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ESSAY

# Theoretical Insights of Evolutionary Psychology: New Opportunities for Studies in Evolutionary Ethnobiology

**Joelson Moreno Brito Moura[1,4] · Risoneide Henriques da Silva[1,4] · Washington Soares Ferreira Júnior[2] · Taline Cristina da Silva[3] · Ulysses Paulino Albuquerque[4]**

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**Abstract**
In this article, we present the central ideas of evolutionary psychology, and discuss how their assumptions can help ethnobiologists to understand the dynamic relationship between people and their environments. In this sense, investigating this relationship from an evolutionary perspective can bring new empirical evidence about human evolution, also contributing to both evolutionary psychology and evolutionary ethnobiology.

**Keywords** Adaptive memory · Hierarchical memory · Human evolution · Naturalist mind · Social-ecological systems

## Introduction

During their evolutionary history, humans have had to interact with their environment, both to capture resources and to avoid threats. This interaction, studied by many scientific fields, may have strongly influenced hominid evolution, such that the relationship between people and nature could be mediated by biases and behaviors shaped in the evolutionary past (see Albuquerque and Ferreira Júnior 2017).

In this regard, a recently developed interdisciplinary field called Evolutionary Ethnobiology (EE) is concerned with understanding how ecological and evolutionary processes influence people's cognition and behavior in relation to their environments (Albuquerque, Medeiros and Casas 2015). To this end, EE promotes the integration and systematization of evolutionary concepts from Cultural Evolution, Genetics, Evolutionary Psychology (EP) among others (Albuquerque and Ferreira Júnior 2017). However, this integration is recent, and little is known regarding how evolutionary biases may operate in the dynamic relationship between humans and nature. The basic premise of EE is that selective pressures during human evolution, associated with the need to have a relationship with the environment in order to survive, have spawned in humans a naturalistic mind that involves a complex cognitive structure that influences the way people perceive and seek to understand the natural world (Albuquerque and Ferreira Júnior 2017). Thus, we believe that ethnobiological studies that fail to take evolutionary biases into account in their hypotheses may fail to completely capture a given phenomena.

One practical example might be data collection in ethnobiological studies. For Albuquerque and Ferreira Júnior (2017), ethnobiological studies that collect empirical data in real systems are actually retrieving data stored in individual memories, and few studies in ethnobiology recognize memory as a bias in data collection. Thus, a key element is to understand how memory can influence the collection and interpretation of information obtained in social-ecological

✉ Joelson Moreno Brito Moura
bmoura.joelson@gmail.com

✉ Ulysses Paulino Albuquerque
upa677@hotmail.com

[1] Programa de pós-graduação em Etnobiologia e Conservação da Natureza, Departamento de Biologia, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, PE 52171900, Brazil

[2] Universidade de Pernambuco, Campus Petrolina, Rodovia BR 203, Km 2, s/n – Vila Eduardo, Petrolina, PE 56328- 903, Brazil

[3] Departamento de Biologia, Universidade Estadual de Alagoas, Santana do Ipanema, AL 57500-000, Brazil

[4] Laboratório de Ecologia e Evolução de Sistemas Socioecológicos (LEA), Departamento de Botânica, Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, 1235, Cidade Universitária, Recife, Pernambuco 50670-901, Brazil

systems.[1] At this point, the concept of *adaptive memory* addressed in evolutionary psychology seems to be fundamental, since it assumes that humans tend to prioritize in memory information of greater adaptive value that are relevant for survival (Nairne et al. 2007). If this is true, it is imperative that ethnobiological studies consider memory mechanisms shaped in the evolutionary past in their data collections, since, for example, medicinal resources highly recalled by individuals from a certain community may contain therapeutic characteristics that are advantageous for survival.

Moreover, a recent study by Silva et al. (2019) noted that the human mind tends to remember information about frequent illnesses or when they are related to previous experiences of the individual with a given illness. Considering the ancestral context, this might reflect adaptations that were important for hominid survival—helping them remember, for instance, dangerous places or the location of food and water—and that persist to this day in human populations (see Nairne et al. 2007).

Although we believe that humans have genetically inherited behavioral tendencies shaped by their ancestral past, these tendencies can be modified, expressed, or silenced according to the environmental context (see Barrett 2012). However, this genetic heritage cannot be ignored, and it seems to precede behavior. For example, for the behavioral complexity of human societies to emerge and increase over time, certain innate mental faculties, genetically selected in some ancestral environment, have to be present—such as the ability to imitate—making cultural evolution possible (see Stanford 2019).[2] Therefore, investigating the evolutionary aspects behind the decisions and behavior of humans regarding nature seems crucial. For this, Evolutionary Psychology shows promise for our understanding the mechanisms operating in this relationship.

