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Review

The impact of ancient tree form on modern landscape preferences

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ABSTRACT

Empirical studies of the relationship between aspects of the landscape and human emotions have been fruitful over the last few decades. In fact, we are awash in data that describes a correlation between natural landscapes and positive human feelings. While this plethora of data has been useful to various disciplines, it has not lead to an explanatory theory as to why and how the landscape should have this affect This paper proposes that the discipline of evolutionary psychology provides an explanatory theory. Rather than a broad explanation, evolutionary psychology drills down on ancient problems of survival and relates those problems to contemporary behavior. Our connection to tree canopy is used as an example of this approach.

"Stand still for a few moments before a tree, and the imagination that moves you will be as primary as that of early *Homo sapiens*" (Perlman, 1994).

1. Introduction

Modern research into the impact of the landscape on the human psyche (hereinafter referred to as restorative landscape psychology) began a little over 40 years ago with British geographer Jay Appleton. Subsequent writers such as Stephen and Rachel Kaplan, Roger Ulrich, Edward Wilson, Stephen Kellert, Peter Kahn, Gordon Orians, Judith Heerwagen, Agnes van den Berg and Yannick Joye have sought to clarify the impact of the landscape on our emotions through empirical studies, anecdotal observation and logical reasoning.

The wide variety of explanations has made it difficult to envision a unified theory. Why would the landscape impact our emotions and health? Many empirical studies focused on psychological processes that appear to be sensitive to tree and woodland experiences. In Stephen and Rachel Kaplans' extensive work, exposure to natural landscapes is shown to be a cognitive process that is restorative and improves focus (Kaplan, 2004). In Roger Ulrich's studies (1983), stress rather than focus is the critical factor. For Ulrich, exposure to natural settings initiates an innate, rapid, affect-driven process that reduces physiological and psychological stress.

Using the circumplex model of affect, Bruce Hull and Antony Harvey (Hull and Harvey, 1989) proposed that the emotions people feel about landscape environments are a function of pleasure and arousal (Hull and Harvey, 1989). Individuals seek out situations that have these qualities. Parallel studies suggest a third dimension, dominance, is also a major factor in assessing human perception, experience and response to the landscape (Bakker et al., 2014).

A fourth model has been proposed by Yannick Joye and Agnes van den Berg (2012). Called the perceptual fluency account, this model suggests our favorable feelings toward natural scenes come from the fact that we (in the following discussion "we" may refer to both contemporary humans and our pre-human hominin predecessors) can process visual inputs from nature more efficiently than modern built environments. It is the fractal aspect of such scenery that is the key. The mind is naturally responsive to the repetition of fractal shapes (Joye et al., 2015).

According to Lothian, because we are lacking an explanatory theory, deductive reasoning and hypothesis testing is impossible (Lothian, 2009). Even so, various disciplines have benefited from the efforts to understand our relationship to the natural world including landscape design, highway design, architecture, city planning, criminal justice, stress management and health. The study of how we react to nature is a popular one and it lends itself to scientific contributions from numerous fields. The negative side of this is that our field is "rampantly empirical" (Porteous, 1982).

Gordon Orians' recent book *Snakes, Sunrises, and Shakespeare* (2014) goes a long way toward resolving this deficiency. Using an evolutionary psychology approach, he explores how contemporary behavior relates to early hominin challenges on the plains of ancient eastern Africa. He cites a variety of examples of this ancient connection including our relationship to habitat, the landscape, hazards, diet, music, ordering nature and our ecological minds. The goal of this paper is to focus on our ancient relationship to tree form and tree canopy.

Some of the strongest evidence for the ancestral roots of modern

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Table 1
Examples Specific to References in Restorative Landscape Restorative Landscape Categor General Examples Psychology Psychology.

