a branch of science now known as evolutionary cognitive neuroscience in an effort to integrate archeology, physical anthropology, paleoneurology, primatology, evolutionary, cognitive and social psychology, in an effort to describe the neural mechanisms that were forged during the long period of human selection, where pressures acted in shaping the human mind (Krill, Platek, Goetz & Shackelford, 2007; Moraes & Millani, 2014).

First, from the perspective of evolutionary psychology, we aim to offer assistance to the difficult dilemmas in addiction. The human mind is structured by means of natural selection, it built brain specializations that to some extent are capable of causing addiction. A group of evolutionary psychologists have created a neurobiological model where it is unanimous the idea that the ancestral environment is totally antagonistic towards the modern environment in a way that the second offers more in terms of drug toxicity than the first. Following that same line of thought, the cognitive mechanisms created to solve adaptive problems are co-opted by psychoactive drugs giving a fake sense of Darwinian aptitude gains. The second hypothesis is that unlike a co-option, the addiction is an adaptation itself, given that the evidence indicates a long evolutionary contact between mammals and psychoactive substances.

This study is divided into three parts including this introduction. In the second part we designed a model of brain evolution valid to all neurobiology and we exposed both evolutionary views regarding addiction. In the last chapter we wrote the conclusions.

2. MIND, BEHAVIOR AND ADDICTION.

2.1. Frame of mind in evolutionary perspective, three-phase model of mind structuring

Fowler notes that in the last 50 years the fields of biology and the social science have produced, within their limitations, major contributions to the study of human behavior. Biology had a remarkable advance in the perception and the development of taxonomies and investigative methods on the brain and its development, and the social sciences have made considerable progress managing to explain the effect of the social environment on the masses and on the political behavior. However, each area has advanced to a limited extent, suggesting that, to fully understand social phenomena increasingly complex, social scientists and biologists should now develop joint efforts, seeking to advance more significantly in studies of human nature (Fowler & Schreiber, 2008). In our article we have the same goal Fowler does, that is, to not bequeath the phenomena and explanations either by biological determinism, or the social determinism. Above all, we sought a more complex and integral understanding of man in the light of evolutionary psychology.

According to Mithen (1995, 2000, 2002), to understand the structure of the human mind, researchers must use various sources of data. One of the most significant are those raised by archaeologists. Understanding the neural structure requires going back at least six million years, because it seems there were two distinct types of apes who followed different paths, one in its evolutionary journey, became “man” and the other, from modern apes, gave origin to chimpanzees and gorillas. Humans are

biological beings with relatively high ability to adapt to different environments and cultures. There were at least four evolutionary forces that provided such conditions to men, these being the mutation, gene flow, genetic drift and the natural selection (Haviland, Prins, Walrath & Mcbride, 2011; Moraes, 2013, 2014).

It must be considered that the main key of natural selection in this line of thought is adaptation, which passed on from generation to generation assists individuals in survival and reproduction. However, there are other changes in the process which can be classified in different ways, such as noise and also byproducts. Noise is a random genetic change that has no significant impact on the life and reproduction of the individual. Byproducts are, so to speak, unintended consequences of adaptation. Commonly the social sciences conceive the mind as a *tabula rasa*, which has no innate activity and only learns from experiences. However, advances in areas of anthropology, neuroscience and biology argue that, on the contrary, the brain already has its own knowledge, and yet, it is modular, that is, it is composed of several specialized modules designed for specific activities (Liddle, Bush & Shackelford, 2011; Gorelik, Shackelford & Weekes-Shackelford, 2012).

Mithen (1998, 2000) divided the mind structuring process into three major phases. At first, the minds are governed by intelligence; so to speak, more general, and a range of rules on decision-making and general learning are acquired. In the second phase, general intelligence has been refined and enhanced with specialized intelligence, where intelligence acts on a specific domain.