Accordingly, the main goal of this article is to demonstrate how Evolutionary Psychology's assumptions can help us discern the complex and dynamic relationship of people and their environments, and particularly what influences their decisions. This is only possible by understanding the evolutionary roots preceding behavior. To this end, we present the theoretical scenario of EP and its applications for studies in the EE field's First, we introduce and describe the key concepts of EP. Then we explain the concept of adaptive memory (an important concept) and how it is empirically tested. Lastly, we bring insights and examples that may guide future studies that seek to use an evolutionary perspective to understand the relationship between people and the biota. This first theoretical effort can help to promote a productive integration with EE.

## A Brief Introduction to Evolutionary Psychology

Evolutionary Psychology is concerned with understanding the functioning of the human mind by analyzing it as the product of natural selection (Buss 1990; Breyer 2015). Thus, it is a functionalist approach—it investigates the functions of the mind. The theoretical trend that most influenced EP was Sociobiology. According to Wilson (1975), the creator of this scientific field, Sociobiology can be defined as the systematic study of the biological basis of animal behavior. From its conception, Sociobiology aimed to create standardized models to understand animal behavior from an evolutionary perspective and expanded this plan to social behavior; in contrast, EP is known for being designed to exclusively understand the psychological mechanisms that precede human behavior (see Breyer 2015). Evolutionary psychologists criticized the neglect of sociobiology with the psychological mechanisms molded in paleoenvironments, and proposed another level of explanation for human nature, giving less attention to human behavior and focusing on the adaptations that allow its expression, in this case, the evolved psychological mechanisms (Hattori and Yamamoto 2012).

Even though sociobiology and EP share the view that human beings evolved through the process of natural selection, the two domains differ in some fundamental respects. For example, according to Buss (1990, 1995), in sociobiology humans have developed adaptations that always aim to maximize their *inclusive fitness*—the ability to, in addition to leaving fertile offspring, the individual also has parental care, since their relatives also carry copies of their genes. Conversely, in EP fitness maximization does not exist because, in principle, natural selection would not have created mechanisms that directed human beings to live for the purpose of leaving descendants in any situation. Some evolutionary psychologists call this idea a "sociobiological fallacy" (Buss 1990). Thus, for many scholars EP is a type of sociobiology, however, less controversial because it is less deterministic, since the mental adaptations shaped by natural selection can be expressed or not in the current environment (see Buss 1990).

EP seeks explanations from the pressures that shaped the human mind in the evolutionary past to solve specific problems connected with the survival and reproduction

[1] Social-ecological systems represent a product of the interaction between sociocultural systems—the set of beliefs, knowledge and behaviors in human groups—and ecological systems—the biotic and abiotic environment of human groups (Berkes and Folke 2000).

[2] Cultural evolution is a scientific field that analyzes changes detected in societies from the perspective of Darwinian evolution theory, and that takes into account such aspects as variation, competition, and inheritance (Mesoudi 2011, 2016).

of the species. In this sense, EP represents a theoretical scenario that integrates aspects of cognitive evolution, the idea that the brain is an information processor of the environment and it relates to evolutionary biology, that like other organs of the human body, understands that the brain has also been the target of natural selection and molded to process one set of information from the environment to the detriment of others (Tooby and Cosmides 1992). It is a relatively recent scientific field, emerging in the early twentieth century and gaining visibility in the 1970s and 1980s.

Although EP is a relatively new academic discipline, functionalist approaches in psychology are ancient, such as in the case of functional psychology, created by William James in the late 19th century, although it has not developed a solid theoretical basis (Gangestad and Tybur 2016). A group of researchers started a series of theoretical and empirical studies (Cosmides and Tooby 1987; Symons 1987; Buss 1989; Cosmides 1989; Barkow et al. 1992) in order to understand the nature and functioning of the human mind, mainly in relation to human preferences in the selection of partners. Among the authors who contributed the most to the popularization and expansion of the EP, we can mention Leda Cosmides, John Tooby, Donald Symons, Jerome Barkow and David Buss.