Category	General Examples	Examples Specific to Restorative Landscape Psychology	References in Restorative Landscape Psychology
Theoretical Research	Evolutionary Biology-Theories Adaption Problems and Selection Pressures	Prospect refuge theory, Savanna Hypothesis, Habitat Theory and`Attention Restoration Theory	Appleton (1975); Orians (1980); Kaplan and Kaplan (1989)
Psychological Research Methods	Self-Report Surveys Field Studies Observer-Reports	Empirical landscape preference studies point to a special design that solves an evolutionary problem. Ex: We prefer to see climbable trees.	Geary (1998); Lohr (2007); Sommer and Summit (1995)
Medical Research Methods	Fertility Studies Physical Health Mental Health	In the city, the absence of tree cover is stressful. Stress impacts birth weight, mental and physical health.	Donovan et al. (2011); Jiang et al. (2014); Ulrich (1984)
Psychological Research Methods	Neuroanatomical-Structures Cognitive Neuroscience Brain and Behavior-Research	Hormonal studies measure stress in treed and untreed environments through cortisol levels. Treed environments are shown to be less stressful with this measure.	Parsons (1991); Thompson et al. (2012); Van Den Berg and Custers (2011)
Genetic Research Methods	Comparative Genetics Population Genetics Developmental-Evolutionary-Biology	Extensive research into the genetic basis for habitat selection relates closely to restorative landscape preferences.	Jaenike and Holt (1991); Mikolajewski et al. (2016); Morris (2011); Weber et al. (2013)
Phylogenetic Research Methods	Primatology Comparative Psychology Physical Anthropology	Comparison across primate species shows the importance of tree canopy for safety. An arboreal lifestyle is not an ephemeral aspect of the primate psyche, it is the very definition of what it is to be a primate.	Green and Alemseged (2012); Potts (1998); Venkataraman et al. (2013)
Hunter-Gatherer Research Methods	Human Sociobiology Human Behavioral- Ecology Cultural Anthropology	Contemporary foraging cultures may exhibit ancient adaptations to the environment more clearly than modern urbanites.	Shultz et al. (2012); Venkataraman et al. (2013)
Cross-Cultural Research Methods	Ethnological Comparisons Ecological Adaptations Human Universal Studies	Cross-cultural research confirms the existence of universal tree form preferences	Coss and Moore (2002); Sommer and Summit (1996)

landscape aesthetics comes from research on trees. Unfortunately, this research tends to blur the effect of individual tree form with the effect of tree groupings in the broader landscape. Wilson's book, *Biophilia,* encourages us to think in broad terms (Wilson, 1984). He suggests humans are equipped with special focus for animals, plants and natural processes. Because Wilson's claims of a special relationship with nature are so broad they have been appropriated and modified by researchers at will until the resultant theory is "a set of genetic predispositions of different strength, involving sorts of affective states toward different kinds of lifelike things" (Joye and De Block, 2011). In restorative landscape psychology the better path may be the reductionist route. It is useful to differentiate the research on our impressions of the broad landscape from our impressions of actual tree forms. By narrowing down to the specifics of tree form we avoid the danger of generalizations and increase the precision of empirical research.

2. Objectives

For all the fascinating studies carried out over the last forty years, we have no robustly articulated model that pulls together the multidisciplinary research to explain why we have such strong ties to certain aspects of nature. Multiple explanations hinder forward movement. Confusion between the discussion of individual trees and clusters of trees compounds the problem. The intention of this paper is twofold: to isolate available research on tree form from research on woodland clusters and to reevaluate the research on tree aesthetics through the insights of evolutionary psychology.

3. Methods

A review of restorative landscape psychology is a cross disciplinary pursuit. Botany, psychology, archaeology, primatology, and aesthetics all play a part. It is not chance that the most influential writers of the field are geographers, psychologists, architects, plantsmen, biologists and ecologists.

For this project, the first requirement was to read and understand the canon of restorative landscape psychology. This was accomplished in preparation of the corresponding author's dissertation: Exploring the relationship between trees and stress in the urban environment (Townsend, 2014). One of the unanswered questions from that research was; how strong is the proof that there is an evolutionary basis for contemporary landscape preferences? Not all the authors cited in that work agreed on the origins of landscape preferences. This led the author to the foundational writings of evolutionary psychology including: Fodor, Pinker, Buss, Barkow, Cosmides and Tooby. Evolutionary psychology seemed to provide a structure to focus our disparate field.