In the third phase, multiple intelligences, general and specialized, seem to work in an integrated manner, converging in a flow between knowledge and behavioral domains. Evolutionary psychology, first, that points to the social intelligence, a specialized field of useful mind to interact with other individuals and also read your own mind. The second trace is an apparent naturalist intelligence, linked to the understanding of the natural world, essential for life of hunters and collectors. The other trace left by intuitive physics is technical intelligence, where the modules responsible for handling and manufacturing utensils were housed. Perhaps in that same line of thought, there is a fourth one, that is, the *linguistic intelligence* (Mithen, 2006).

Compared to the mind of our closest ancestors, the apes[2], although there are consistent similarities, there are huge discrepancies in relation to the knowledge base of the ape interaction with the natural world in a line of thought which, although

2 With the completion of the genome, important quantitative and qualitative comparisons can be made. An interesting debate at this point is in the quantitative analysis of DNA difference of humans and chimpanzees is set at 98.5%, however some argue against this number and say if they are added in the count insertions or textual deletions certainly the number drops to 95 % (Riddley, 2004). The most striking differences between men and apes are in brain size (significantly bigger) and the fact that men are bipeds. Apparently bipedalism is also related to brain growth, because it occurred after a stage of development where the brain had a greater volume than the other primates (Haviland, Prins, Walrath & Mcbride, 2011).

Table 1. Stages of human evolution

Between 4.5 and 6 million years ago there were no significant traces, which lead the investigation of this period almost to the complete darkness. The only common ancestor that appears in this period is the ape in Africa.	From 4.5 to 1.8 million years ago, a period of 2.7 million years is a period that left some archaeological evidence that interpreted today, gives us some light on evolution, but still leave room for speculation. Some specialists prefer to highlight, among the possible beings of this period, the *homo habilis*, but it is speculated that there have been other two, the *homo rudolfensis* and *homo ergaster*. The three, along the development of their characteristics, showed differing patterns of behavior, especially concerning the *homo habilis*[3], which added the meat[4] to its diet and learned to manipulate tools. The other two were vegetarians and they presented themselves with a much stronger morphology in comparison to *homo habilis.*
Later in history, between 1.8 million and 100,000 years ago, we have the presence of *Homo erectus*, which, it seems is descended from *Homo habilis*. *Homo erectus* appears to have arrived simultaneously at three different points in the world: East Africa, China and Java, a scenario which now includes the Middle East, East Asia and South. Around 150,000 years ago another being emerged, *homo neanderthalensis* – or in English, Neanderthal Man. The tools found dating back to this period, within an interval of at least 1 million years, are like *kits of tools* basically composed of rearranged items, some showing a high and sophisticated level of skill in manufacturing, most of them were made of stone or wood, and in some cases bones.	Finally, a range even shorter and recent, from 100,000 years ago to the present day, appears in this scenario the most curious being of all, our own species, *Homo sapiens*. It is first seen in South Africa and the Middle East, in a group that includes Neanderthals and *Homo sapiens archaic*. However, the most surprising event seems to have occurred 60.000 years ago, when combined with the construction of the first vessels and a restricted number of tools, the building a wide variety of objects began, made with a multitude of materials. Then, men start building houses, practicing arts, manufacturing sophisticated tools, in accelerating pace of cultural production, which continues to the present day.

Source: preparation based on Howells, 1997; Mithen, 1997, 2002, 2009; Dutton, 2009.

3 *Homo habilis* appears to have been disposed of the ability to build great mental banks on the characteristics of the world, and also there seems to be a complement about that where evidence points that it was also able to follow and decipher visual keys and to develop hypotheses, for example on the whereabouts of a possible prey. What we can say is that multiple intelligences are still developing and the greatest *background* is still the *general intelligence*. However, the size of the brain of the *homo habilis* compared to its predecessors already suggested that it was also endowed with a great *social intelligence* (Mithen, 1995).

4 Our bodies today are adapted physiologically to the diet of Pleistocene hunters, wild animals, fruits, nuts, and vegetables. One has to consider that many of the diseases today, such as the circulatory, are linked to our current diet which very little resembles the one our body is adapted to (Moraes, 2013, 2014).

Table 2. Three-phase model of the evolution of the human mind.