Since then, EP has progressively gained the attention of important scientific areas that analyze the evolution of human behavior. The field of political science, for example, has published studies on how people's political opinions can be affected by behaviors linked to the ancestral past (see Edwards 2003; Brown 2013; Kubinskia et al. 2018; Petersen 2018). The *marketing* area also brought interesting empirical findings about how human consumption patterns are influenced by evolutionary factors (ver Saad and Gill 2000; Hartmann and Apaolaza-Ibáñes 2010, 2013; Hasford et al. 2018). Table 1 shows some fields of research interest in EP.

The EP studies are based on the essential premise that a lot of human psychological mechanisms are evolved as a result of the selective pressures that hominids were subjected to in the Pleistocene (Buss 1995). Similar to the other organs of the human body, the underlying information processing mechanisms localized in the brain are biological adaptations that enabled the survival and reproduction of early hominids (Buss 1990; Klasios 2016). Thus, the human mind functions in a similar way to a computational system, designed by natural selection to solve adaptive problems faced by our ancestors (Tooby and Cosmides 2015), and that due to this human behave adaptively (Klasios 2016). This evolutionary perspective was a great novelty for researches in psychology that formerly attempted to commonly understand human behavior only influenced by the current historical and social context. However, this new approach has generated some theoretical confusion due to its similarity to sociobiology and, especially, to the concept of modularity of mind (see next section) (Townsend and Barton 2018).

Based on these premises, some essential concepts were created that lead to the majority of research on EP (see Bolhuis et al. 2011), which are summarized in the next session. It is worth noting that these concepts are, to some extent, criticized by some scientists. Thus, we also describe some of these criticisms and alternative views.

## Basic Concepts of Evolutionary Psychology

Assuming that humans behave adaptively only makes sense if we assume that there were one or more environments that promoted such adaptations. Thus, the EEA concept argues that our psychological mechanisms evolved in response to the stable characteristics of EEAs (Tooby and Cosmides 2015) present, for example, in African savanna and Pleistocene rainforest environments. However, its first version of the concept was widely criticized, since only savannah was considered an EEA (see Bolhuis et al. 2011). The recent concept of EEA is broad and less specific, which considers all relevant selective environments of the ancestral past (see Tooby and Cosmides 2015).

Thus, EEA is not limited only to the African Pleistocene savanna (see Tooby and Cosmides 2015). In this sense, hominids may have developed psychological mechanisms in different environments during their evolution in the Pleistocene, in a period before or after their settlement in the savannah (see Hartmann and Apaolaza-Ibáñes 2010; Moura et al. 2018).

### Modularity of the Mind

The human mind consists of specific domain modules that evolved to solve distinct adaptive problems that arose in the ancestral past (Tooby and Cosmides 2015). For example, modules linked to the detection of cheaters, cooperation, identification and escaping from predators, among others. According to Townsend and Barton (2018), we inherit the specific modules of our ancestors. For example, it was extremely important for early hominids to identify and avoid poisonous animals, such as snakes and spiders, so that, over time, natural selection favored individuals capable of detecting such threats. This may explain even the current phobia behavior of humans in relation to these animals (for a more complete argument, see Tooby and Cosmides 2015). In addition, the ability to memorize information that helps to survive in environments similar to the Pliestocene savanna seems to be a psychological mechanism of extreme importance (see Nairne et al. 2007).

Other psychological mechanisms documented in the literature are: facial recognition of relatives, fear of spiders,

**Table 1** Some fields of interest in evolutionary psychology.

| Fields of interest | Purpose | Some publications |
|---|---|---|
| Cognition and human behavior | Understanding the factors that influence the evolution of cognition and human behavior | Stevenson et al. (2014), Roberts (2015), Roos et al. (2016), Ferera et al. (2018) and Wilke and Todd (2018) |
| Religious behavior | Understand the influence of natural selection on religious behavior | Boyer and Bergstrom (2008), Leathers and Raines (2014), Franek (2016) and Smail (2018) |
| Political theory | Understand how people's political views can be affected by behaviors linked to the evolutionary past | Edwards (2003), Brown (2013), Kubinskia et al. (2018) and Petersen (2018) |
| Evolution of art | Understand the role of art in the evolutionary history of human beings | Sugiyama (1996), Hagen and Bryant (2003), Honing and Ploeger (2012) and Sütterlin et al. (2014) |
| Economy | Analyze the evolution of the economic logic of human beings | Hoffman et al. (1998); Li et al. (2012), Lawrence and Pirson (2015) and King (2018) |
| Human preferences | Analyze how the evolutionary past shaped the preferences of human beings. For example, preference for landscape and objects | Altman et al. (2016), Balling and Falk (1982), Orians and Heerwagen (1992), Li et al. (2013), Bøggild and Laustsen (2016) and Townsend and Barton (2018) |
| Marketing | Identify patterns of human consumption | Holbrook and O'Shaughnessy (1984), Saad and Gill (2000), Hartmann and Apaolaza-Ibáñes (2010, 2013) and Hasford et al. (2018) |
| Sexual selection and gender differences | Understand the influence of gender difference in mate selection | Buss et al. (1992), Buss and Schmitt (1993), Schwarz and Hassebrauck (2012), Conroy-Beam and Buss (2018), DeLecce et al. (2017) and Jeffery et al. (2018) |
| Human emotions | Understand how natural selection has shaped emotions over time | Tooby and Cosmides (1990), Al-Shawaf et al. (2016), Klasios (2016) and Eisend (2018) |