Evolutionary psychology is an approach to studying human development that employs Charles Darwin's evolutionary principles to explain how the modern personality evolved. Darwin laid the groundwork for the science in 1872 by suggesting the process of natural selection applies not only to our human physical characteristics (Darwin, 2009) but also to "the mind of an animal and to expressive behavior" (Crawford and Krebs, 2008). In contemporary evolutionary psychology it is proposed that the brain is a computing organ evolved to process information from the environment. How we act day in and day out is dependent on the information our brains pick up from the environment. To understand behavior, it is helpful to describe the neural routines that generate behavior. Those routines, or adaptations, have evolved over time because they gave their owners survival and reproductive advantage. Adaptations arose through Mendelian genetic variation. Natural selection, by its very nature, fosters different special purpose adaptations to solve the varied problems of survival and procreation. A generalized computing organ would not have the capacity to evolve these specific answers to ancient problems. The adaptations we still carry may or may not provide the advantage they once did since they evolved eons ago. By uncovering the origin of the adaptations we all carry, we gain insight into our own personalities and behavior (Buss, 2005).

Evolutionary psychology itself is the subject of controversy (Joye and De Block, 2011). Unlike other scientific pursuits, it must rely on a variety of disciplines to paint an accurate picture of what life was actually like in the eastern rift valleys of Pleistocene Africa. Empirical research is impossible to carry out on 2-million-year-old hominins. In defense of the discipline, David Schmitt laid out eight categories of research methods commonly used in evolutionary psychology (Schmitt, 2008, p. 218). This categorization guided the author in research (see Table 1). According to Schmitt, researchers typically use only two or three of the categories to demonstrate that a particular behavior is an evolutionary adaptation. The first two columns of Table 1 are adapted from Schmitt (ibid.). It is clear from the references in the third and fourth columns that most of the research categories Schmitt laid out have been thoroughly explored in the restorative landscape literature.

For the sake of brevity, the following discussion does not make use of every reference cited above but Schmitt's template was a valuable resource.

4. An explanatory model and discussion

Our primate ancestors may have left the jungle canopy and ventured tentatively onto the savanna of East Africa as far back as 5 million years ago (Dunbar and Barrett, 2000). The savanna was not total grassland. More likely it was a mosaic of woodland, tall grasses and water features (Domínguez-Rodrigo, 2014). To make things complicated, our ancestors did not come in one version of ancient hominin but multiple taxonomically diverse hominin groups in overlapping geographical ranges (Butzer, 1977).

The Pleistocene epoch, 2.5 million years ago, is considered by researchers to be the time when ancient australopithecine apes were replaced in East Africa by more modern hunter-gatherers resembling ourselves. Evolutionary psychology refers to this as our environment of evolutionary adaptation (EEA). This was the formative time when much of our present physiognomy and behavior evolved. It is the solutions evolved at that time that modern humans still carry. We may live 21st century lives but we have caveman brains. Evolutionary psychology attempts to understand what the challenges were in the Pleistocene and tries to discern how the solutions to those challenges effect contemporary human behavior.

Evolution works slowly. As humans we have lived in urban/agricultural environments for only a small proportion of our developmental history. We existed as hunter-gatherers for 99.6% of our history. Our time as farmers and urbanites up to today only represents 0.4% ("Putting Time In Perspective - UPDATED," 2013). What happened in the early years when we separated from our primate cousins and relocated to the savanna? We may have become bipedal as we maneuvered the tall grasses of the savanna. We stood upright to look over the tall grasses for prey and predators. We became runners pursuing prey. We learned to use fire. We organized as bands of hunters. We developed a social structure.

Did we voluntarily leave the trees behind when we came down from the jungle canopy (Potts, 1998)? It may be the trees left us. Some climate scientists suggest that in Pleistocene East Africa the climate was drying. This resulted in a reduction of lush jungle canopy. Those primates who could thrive in drier climates prospered (Dunbar and Barrett, 2000). Moving onto the savanna grassland required a different lifestyle but the payoffs were enormous. A protein diet much richer than tree canopy fruit was available on the savanna (Orians, 2014). The hunting of ungulates on the savanna provided abundant protein that allowed the development of larger brains. The move to drier grasslands was the watershed moment for the emergence of our human-like ancestors.

This model of human development on the savanna is not without controversy. Archaeological finds continue to modify the picture. For example, there is some evidence that we became bipedal, not on the savanna, but while we lived in the trees (Shreeve, 1996). Walking along limbs upright allowed us to gather fruit more efficiently. However, the bottom line is our ancestors left the jungle canopy for a hunter-gatherer lifestyle. Yet even in our new savanna home, trees and tree canopy were critical. Arboreal behaviors coexisted with bipedal locomotion (Green and Alemseged, 2012). It was not a clean break between the two behaviors. Possibly early hominins ventured onto the grassy planes for hunting and returned to the jungle canopy for nesting. As life on the planes became more comfortable, trees became way stations where hunters could flee in time of danger and nest in security overnight. The famous Australopithecine, Lucey, was both bipedal and arboreal (Larson, 2012). Studies in primatology suggest that for the majority of primates tree canopy is the preferred ancestral habitat (Schmidt, 2011).