In the first phase, the mind is dominated by a single module where every thought process occurs. In its development, this phase provided a series of rules of general learning and decision-making, although in this scenario the cognitive faculties were still somewhat improved, with frequent mistakes, not finding any significant signs of sophisticated behavior patterns.	In the second phase, the general intelligence nature remains, but a series of specialized intelligences appeared and developed, where each of the intelligences is effective in a given area that is vital to the functioning of the mind as a whole. During this period, it seems, there were at least three dominant thought areas.	In the third phase, there is some fluidity between the information of the various areas, once virtually incommunicable, in a dynamic way, with free access of information among the areas. In this phase, the evolution led the mind to manage jointly thoughts and specialized intelligences.

Source: preparation based on Mithen, 1998, 2005.

unable to establish a complex relationship with the natural, it seems to be little endowed with creativity to manage the knowledge of the natural world. Apparently, unlike us, the other primates seem to have a mind with a few micro domains that enable the construction of natural mental "maps" (Mithen, 1997, 2006).

Observing a newer part of the history of human evolution, *Homo habilis*, throughout its evolution, structured a mental[5] cathedral very similar to its ancestor six million years ago, with the difference that the areas of social intelligence and technique were greater. They were still incomplete (Mithen, 2002; Moraes & Millani, 2014).

2.2. The addiction to psychoactive drugs as a co-option of adaptive functional mechanisms

As for the researches on addiction, it is clear that there are few studies that in evolutionary perspective treat the neurochemical effects of addiction in the brain. Our body has developed a wide range of stimuli processors, in this sense, psychoactive

5. Through the entire nervous system the brain allows us to perceive the world that goes well beyond the classic 5 senses, named sight, hearing, touch, smell, and taste. Through a range of specialized cells, the energy projected on the environment, an interface to the body, is perceived in many different ways. The body detects from subtle changes in temperature, lights, sounds, tastes, humidity, etc. Even the classic senses, when analyzed more closely, show very complex patterns, like the vision for example, we are able to identify colors, moving colors, lights. The same applies to the other senses. The specific receptors in the body can be classified as follows: 1) mechanoreceptors, 2) photoreceptors, 3) thermoreceptors and 4) chemoreceptors. Moreover, each of these is divided into many other subtypes even more specialized. However, not all the information that is obtained through these mechanisms becomes aware and much of this information remains at the level of unconscious information and is used for example for the coordination of motor skills, and for the functioning of the organs.

substances act on these emotional mechanisms and cause situations of apparent gains of aptitude, sense of well-being. These mechanisms are not developed in order to be effective receivers of psychoactive substances, but something like a thermometer, which from the body chemicals results indicates their status. In this sense, addiction seems to be closely linked to the chemical imbalance of the brain, as well as social (Koob & Moal, 2001; Panksepp, Knutson & Burgdorf, 2002; Durrant, Adamson, Todd & Sellman, 2009).

We can say that emotions and their regulators were made by natural selection in order to expand the reproductive possibilities, that is, they are not guided only on survival as well as the maximization of individual skills, and not necessarily those of the group. This means that the pressures of natural selection caused changes in the brain system. Emotions were shaped by adaptive challenges, and in this sense we can say in advance that emotions on an evolutionary scale can to some extent be defined as pleasurable or painful, so there are no neutral emotions. Emotions forced the more or less advantageous individuals the necessity of natural selection to breed, and also positive emotions such as euphoria and excitement, provided health gain. But negative emotions seem to have been developed as defenses. Anxiety and pain, for example, appear to be defenses leading the individual (or should lead) to manage their potential threats (Nesse & Berridge, 1997; Nesse, 2002; Saah, 2005).