sexual attraction by partners who demonstrate gentleness and intelligence, detection of cheaters in everyday situations, possible preference for environments that are similar to savannah, among others (see Townsend and Barton 2018; Buss 1995; Tooby and Cosmides 2015). However, among the concepts of psychology this is the most controversial.

According to Bolhuis et al. (2011), there is evidence of neuroscience that does not corroborate the existence of modularity. For example, there is evidence that animals learn and establish causal relationships among a wide variety of events, and this is only possible if the mind is not modular (see Bolhuis et al. 2011). There is a broad connection of the various neural structures in various psychological processes (Bolhuis et al. 2011). Thus, the human mind can work through more general cognitive procedures, which allows learning and problem solving in different environmental and social conditions (see Bolhuis et al. 2011). Moreover, Barrett (2012) argues that the mind can be composed of both general and specific modules. In this case, adaptations of the brain are flexible and can integrate, for example, mechanisms molded in paleoenvironments with mechanisms constructed during the ontogenetic development of the individual (see Barrett 2012).

## Universal Human Nature (UHN)

It is assumed that the psychological mechanisms evolved in the human mind are responsible for producing a UHN, that is, a "typical species" (Tooby and Cosmides 2015). This characteristic of human beings is expressed through different environmental and social conditions (see Tooby and Cosmides 2015). In this sense, the main long-term objective of EP is the mapping of this UHN (Tooby and Cosmides 2015). However, the main criticism regarding the concept of UHN is the fact that behaviors observed in specific human populations are generalized to all populations (see Bolhuis et al. 2011). For example, many studies in EP are carried out with university students, considered a representative sample of human nature (see Bolhuis et al. (2011). In this case, universalism ignores aspects of ontogenetic development, since the environment will evoke genetically pre-determined responses (Bolhuis et al. 2011).

In investigating the evolution of human nature, it is important to integrate concepts and theories, such as Epigenetics and Niche Building Theory, which understand human beings as active constructors of their environments. In this sense, due to the diversity of environmental conditions, the person-environment interaction may have generated distinct adaptive responses during evolutionary history (see Bolhuis et al. 2011; Laland and Brown 2006).

## Gradualism

The human mind has a set of genes coadapted to the ancestral environment that do not respond rapidly to the selective pressures of the current environment (Tooby and Cosmides 2005, 2015). Evolutionary processes are slow and need hundreds of generations to build a highly complex "mental" program. In this sense, human minds would still be adapted to the world of our ancestors (Tooby and Cosmides 2015). People commonly experience an adaptive delay when facing the challenges of industrialized societies, because these environments are different from the environment in which we evolved. For example, the taste for fatty foods is an adaptive behavior for ancestral environments, in which fat was scarce, but is non-adaptive in the current environment because it increases the incidence of cardiovascular diseases (Cosmides and Tooby 2003). However, there is evidence of recent major genetic changes in human populations that contradict gradualism (Bolhuis et al. 2011).

Perhaps one of the greatest shortcomings of EP is its failure to take into account the extent to which human activities can accelerate biological evolution by modifying or silencing certain genetically inherited predispositions (see Stanford 2019). For example, the inclination to favor open environments such as the savanna proposed by some EP studies is no longer observed in some cultures, which might result in the establishment of humans in different modern environments (see Moura et al. 2017, 2018). Furthermore, there is evidence that cultural practices may have influenced human evolution by altering selective pressures, resulting in the selection of specific genes. An example would be the increase over time of the frequency of the *CD72* gene and of other genes that improve malaria resistance in West Africa as a result of the adoption of agriculture, which exposed the populations in this region to this disease (see Laland et al. 2010; Santoro et al. 2017). In this way, the interaction between genes and culture has some influence on the evolutionary history of humans (Laland et al. 2010).