An insight into brain structure by Jerry Fodor explains how this could be. The theory of modularity suggests our mind is made up of multiple problem solving neural circuits (Fodor, 1983). These networks were first envisioned as occupying physical space. This concept was supported by studies in brain injury where damage to a certain part of the brain resulted in a specific behavioral modification (Carruthers, 2008). Some examples of loss related to discrete brain injury include: damage to our language faculty while most other faculties remain intact; the loss of ability to name living things while retaining the ability to name inanimate objects; the loss of ability to name fruits while maintaining the ability to name animals; and the loss of ability to recognize human faces. A mind built as a general problem solver would not have these discrete localized abilities. Damage to a general problem-solving brain would affect all faculties.

If evolutionary psychology asks us to envision life on the Pleistocene plane, it also asks us to imagine what challenges early hominins had to solve to make that life workable. Major challenges included recognition of kin, food acquisition, procreation and habitat selection. Evolutionary psychology proposes that we have a dedicated neural module for solving each of these challenges. Quoting Pinker (1996):

> All the wonderful complex things that people do — repairing carburetors, following soap-opera plots, finding cures for diseases — might come out of the interactions among a smaller number of basic modules. The mind might have, among other things, the following: a system for intuitive mechanics — that is, our understanding of how physical objects behave, how things fall, and so forth; an intuitive biology — that is, expectations about how plants and animals work; a sense of number, the basis of mathematics and arithmetic; mental maps, the knowledge of large territories; a habitat-selection module, recognizing the kinds of environments we feel comfortable in; a sense of danger, including the emotion of fear and a set of phobias all humans have, like fear of heights and of venomous and predatory animals; intuitions about food, about contamination, about disease and spoilage and what is icky and disgusting.

As a scientific study, habitat selection has a deep history. Current research comes from the study of birds, mammals, fish and insects. The general outline is that individuals seek habitat, in part, based on their inheritance as a species (Weber et al., 2013). Field mice select field habitats, not mountaintops. Habitat selection is often influenced by where the individual was born. Individual selection of habitat may be affected by population density, opportunity and the time frame. The habitat selection module therefore would not simply picture one ideal location (Geary, 1998). It would contain algorithms for determining whether a particular location is suitable in an appropriate time frame. It would contain a variety of habitats dependent on contingencies. Regardless of where we learned to walk or learned to stand up, over the 65 million year history of our order (Dunbar and Barrett, 2000), the habitat most closely associated with primates is tree canopy.

Even if we accept that habitat selection was important to our ancestors and was controlled by a neural module, how could that possibly affect us today? If you think it's a stretch that the observation of broad spreading trees has an impact on your sense of safety and wellbeing, consider empirical data showing how a warm or cold cup of water held in the hand will affect our judgment of personalities as warm or cold, or the kind of chair you sit in whether straight back or soft/comfy affects the kind of decisions you make. These are adaptive behaviors where the brain employs an actual object in a metaphorical way (Sapolsky, 2011).

Evolutionary psychology suggests that modules are inherited species-wide from one generation to the next as adaptations. The earliest primates resembled small cats or squirrels, walking on all fours, possessing claws, fur and a tail. Tree canopy was an ideal habitat because it offered relative security from predators such as contemporary dinosaurs (Science Magazine Staff, 1998). Elevation to look out over the surrounding jungle for danger, the presence of edible fruit and numerous insects made tree canopy a good home. Physical modifications that improved survival chances spread rapidly through the early primate population because they provided adaptive advantage.

Two examples are color vision and our modern shoulders. Color vision developed because it enabled us to locate ripe fruit. Fruit hung high up at delicate tree branch ends and required good vision to spy. It also required dexterity to reach. Changes to our shoulders allowed us to become better climbers. Our shoulders changed through time to allow us to hang and swing from tree limbs. This is called brachiation and is still utilized by multiple species of primates today (Schmidt, 2011). It allows them and us to swing our arms in a complete circle, front to back and over our heads. Now as an adaptation from the Pleistocene or earlier, it is remarkable that except for children, arborists and gymnasts, we seldom climb today, but we still have this limb structure and it comes in handy. Throwing a spear, pitching a ball, climbing a tree and gymnastics would all be impossible without this shoulder arrangement. Note that we retain this adaptation in spite of the fact that it no longer provides survival advantage (Coss and Moore, 2002).