Actions that increase the skills of Darwinian type tend to generate pleasure, such as friendships, or good food, or sex. In this sense, psychoactive drugs such as opium or cocaine[6] seem to act as a shortcut in the pleasure mechanism. We understand that they remind us of sensations that in remote periods did not necessarily remind us of happiness, but the feeling of satisfaction, health, and time to maximize their aptitude indicators. In ancient times these feelings were linked, for example, to the embodiment of a mating ritual, or a successful hunt. However, the use of substances that alter our mental states do not offer the same expected gains of aptitude indicators, and ultimately, it can act in a pathogenic way imposing a cycle between mental circuits, because these drugs act mainly on still archaic mechanisms of the brain and while inducing positive emotions, it is often made by default, for example, of

6. Cocaine, when smoked, snorted or injected acts in the body providing an accumulation of dopamine. Once fixed, dopamine starts to stimulate the neural receptors and alter the electrical impulses in the receiving cells, altering the functions of these cells. To maintain the chemical balance the brain has produced more or less dopamine. Cocaine accordingly interfering in this control mechanism, occupies the cells that transport dopamine, leading to an accumulation of dopamine. But Cocaine also acts preventing the action of other neurotransmitters such as serotonin and norepinephrine, but to a lesser extent (Nestler 2005). Based on the test with insects (bees) in contrast to the data form test with mammals, with the use of cocaine, there was the hypothesis that cocaine is an effective compound of defense from the plant which acts through the disorder of the herbivore motor control. In this case the neurochemical systems targeted by cocaine modulate the reward processing, this way the reinforcing properties / cocaine addiction are a side effect (Barron, Maleszka, Helliwell & Robinson, 2009).

neurobiological defenses. If the use is extended, these mechanisms are destabilized, which can lead the normal life to become even more unpleasant and induce more to addiction (Nesse, 1994; Pharo, 2011; John-Smith, McQueen, Edwards & Schifano, 2013; Fox, Oliver & Ellis, 2013).

One of the causes that also lead to compulsive[7] use is the masking of negative emotions. However, the chemical wear that substances cause to the brain flora does not allow these effects to last long. Therefore, we propose that the addiction is in correlation with a complex system of rewards the brain structure owns (Saah, 2005).

In summary we can understand that the high perception of dopamine and serotonin, in a remote period where the brain was more emotional and sensitive to these substances[8], can be understood as a high adaptive capacity for this time, however, compared to our current habits, this need for dopamine and serotonin in the body, combined with the use of psychoactive substances, represents a profound disadvantage (Wise, 1988, 1996; Savage, Joranson, Covington, Schnoll, Heit & Gilson, 2003).

Anyway only the dopamine deficit in due deficit to drug use, and the serotonin deficit that may decrease rationality in decision making, are not fully determining factors for addiction. One has to consider, above all, the social structure in which the individual is addictive inside.

At first, the exposure of the arguments in this section leads us to believe that, it seems, there is still a strong influence of factors related to the very structure of the brain and natural selection. In this case, what is stated is that the brain is not adapted to the use of psychoactive substances; in this case, the use can lead to addiction, especially due to the chemical imbalance caused in the brain. This is the broader view in evolutionary psychology, however, there are few authors who point out an opposite direction, that supposedly we would have adapted to the use of drugs, and yet, they would have been decisive for the survival of our ancestors. This matter will be dealt briefly below.

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7 About the adaptive effects from the pressures of natural selection, there are those effects that require fairly large periods of time. It is possible to say that given the fact of recent changes in human habits, we are not biologically adapted to many of them and many of our adaptations of the past today represent disorders, and in many cases, disadvantages (Krill, PlatekGoetz & Shackelford, 2007). There are new neurological evidence indicating wear, especially in the prefrontal cortex, a region that accounts for complex functions such as behavioral autonomy and self-control. We understand then that because some drugs cause wear in this region, there is a tendency to develop a more compulsive behavior in neuropsychological tests with brain imaging revealed that the frontal lobes are particularly vulnerable to the effects of drugs, especially cocaine and alcohol (Lyvers, 2000).

8 One has to consider the role of economic globalization, according to Gonçalvez (1999; 2003). Globalization in Latin America has increased drug trafficking, and the levels of violence.

2.3. The addiction to psychoactive substances as a biological adaptation.

There is an interesting paradox, on the one hand, it seems various plants and vegetables developed toxicity levels as a natural defense to avoid being consumed. However, how is it that some mammals have not only developed some level of tolerance towards this toxicity, but in the end, have become addicted to it? On the one hand we have the explanation, as given earlier in this article, that addiction is linked to the functionality of own reward pathways of the brain structure, however it is possible to raise a doubt about it, or at least introduce other explanatory way.