According Laland and Brow (2006), human beings have the capacity to modify the environment, that is, they modify the environment in which they live to suit themselves and with that they reduce the adaptive delay. These authors argue that there is an adaptive complementarity of the organism and the environment, with a dynamic interaction between natural selection and the construction of cultural niches. In this case, even if human beings are affected by cardiovascular diseases, they have the capacity to build hospitals or remedies to deal with these diseases (for a more complete argument, see Laland and Brown 2006).

## Adaptive Memory: An Important Model for Evolutionary Ethnobiology

Based on the evolutionary psychology's perspective that the human mind has evolved to favor specific information to deal with the threats of ancestral environments (Tooby and Cosmides 2015), the adaptive memory model proposed by Nairne et al. (2007) describes the differential behavior of the human mind in a survival situation, suggesting that our memory system evolved through natural selection to prioritize information that is relevant to survival and reproduction. According to Nairne and Pandeirada (2008), this propensity of the human mind to favor this type of information originated as a result of the selective pressures of ancestral environments, and may have been of extreme relevance for early hominids to recall information such as feeding sites, predator action and partner behavior.

The experiments of Nairne et al. (2007) showed that when people were asked to imagine prey in an environment similar to a "African Pleistocene Savannah" without basic survival supplies, such as water and food, and having to avoid predators, they tended to better remember words that would be relevant to this survival scenario over other less critical scenarios, such as the "moving to a foreign environment" scenario.

Since then, the behavior of the human mind to prioritize information relevant to survival has been consistently debated in an emerging body of studies (see Nairne et al. 2007; Nairne et al. 2008; Nairne and Pandeirada 2008; Nairne et al. 2009; Nairne et al. 2012; Seitz et al. 2018), and several investigations have replicated the findings of Nairne and colleagues (Weinstein et al. 2008; Sandry et al. 2013; Yang et al. 2014), whether these investigations were conducted with people of different age groups (Nouchi 2012; Prokop and Fančovičová 2014; Broesch et al. 2014), or who live in different environmental contexts (Barrett and Broesch 2012; Prokop and Fančovičová 2014).

For example, in studying the recall of dangerous and non-dangerous animals, Barrett and Broesch (2012) found that children living in the city of Los Angeles in California and children in a Shuar village in the Ecuadorian Amazon presented high levels of recall when images and information on the name and diet of dangerous animals were presented. This result suggests that the human propensity to recall important information for survival may be innate in our species and, regardless of the environmental context in which people live, there is a human memory tendency to prioritize this information to the detriment of any other information.

Another interesting aspect that has generated controversy among some evolutionary psychologists is the fact that some studies defend the idea that the human capacity to recall this information is not necessarily tied to situations that refer to threats of ancestral environments. Yang et al. (2014) have observed, for example, that important words for survival were well remembered by people both in ancestral (pasture) survival scenarios and in non-ancestral /modern environments (mountains). In addition, Young et al. (2012) by testing human attention to threats, have noted that threats from modern environments—such as firearms and cars—also capture and maintain attention in the same way as would be expected for threats from ancestral environments—such as snakes and spiders. This suggests that the human capacity to recall adaptive information—threats that could compromise human survival and reproduction—may also be observed in people occupying distinct environmental contexts, regardless of whether this information is associated with a threat of ancestral environment—African savannah Pleistocene—in opposition to what some evolutionary psychologists still suggest. What is interesting in these findings is that they show that, although there are cognitive adaptations resulting from selective pressures, these are not hardwired to respond only to ancestral threats. This may be related to the human ability to adaptively respond to situations that can compromise their survival (for example, see the study by Silva et al. 2019).

Based on this perspective, Nouchi (2012), when comparing the effect of survival in the memory of young and old people, observed that by classifying words in a situation of survival and self-referral—which encourages participants to explicitly recover personal episodic memories—the participants tended to recall a greater amount of stimuli linked to the survival situation. According to Wixted et al. (2018), the episodic memories correspond to the recollection of past individual experiences that occurred at a particular time and place. This fact is interesting, since Nouchi's study (2012) reveals that the recall of information related to past personal experiences did not receive a better recall of people; on the contrary, there was a tendency to recall information associated with a survival context.