The theory of modularity posits that the neural modules that make up our brain are passed from one generation to the next much the same way as physical adaptations like color vision and the brachiating shoulder. Modules may be the unit of evolution in the brain (Carruthers, 2008). For our brachiating shoulder there had to be a neural network that developed alongside the newly modified shoulder to coordinate the musculature and insure ready activation if danger arose (Geary, 1998). That module must also have had the ability to differentiate branch arrangements suitable for climbing from those that were not.

Our primate ancestors could not only swing from the trees, but they knew which trees to swing from. Orians and Heerwagen describe the early hominin exploring new sites (Orians and Heerwagen, 1992). When hominins approach a new location the first decision is to enter and explore or to leave for a better site. In moments of danger this decision must be made immediately to avoid becoming a leopard's meal. Good sites for refuge or lingering, therefore, are the ones that can be evaluated quickly. Canopy structure is among the qualifications that make a good refuge or habitat site. Can I climb these trees if need be?

Another aspect of the modularity thesis is that decisions are made rapidly and unconsciously by the modules. Landscape evaluation can be unconscious and almost instantaneous, as short as 200 ms (Hietanen and Korpela, 2004). Modular processing is obligatory, we have no control over it. For refuge and habitat selection the decision is a simple one, to stay or to flee. This verdict is communicated quickly as like or dislike. As an emotional feeling, this binary choice is called affect. We either like something or dislike it. We may have no idea why, but the internal workings of our mind have already examined all the options to report this simple decision.

Fodor and later researchers suggest modules are encapsulated (Fodor, 1983). This means that they have their own internal protocol for decision-making. They have their own specific inputs. The module for family recognition is not concerned with berry type, ripeness or how to avoid the thorny bushes. The family recognition module deals with such things as facial features, tone of voice and behavior. Each module processes its specific data and reports its conclusions to a higher authority. In his recent book, *Why Everyone Else is a Hypocrite*, Robert Kurzban points out that modularity has long been recognized by computer programmers as the most efficient method for handling complex digital problems (Kurzban, 2010). We regularly have personal experience of the mind's modularity. An example is shopping in an expensive store: part of you says go ahead and buy that expensive item, you deserve it; while another part says, don't waste your money here, you need that money to fix the car. Modularity enables us to have two opposite feelings about something at the same time.

Evolutionary psychology provides more insight into how a modular mind behaves. Not all modules function at the same level throughout one's lifetime. There is a developmental aspect to modularity (Bjorklund and Pellegrini, 2000). In the animal kingdom, it is the general rule that the shorter the life span the more reliance is placed on inherited information (Geary, 1998). Bees, for example, know their respective jobs from the pupal stage. Human infants, upon birth, must deal with their own survival problems without training. These problems are different from adult survival problems. Pre-adolescents from both North America and Africa have similar preferences for savanna landscapes, while adolescents from the two continents prefer scenes denoting urban mobility, action and excitement (Kaplan and Kaplan, 2002). After adolescence, the data demonstrate a return to pre-adolescent preference for savanna and the addition of a second preference, the home landscape. The conclusion of these studies is that while initial preferences from innate modules seem to have an evolutionary basis, they can be modified through experience (Falk and Balling, 2009). For adolescents, the urge is to meet and socialize with contemporaries. This can be seen as the preference of the procreation module. In adolescence, this module overwrites traditional habitat preferences. When the age of choosing a mate is past, the procreation module recedes into the background.

In evolutionary psychology, there is a debate regarding how modular the mind actually is. Massive modularity suggests every aspect of the mind has been molded through evolution (Carruthers, 2008). At the other extreme, traditional psychology suggests the mind is a general-purpose problem solver without modules. It starts out at birth with little guidance from our evolutionary past (Geary, 1998). David Geary proposed a middle ground where modules provide an exoskeleton, a propensity to learn in specific domains (Geary and Huffman, 2002). Our genetic makeup codes for a brain structure of modules that address problems faced by our species, problems invariant over millions of years. These modules show themselves in youth. In youth, they are plastic. They develop according to the environment in which they reside. With age they are modified by experience (Shettleworth, 2010). A module or neural circuit that processes scenery seems to be located in the left and right parietal-occipital junctions and portions of the left and right hippocampus (Nakamura et al., 2000) (Fig. 1).