Interestingly, archaeological evidence shows that at least 13,000 years ago, men were using a wide range of psychoactive[9] substances. The substances found included coffee, tobacco, khat, coca, and betel nut in various locations around the globe. Two anthropologists at the University of Berlin, Sulivan and Hagen, believe that the compulsive use of psychoactive substances may have been introduced as human social practice in even very remote times, as a way to relieve tension and discomfort when facing difficult times of scarcity of nutrients. Through substances that increased the amount of neurotransmitters of dopamine and serotonin in the body, the man may have fought in ancient times against the cold, hunger, mood, fatigue, pain (Sulivan & Hagen, 2002).

The argument here goes against the traditional view proposed that addiction is linked to the mechanism of pleasure, there is a relation of rewarding feedbacks. However, the most common addictive drugs used today are derived from plants that have evolved mechanisms to punish those who do not use it for gratification.

9 Almost all recreational drugs today, ranging from caffeine, nicotine, THC (active substance of cannabis), cocaine, amphetamines and heroin (except alcohol) are neurotoxins plants, including synthetic drugs that are composed of several of these neurotoxins. In this sense there are two trends of dichotomous explanatory; the first stream comprises phyto biologists, ecologists and pharmacologists that studying plants and interaction with herbivores conclude that the psychoactive effects of some plants are intended to scare away the herbivores; otherwise there is a group mainly composed by neurobiologists that emphasize the role of reward dependence, then the addiction would be a result of drug interference with the natural reward systems (which is where it fits this article). For the two perspectives the authors raise some points, first, there are interesting data on the domestication of plants that signal that the man may have a very long relationship with psychoactive substances; Second, it seems that it is unlikely that the first human populations applied significant selective pressure on plants, in this case, we understand that plants evolved to defend themselves, especially invertebrate and vertebrate herbivores, in this case, a precedent for further studies comparing the similarity of action of neurotoxic drugs on dopamine systems of vertebrates and invertebrates was opened up. The plant drugs may have been used as a signaling component, which means that in addition to toxic effects, the plant may have evolved to trigger the central nervous system of herbivores, especially the areas related to attention and learning about local environment certainly dangerous. Finally, considering that most drugs are toxic, the relative absence of overdose can indicate the presence of mechanisms mediating this case, resistance. Here is the speculation in the meaning that the drug may have provided along the natural selection, benefits that outweigh its costs (Hagen, Sullivan, Schmidt, Morris, Kempter & Hammerstein, 2009).

There is a small group of authors that present some interesting evidence, either in evolutionary plant ecology, or in genetic of hepatic enzymes, there is a growing research around the *cytochrome p450*, indicating that it seems the hominids were exposed to the toxins of plants along of all their development, including those that affect the nervous system of animals. In this case, in summary, there may be the possibility of humans have evolved to acquire increased strength in relation to neurotoxins, as a way of counterweight to the adapting of plants to become harmful (Sulivan, Hagen & Hammestein, 2008). In the Table 3 below, we listed the main examples of enzymes that interact with *cytochrome p450* to promote detoxification in the metabolism. We understand that the phylogenetic data presented here on the *cytochrome p450* in mammals are evidence of the existence of a long evolutionary history of exposure to plant toxins. This fact alone seems to distort the hypothesis that human exposure to toxins is evolutionarily recent which in turn promotes a mismatch between current drugs and the ancestral period.

Table 3. Examples of human enzymes of cytochrome p450 important in drug metabolism.

CYP1A2	**CYP2A6**	**CYP2C8**	**CYP2C9**	**CYP2D6**	**CYP2E1**	**CYP3A4**
Caffeine (Coffee)	Nicotine (Tobacco)	Taxol (*Taxus brevifolia*)	Δ9-THC (*Canabis sativa*)	Codeine (*Papaver somniferum*)	Theobromine (Cocoa/ Chocolate)	Cocaine (*Erythroxylon coca*)
Theophylline (*Camellia Sinensis*)	Coumarin (*Bean tonka dipteryx odorata*)	***	***	Harmala (*Peganum harmala*)	***	Quinine (*Cinchona*)
Theobromine (Cocoa/ Chocolate)	Cotinine (metabolite of nicotine)	***	***	Harmala (*Peganum harmala*)	***	***
***	***	***	***	Sparteine (*Lupinus*)	***	***
***	***	***	***	Yohimbine (Pausinystalia yohimbe)	***	***

Source: (Sullivan, Hagen & Hammerstein, 2008; Kirkham, 2009; Forbey & Foley, 2009; McKey, Cavagnaro, Cliff & Gleadow, 2010).