These results reveal some interesting insights when compared to other findings. Empirical studies have shown that past personal experiences with environmental catastrophes, for example floods, tend to receive more attention in people's memories (see Ruin et al. 2007), which leads us to think that episodic memories are intensified only in critical situations involving survival. Sousa et al. (2016), for example, when conducting a study in a rural community located in the Northeast of Brazil, observed that people tended to prioritize in memory information on medicinal plants used in the last year, which are also indicated as the most important. In this case, prioritizing in memory important resources

in medicinal use linked to recent previous experience may favor the survival of people in dealing with diseases.

Another important aspect is that human memory seems to behave differently when confronted with information relevant to health care. For example, Alqahtani et al. (2017) found that emerging infectious diseases, in which people were most susceptible to, such as Middle Eastern respiratory syndrome, received more attention in people's memories than mass catastrophes that occurred recently in the population.

In another study, Prokop et al. (2014) observed that information on parasitic diseases considered to be of adaptive relevance to humans were better remembered, rather than information on hormones, which were considered as irrelevant information in a survival situation. Besides that, Fernandes et al. (2017) observed that adult persons have a better recall of objects that have been described as being touched by people with serious diseases—transmissible or lethal—to the detriment of items described as touched by healthy people. This suggests that human memory may perform better when information relevant to health care is presented. Interestingly, the same information seems to emerge in remembrance when other survival-related information is being presented simultaneously (see Alqahtani et al. 2017).

In addition, it is noted that as humans are confronted with adaptive information that is related to the natural world, memory also seems to behave differently. For example, Prokop and Fančovičová (2014) found that children exposed to toxic and non-toxic plant information associated with fruit images of different stains that were associated to these plants—red and black = toxic, and green plants = non-toxic plants—the information of plants with fruits of black coloring was better remembered by the children due to the association with toxic fruits. Barrett et al. (2016) also observed that children of different cultures better recalled information about dangerous animals, followed by food and dangerous objects. These results may also be indicating that the human memory performs best when exposed to certain information about the natural world.

These findings appear to be consistent with the idea of a hierarchical memory proposed by Sandry et al. (2013). These authors studied the memorization of words in different scenarios related to adaptive mechanisms—survival, fear and phobia, selection of partners, avoidance of incest, detection of cheaters, jealousy, infidelity and gaining or maintaining status—and observed that the survival scenario excelled in word recall over all other adaptive mechanisms. The explanation found by Sandry et al. (2013) for this result is that this occurs because the survival scenario has a more general structure, that is, it can invoke all of these adaptive mechanisms simultaneously, and as a consequence manages to activate larger areas of the brain associated with memory, rather than a single adaptive mechanism in isolation—for example, only phobia. Therefore, it is likely that human memory functions hierarchically during recall of this information, that is, memory does not retain them equally. Thus, if human memory were a rigid system for prioritizing this information, all of them would be expected to present similar levels of recall.

In this case, it would be expected that in the study by Barrett et al. (2016), for example, people would similarly remember information about animals, food and dangerous objects, because all this information is important for survival. However, as noted by the authors, people tended to better remember information associated with dangerous animals than information about food and dangerous objects. This may be happening, as suggested by Sandry et al. (2013) because some of this adaptive information, for some unknown reason, may be prioritized in memory. Moreover, a relevant insight from the findings of Barrett et al. (2016) is that human memory may operate differently within the survival scenario when confronted with certain information about the natural world to the detriment of others that are also linked to survival.

Thus, it is likely that human memory functions hierarchically to recall this type of information (Fig. 1), and performs differently when this information involves the adversities of natural environments. This brings us to the idea of the existence of a *human naturalist mind*, apt to remember better this information to the detriment of any others. This memory behavior can be observed in several modern environmental contexts and in different cultures.

## Insights from Adaptive Memory for Evolutionary Ethnobiology

An interesting fact that derives from the idea of adaptive memory concerns the understanding of how memory bias can affect people's relation to nature (Silva et al. 2017). Adaptive memory provides us with some important insights that can help evolutionary ethnobiologists to understand how human cognition works in the face of environmental challenges. Can an ethnobiologist question, for example, why people remember one food resource better than another? Why do people remember one particular medicinal plant better over another? How does remembering information that is important for survival affect the human's relationship to biota? These are just some of the inquiries that can be made using adaptive memory as background. In the following, we detail some theoretical insights that we consider important and that can serve as a basis for the development of studies in evolutionary ethnobiology.