Either way one might reasonably ask how a neural circuit or module can evolve to dictate behavior or preference. Modules direct our behavior through affect, likes and dislikes. These are not superficial emotions (Mehrabian and Russell, 1974). These emotions have saved lives for millions of years. They provide that gut feeling, shall I stay, or shall I go? Research indicates that ignoring our need to live in

Photo Credit: J.B. Townsend

Fig. 1. Children in a Maine public park cannot resist playing in a good climbable tree.

association with appropriate tree canopy is highly stressful. Life in a treeless cityscape has been shown to be stressful. In a way, stress is the consequence of ignoring our prehistoric emotions (Townsend, 2014). Robert Sapolsky has shown the negative effect of stress on our chimpanzee cousins (Sapolsky, 2005). Other researchers have shown the health consequences of ignoring stress (Boardman, 2004; Bredar, 2008; Ensel and Lin, 1991). Understanding that our minds seek habitable spaces, spaces associated with trees, becomes not only an aesthetic goal but also a health goal.

The curious aspect of this research is that writers are so eager to jump from specific data to grand visions. Much has been written about how the ancient savannah looked. Much is written about how quality urban parks resemble that savanna (Lothian and Bishop, 2017). The assumption seems to be it is the broad picture, not the components that provide positive affect. This is where we get into trouble. Savanna-like landscapes are used to represent all nature. All of a sudden we are talking about humans' love of nature, biophilia (Kellert and Wilson, 1993; Wilson, 1984). At each step of generalization, we get further away from the primary link–the connection between trees and survival.

This is not to say tree groupings do not have their own ancestral pull on our emotions. We like open woodland (Hull and Harvey, 1989). We like woodland where we can see but avoid being seen (Appleton, 1975). We enjoy the shade and protection clumps of trees provide. However, taken from an evolutionary psychology point of view, the reasons why single tree form is important are different from the reasons why distant clumps of trees on the grassy savanna are favored (Fig. 2).

4.1. Applying evolutionary psychology to earlier research

Why is evolutionary psychology any better as an explanatory theory then Ulrich's model of stress reduction, the Kaplans' model of attention restoration, Joye's model perceptual fluency or Hull and Harvey's circumplex model of affect? The value of evolutionary psychology is that it pulls all of this valuable research into a single broad theoretical structure.

Evolutionary psychology suggests ancient solutions to long-term problems affect our behavior and preferences in the present. The basic long-term problem for every creature is survival/safety. The earliest primates found safety in trees. This habit separated them from other mammals. In psychological terms, trees offered an affordance to those small furry creatures. "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill…. It implies the complementarity of the animal and the environment" (Gibson, 2011). Affordance suggests a relationship between the environment and the animal. An environmental feature out of proportion or beyond the comprehension of an animal is not an affordance. Trees offered escape to the earliest primates because they could scurry up their trunks.

To place restorative landscape research into the evolutionary psychology model it is useful to think of the affordances offered to our ancestors in chronological order. The availability of climbable trees in times of danger is the most ancient affordance to early primates. Trees provided refuge (Appleton, 1975). The primary consequence of finding safety in canopy was reduction of physiological stress. Prospect (ibid.) and habitat (Orians, 1980) are secondary affordances. Reduced stress (Ulrich et al., 1991) is not an affordance, it is the consequence of achieving safety in tree canopy.

Improved focus and attention restoration (Kaplan and Kaplan, 1989; Kaplan, 1995) follow a similar path to the stress reduction model. They are the mind's response to achieving the safety of tree canopy. The adaptive value of these affordances and their consequences lingers in our minds today as preferences that evoke pleasure and arousal (Hull and Harvey, 1989). Joye's description of perceptual fluency (Joye and van den Berg, 2011), while convincing, does not rise to the level of survival. It applies more to the quality of the message than to the message itself.

Table 2 plots our adaptive responses to danger and threats in the most basic form. For an expanded discussion of stress and attention responses see Hartig and Evans (1993). Physiological stress and directed attention at times of danger are traits common to all higher animals. While modern dangers and threats are dissimilar from ancient ones, our bodies and minds respond the same way our ancestors responded. It is difficult to separate these two concepts in an "unambiguous fashion" (Kaplan, 1995) because they are so intricately bound, but an evolutionary approach at the basic level adds some clarity.