In this sense, it can be said here that humans have adapted to drug use, just to enjoy its benefits, if it was not for the adjustments related to *cytochrome p450* within a few generations, in case they did not have any use, they would disappear

due to the mechanism of genetic drift. In addition to the evolutionary aspect implicit in the human propensity to addiction to drugs is precious that we consider the role of epigenetics. In this sense one has to consider that the use of drugs can in some measure changing the pattern of DNA methylation. In the Table 4 below are the five factors that should be considered about drugs and epigenetics. If humans throughout their evolutionary history outside exposed to psychoactive drugs, it is very likely that the epigenetic mechanisms proposed must have exercised enormous influence in shaping the human cognitive framework. In this case is to say that epigenetics may have become faster and the dynamic process of co-evolution between humans and psychoactive drugs.

3. CONCLUSION

Undoubtedly it is necessary that we advance forward regarding the understanding of the neurobiological addiction and its vectors. Future researches should include the elements of ecology and evolutionary psychology in order to assess how the toxins and the human cognition co-evolved.

A large part of the evolutionary psychologists argued that drugs represent a shortcut into the mechanisms that were created by natural selection to manage functional emotions. This argument assumes the premise that the ancestral environment is toxicologically very different from the ancestral period, so the addiction to drugs can be defined as a co-optation. The other view is that the addiction to drugs is not an evolutionary accident, that is because evidence indicates (especially that linked with *cytochrome p450*) that exposure to toxins comes from a long evolutionary history, and in that sense the addiction would not be a co-option but an adaptation.

It is beyond the scope of this study to answer which of the two views are right, only future studies will be able to tell us. Anyway, both assumptions predict that some drugs are more physically aggressive than others. Regardless of addiction being an adaptation or co-optation of functional mechanisms, the replacement of drugs with greater epidemiological weight (more physically aggressive, more addictive) by milder drugs (physically less harmful and less addictive) seems to be one way for functional preventive health and that meets the singularities of human neurobiology.

4. REFERENCES

Barron, A. B.; Maleszka, R.; Helliwell, P. G. & Robinson, G. E. (2009). Effects of cocaine on honey bee dance behaviour. *Journal of Experimental Biology*, *212* (2), 163-168. DOI: http://dx.doi.org/10.1242/jeb.025361

Durrant, R.; Adamson, S.; Todd, F. & Sellman, D. (2009). Drug use and addiction: evolutionary perspective. *Australian and New Zealand Journal of Psychiatry*, *43* (11), 1049-1056. DOI: http://dx.doi.org/10.3109/00048670903270449

Dutton, D. (2009). *"The" Art Instinct: Beauty, Pleasure, and Human Evolution*. Oxford: Oxford University Press.

Forbey, J. S. & Foley, W. J. (2009). PharmEcology: A pharmacological approach to understanding plant-herbivore interactions: an introduction to the symposium. *Integrative and comparative biology*, *49* (3), 267-273. DOI: http://dx.doi.org/10.1093/icb/icp020

Fowler, J. H. & Schreiber, D. (2008). Biology, politics, and the emerging science of human nature. *Science*, *322* (5903), 912-914. DOI: http://dx.doi.org/10.1126/science.1158188

Fox, T. P.; Oliver, G. & Ellis, S. M. (2013). The Destructive Capacity of Drug Abuse: An Overview Exploring the Harmful Potential of Drug Abuse Both to the Individual and to Society. *ISRN Addiction*. DOI: http://dx.doi.org/10.1155/2013/450348

Gerald, M. S. & Higley, J. D. (2002). Evolutionary underpinnings of excessive alcohol consumption. *Addiction*, 97 (4), 415-425. DOI: http://dx.doi.org/10.1046/j.1360-0443.2002.00023.x

Gonçalvez, R., (1999). *Globalização e desnacionalização*. 1ª ed. São Paulo: Paz e Terra.