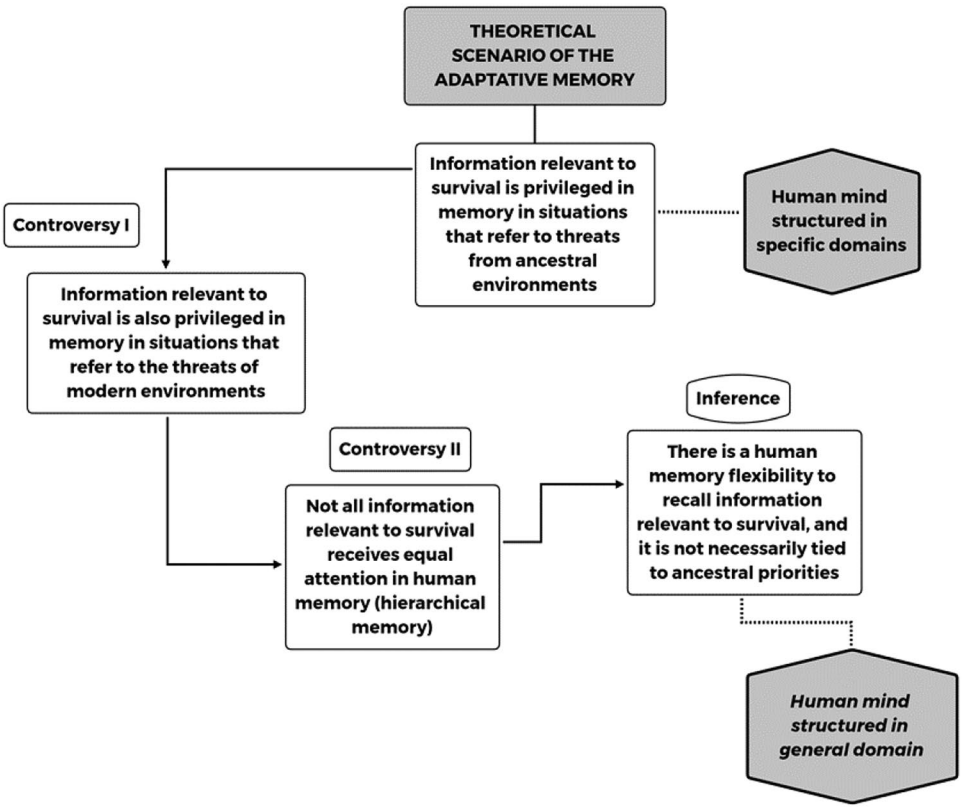


**Fig. 1** Theoretical scenario of adaptive memory, controversies and possible inferences

## Adaptive Memory is Observed in Different Environmental and Cultural Contexts

The adaptation of memory to privilege important information on survival is innate in the human species (Nairne et al. 2007), and the adversities of ancestral environments are not necessarily attached to it (Young et al. 2012; Yang et al. 2014). Such a mnemonic feature can be observed in different environmental and cultural contexts (see Barrett and Broesch 2012; Barrett et al. 2016; Sousa et al. 2016).

## Adaptive Memory Functions Hierarchically

Human memory favors some information that are relevant for survival better than others (see Sandry et al. 2013; Silva et al. 2019). In addition, there is a tendency for memory to prioritize information related to challenges of natural environments to the detriment of other information that are also important for survival (see Barrett et al. 2016).

## Humans have a Universal Naturalistic Mind

A greater retention in human memory of information relevant to survival occurs when it is associated with natural environments (see example in Barrett et al. 2016). It leads us to consider the existence of a universal human naturalistic mind (Albuquerque and Ferreira Júnior 2017). The naturalistic mind can be understood as a structure of cognition that has evolved in response to the adversities of different natural environments occupied by humans throughout the evolutionary process (Albuquerque and Ferreira Júnior 2017). The pressures of these different environments may have led the human brain to develop an effective cognitive and behavioral apparatus to solve more recurring natural challenges, that is, that present greater regularity in the environment (Ferreira Júnior et al. 2019).

This assumption may be the key to understand why certain information linked to the natural world is best remembered by humans.

Thus, we agree with the idea proposed by Barrett (2012) that our mental mechanisms may be heterogeneous, with new structures evolving from older structures, in a combination of ancestral characteristics with relatively recent characteristics. In this case, the cognitive adaptations observed in modern humans would not necessarily be products of responses to adversities imposed by a specific environment of the ancestral past, but may reflect the selection of general strategies of the human mind to meet challenges in diverse environments.