4.2. The safety connection

Safety in tree canopy is the link between ancient survival and modern landscape preference. According to Coss and Charles, "There has never been a *Homo sapiens* who, when looking at trees and crevices, did not perceive affordances of shelter and safety (Coss and Charles, 2004)." The affordance of safety in tree canopy was very real for our ancestors. Today, few of us seek safety in climbing, but trees still represent a source of safety. This association often comes up in empirical studies. While contemporary researchers query respondents about positive affect, focus, stress level or arousal, it is the safety connection that is in the background. Data indicating urban residents feel safer on treed streets is plentiful (Coss and Moore, 2002; Kuo and Sullivan, 2001; Townsend, 2014; Westphal, 2003). Sociological theories such as "eyes on the street" (Jacobs, 1961) and "crime prevention through environmental design" (Gardner, 1981) lend credence to the concept that there is an evolutionary association between tree cover and sense of safety.

Photo Credit: Michael Ver Sprill/ Shutterstock.com.

Fig. 2. The eminently climbable but protected Angel Oak, Charleston, SC.

Table 2
A comparison of the Kaplans' attention restoration model to Ulrich's stress reduction model using an evolutionary approach.

Stimulus	Response	Affordance	Consequence	Benefit	Contemporary Preference
Danger or threat (Ulrich)	Stress (this is a physiological process that leads to exhaustion).	Tree canopy safety & refuge.	Reduced stress, possible prospect & habitat.	Adaptive advantage	Broad, accessible tree canopy signaling safety.
Danger or threat (Kaplan)	Attention directed toward perceived danger or threat (this is a cognitive process with limited resources; depletion may lead to stress).	Tree canopy safety & refuge.	Restoration, improved focus.	Adaptive advantage	Information-rich landscapes signaling survival through coherence complexity legibility mystery.

4.3. The aesthetics connection

We have covered how the ancient problem of good habitat for early primates was solved. Those primates with a preference for climbable tree canopy were the ones who passed their genes and their preferences on to us. Most likely, a module in our brain evolved to direct early hominins toward accessible tree canopy. That preference expressed itself emotionally. Zajonc refers to such preferences as preferenda.

> Affective [emotional] reactions to stimuli are often the very first reactions of the organism, and for lower organisms, they are the dominant reactions. Affective reactions can occur without extensive perceptual and cognitive encoding, are made with greater confidence than cognitive judgments, and can be made sooner. (Zajonc, 1980, p. 151)

We suspect our ancestors did not discuss canopy quality with their peers, they just knew. This internalized gut feeling was an aesthetic preference. For them good canopy was a thing of beauty. The study of aesthetic preferences is an ancient pursuit and over the thousands of years it has gone on, no clear model or answer has emerged to explain beauty and aesthetic preferences. Is beauty in the object being observed or is beauty in the eye of the beholder?

Landscape studies offer a limited way out of this conundrum. The case that our preferences for certain landscape components have an adaptive origin is a strong one. The beauty of good tree canopy is based on its survival value for our primate ancestors. Quoting Steven Kaplan:

> Although aesthetics in the narrow sense is sometimes viewed as an elitist concern, in the current context it refers to a broad and widely shared inclination that is concerned, not with the contents of museums but with the realities of the outdoor environment. In other words, aesthetics is seen as applying not only to a broader population but also to a broad class of stimulus patterns as well. Aesthetics in this perspective is a functionally based way of responding to the environment. (Cosmides and Tooby, 1995, p. 585; Kaplan, 2018)

In spite of Kaplan's assertion that aesthetics has a functional origin, we need to take a step back. It is not helpful to draw broad inferences from landscape aesthetics and proclaim that all aesthetics are based on our experience in the Pleistocene. It is hard to see how the appreciation of painting or music have a similar prehistoric lineage as the aesthetics of the landscape (Davies, 2012).