Gonçalvez, R., (2003). *O nó econômico*. 1ª ed. Rio de Janeiro: Record.

Gorelik, G., Shackelford, T. K., & Weekes-Shackelford, V. A. (2012). *27 Resource Acquisition, Violence, and Evolutionary Consciousness*.

Hagen, E. H.; Sullivan, R. J.; Schmidt, R.; Morris, G.; Kempter, R. & Hammerstein, P. (2009). Ecology and neurobiology of toxin avoidance and the paradox of drug reward. *Neuroscience*, 160 (1), 69-84. DOI: http://dx.doi.org/10.1016/j.neuroscience.2009.01.077

Haviland, W.; Prins, H.; Walrath, D. & Mcbride, B. (2011), *Princípios de Antropologia*. São Paulo: Cengage Learning.

Howells, W. W. (1997). *Getting here: The story of human evolution*. Howells House.

House. John; Smith, S.; McQueen, D.; Edwards, L. & Schifano, F. (2013). Classical and novel psychoactive substances: rethinking drug misuse from an evolutionary psychiatric perspective. *Human Psychopharmacology: Clinical and Experimental*, 28 (4), 394-401. DOI: http://dx.doi.org/10.1002/hup.v28.4

Kirkham, T. C. (2009). Endocannabinoids and the non-homeostatic control of appetite. In *Behavioral Neurobiology of the Endocannabinoid System*. Berlin: Springer, p. 231-253.

Koob, G. F., & Le Moal, M. (2001). Drug addiction, dysregulation of reward, and allostasis. *Neuropsychopharmacology*, *24* (2), 97-129.

Krill, A. L., Platek, S. M., Goetz, A. T., & Shackelford, T. K. (2007). Where evolutionary psychology meets cognitive neuroscience: A precís to evolutionary cognitive neuroscience. *Evolutionary Psychology*.

Liddle, J. R., Bush, L. S., & Shackelford, T. K. (2011). An introduction to evolutionary psychology and its application to suicide terrorism. *Behavioral Sciences of Terrorism and Political Aggression*, 3 (3), 176-197. **DOI:** http://dx.doi.org/10.1080/19434472.2010.512157

Lyvers, M. (2000). "Loss of control" in alcoholism and drug addiction: a neuroscientific interpretation. *Experimental and clinical psychopharmacology*, 8 (2), 225. DOI: http://dx.doi.org/10.1037/1064-1297.8.2.225

McKey, D.; Cavagnaro, T. R.; Cliff, J., & Gleadow, R. (2010). Chemical ecology in coupled human and natural systems: people, manioc, multitrophic interactions and global change. *Chemoecology*, 20 (2), 109-133. DOI: http://dx.doi.org/10.1007/s00049-010-0047-1

Mithen, S. (1994). Technology and society during the Middle Pleistocene: hominid group size, social learning and industrial variability. *Cambridge Archaeological Journal*, 4 (01), 3-32. DOI: http://dx.doi.org/10.1017/S0959774300000949

Mithen, S. (1995). Palaeolithic archaeology and the evolution of mind. *Journal of Archaeological Research*, 3 (4), 305-332.

Mithen, S. (1997). Cognitive archaeology, evolutionary psychology and cultural transmission, with particular reference to religious ideas. *Archeological Papers of the American Anthropological Association*, 7 (1), 67-74.

Mithen, S. (1998). A creative explosion. *Creativity in human evolution and prehistory*, 155-193.

Mithen, S. (2000). Mind, brain and material culture: An archaeological perspective. *Evolution and the Human Mind: Modularity, Language and Metacognition.* Cambridge: Cambridge University Press, 207-217.

Mithen, S. (2002). *A pré-historia da mente. Uma busca das origens da arte, religião e da ciência.* 1ª ed. São Paulo: Unesp.