In summary, we believe that: (i) people remember important information for survival independent of their environment and culture; (ii) the ability to recall this information is not exclusively tied to ancestral priorities; (iii) adaptive information is remembered hierarchically; and (iv) we were

endowed with a naturalistic mind capable of promoting information about the natural world. By assuming these assumptions are true, we may investigate in EE studies, for example: what kinds of cognitive mechanisms may be involved in intensifying information that are relevant to survival in modern environments; what information about the natural world is prioritized in memory; what factors intensify recall; and how this may influence human behavior in relation to nature.

### Frequency of Involvement and Previous Experience with Risk Events Act as Enhancers of Adaptive Memory in Social-Ecological Systems

Some empirical studies have pointed out that environmental variables, such as the frequency of involvement in a risk event, and life history, such as past personal experiences with a critical event, may intensify the recall of important information survival in human memory (see Ruin et al. 2007; Sachs et al. 2017; Scheideler et al. 2017). In addition, in the ethnobiological context, there is evidence indicating a possible influence of these variables on the recall of this type of information in social-ecological systems (see Sousa et al. 2016). This suggests the existence of a possible influence of the frequency with which environmental events affect people and previous experience with them as enhancers of this adaptive information in human memory in social-ecological systems. Therefore, we believe that the same variables that lead to prioritization in the memory of information to deal with a risk situation—frequency and previous experience—may also be the mechanisms responsible for interfering with human strategies to deal with the adversities of their environment. Santoro et al. (2015) have noted, for example, that people tend to select more species for the treatment of recurrent diseases in local medical systems. Another study by Santoro et al. (2017), also observed that the incidence of malaria affected the use of antimalarial medicinal plants in African human groups in periods when there were no public policies to control the disease. Therefore, this aspect may be indicative that the frequency of involvement of a risk event may intensify the recall of information in human memory. This may trigger greater efforts to solve it, leading to substantial modifications in the environmental niches that people occupy.

In addition, we believe that the changes generated in the environmental niches that people live and that may have originated from these same cognitive biases may also affect the recall of important information for survival. According to Silva et al. (2017), for example, the selection of a given medicinal resource through its advantages that are linked to the use within a local medical system can lead to cognitive biases that make information about this resource more memorable. Thus, a hypothetical example for such an assumption would be that people in dealing with recurrent illnesses would also tend to concentrate the resources needed to treat them near their homes—optimization advantages within the medical system—in this case, these resources become more memorable due to the influence of continuous and direct contact with it.

This discussion, combined with the evidence for hierarchical memory, may suggest that the naturalistic mind deals with environmental complexity by filtering information about survival, prioritizing those that affect it immediately, to the detriment of other information involving less immediate situations. This may explain both the evidence from ethnobiological studies involving recurrent diseases, and the behavior observed in hierarchical memory. For example, the fact that information about dangerous animals is more remembered than dangerous food (Barrett et al. 2016) may reveal the functioning of a mind that operates to deal with current situations. In the evolutionary past, identifying and fleeing a predator may have required a greater activation of memory-bound areas of the brain in order to respond immediately to this situation when compared to the identification of toxic foods (a situation that also affects survival, but less immediately). This may have been the evolutionary scenario of the naturalist mind, so that today it is reflected in the construction of social-ecological systems, directed to respond to recurring events.

Thus, understanding what kinds of variables interfere with the recall of adaptive information that involves the natural world may be the first step in understanding how the naturalistic human mind has evolved and operates in dealing with nature adversities, as well as the human behavioral patterns that can emerge from this relationship. Understanding these mechanisms may represent an important step in understanding human behavior in relation to biological resources, which is the focus of interest in evolutionary ethnobiology.

## Final Considerations

Tracing the human evolutionary path is not an easy task, which may be why so many scientific disciplines talk to each other, and promoting this dialogue is one of EE's key missions (see Albuquerque and Ferreira Júnior 2017). This is a recent endeavor, which requires building bridges. For Stanford (2019), overcoming the barriers between psychology and the social sciences and between those sciences and those that study other organisms are key steps.

In this wise, it is difficult to assert, for example, that people's attitudes towards nature result only from genetic or cultural factors. Our advanced cognitive capacity seems to have evolved not only through genetic factors, but also through human practices, indicating gene-culture coevolution

(Altman and Mesoudi 2019; Stanford 2019; see also Albuquerque et al. 2019).

Considering that certain mental capacities must be present for a given culture or socio-ecological system to evolve (see Stanford 2019), ethnobiological studies that analyze human behavioral patterns without taking into account the evolutionary factors that precede a certain behavior may not completely capture this phenomenon. Thus, we believe that dialogue among the scientific disciplines that analyze the relationship between people and their environment is relevant for the growth of EE.

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