Mithen, S. (2005). *The singing Neanderthals: The origins of music, language, mind, and body*. Harvard University Press.

Mithen, S. (2006). Ethnobiology and the evolution of the human mind. *Journal of the Royal Anthropological Institute*, 12 (s1), S45-S61. DOI: http://dx.doi.org/10.1111/j.1467-9655.2006.00272.x

Mithen, S. (2009). The Music Instinct. *Annals of the New York Academy of Sciences*, 1169 (1), 3-12. DOI: http://dx.doi.org/10.1111/j.1749-6632.2009.04590.x

Moraes, T. P. B. (2013). ¿Por qué los hombres presentan un comportamiento más agresivo que las mujeres? Por una antropología evelutiva del comportamiento agresivo. *Nómadas: Revista Crítica de Ciencias Sociales y Jurídicas*, 37 (1), 93-111.

Moraes, T. P. B. (2014). Politica, biologia e natureza humana. Uma introdução aos estudos de biopolítica evolutiva. *Revista Electrónica de Psicología Política*, 12 (32).

Moraes, T. P. B., & Millani, F. (2014). Consumo Conspícuo e Racionalidade Limitada. Uma Crítica à Teoria da Escolha Racional a Partir da Psicologia Evolucionista. *UNOPAR Científica Ciências Humanas e Educação*, 15(2).

Nesse, R. M. (1994). An evolutionary perspective on substance abuse. *Ethology and Sociobiology*, 15(5), 339-348.

Nesse, R. M. (2002). Evolution and addiction. *Addiction*, 97(4), 470-471.

Nesse, R. M. & Berridge, K. C. (1997). Psychoactive drug use in evolutionary perspective. *Science*, 278 (5335), 63-66.

Nestler, E. J. (2005). The neurobiology of cocaine addiction. *Science & Practice Perspectives*, 3 (1), 4.

Nestler, E. J. (2014). Epigenetic mechanisms of drug addiction. *Neuropharmacology*, 76, 259-268. DOI: http://dx.doi.org/10.1016/j.neuropharm.2013.04.004

Panksepp, J., Knutson, B., & Burgdorf, J. (2002). The role of brain emotional systems in addictions: a neuro-evolutionary perspective and new 'self-report' animal model. *Addiction*, 97(4), 459-469. DOI: http://dx.doi.org/10.1046/j.1360-0443.2002.00025.x

Pharo, P. (2011). Sociologie cognitive et morale de l'addiction. *Revue française de sociologie*, 51(4), 692-719. DOI : http://dx.doi.org/10.3917/rfs.514.0692

Pinker, S. (2004). *Tábula Rasa. A negação contemporânea da natureza humana*. São Paulo: Companhia das Letras.

Riddley, Matt, (2004). *O que nos faz humanos. Genes, natureza e experiência*. 1st ed. São Paulo: Record.

Saah, T. (2005). The evolutionary origins and significance of drug addiction. *Harm reduction journal*, 2 (8), 2-8. DOI: http://dx.doi.org/10.1186/1477-7517-2-8

Savage, S. R.; Joranson, D. E.; Covington, E. C.; Schnoll, S. H.; Heit, H. A. & Gilson, A. M. (2003). Definitions related to the medical use of opioids: evolution towards universal agreement. *Journal of pain and symptom management*, 26 (1), 655-667. DOI: http://dx.doi.org/10.1016/S0885-3924(03)00219-7

Sullivan, R. J. & Hagen, E. H. (2002). Psychotropic substance seeking: evolutionary pathology or adaptation? *Addiction*, 97(4), 389-400.

Sullivan, R. J., Hagen, E. H., & Hammerstein, P. (2008). Revealing the paradox of drug reward in human evolution. *Proceedings of the Royal Society B: Biological Sciences*, 275(1640), 1231-1241. DOI: http://dx.doi.org/10.1098/rspb.2007.1673

Wise, R. A. (1988). The neurobiology of craving: implications for the understanding and treatment of addiction. *Journal of Abnormal Psychology*, 97 (2), 118.

Wise, R. A. (1996). Neurobiology of addiction. *Current opinion in neurobiology*, *6* (2), 243-251.