4.4. Single tree and canopy studies

The echo of our ancient preference for tree canopy is discernible in numerous empirical studies. Bruce Hull and Antony Harvey published a paper called "Explaining the Emotion People Experience in Suburban Parks" (Hull and Harvey, 1989). They queried sixty residents from Melbourne, Australia. Half were from an urban neighborhood and half were rural. The respondents were asked to view color photographs of hypothetical parks and record their emotional responses. While this study does not specifically refer to canopy structure, it does refer to forest structure. Relevant to our discussion, wooded scenes with little underbrush were favored by both groups. Limited undergrowth from an evolutionary perspective permitted easy access to the safety of the tree canopy in time of danger.

In 1993, Gordon Orians and Judith Heerwagon contributed a chapter to Kellert and Wilson's *Biophilia Hypothesis* (Kellert and Wilson, 1993). Titled "Humans, Habitats, and Aesthetics", the authors surveyed 102 individuals. The questionnaire they used contained black and white photographs of various tree shapes. The most important variable was the attractiveness rating. The researchers were specifically looking for aesthetic judgments from the respondents. The results suggest that attractiveness is based on low trunk height, canopy layering and a high ratio of tree canopy width to tree height. In other words, broad canopy trees with short trunks and horizontal branch clusters were deemed most attractive. This form is similar to the presumed predominant tree of Pleistocene East Africa, *Acacia tortilis*. It would be an easy tree to climb, easy to hide in and helpful in providing shelter. Today the *Acacia tortilis* is covered in thorns but that wasn't always the case (Charles-Dominique et al., 2016) (Fig. 3).

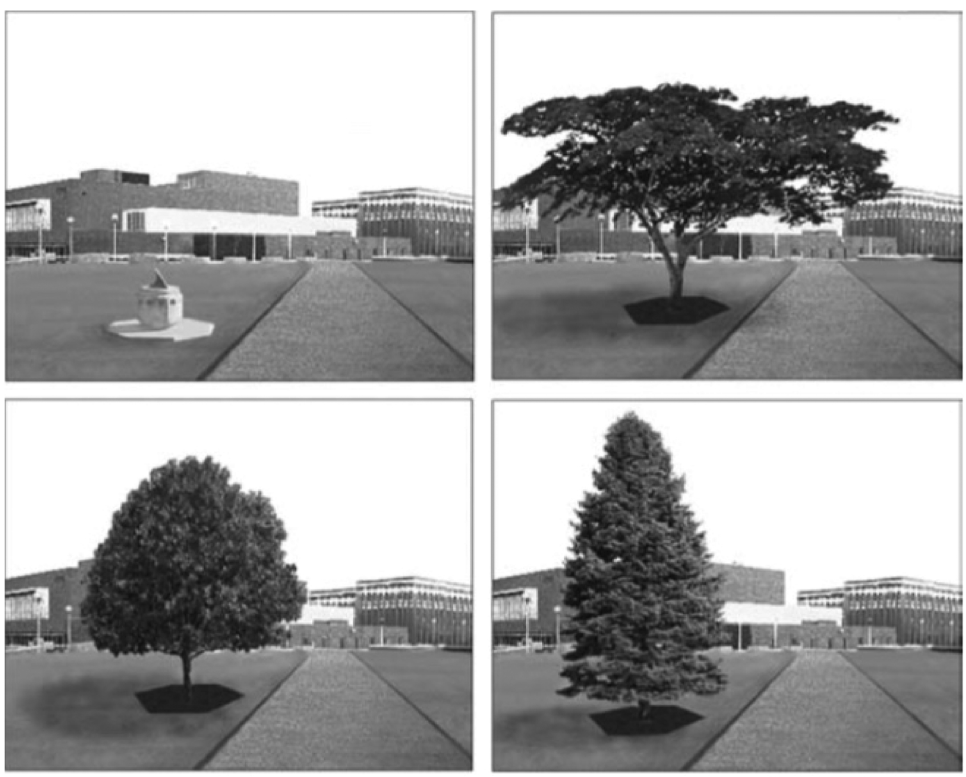
Robert Sommer and Joshua Summit conducted two tree shape studies four years apart (Sommer and Summit, 1995; Summit and Sommer, 1999). Both projects studied U.C. Davis students. The studies employed differing methods and research questions, but one consistency prevailed. Respondents invariably preferred broad canopy, short trunked trees.

In 1996, the same team explored human responses to tree shapes in Australia, Brazil, Canada, Israel and Japan. They came up with the same conclusions as the two earlier studies. The international nature of this last study is particularly significant. The modularity of the mind concept requires that an adaptation acquired in the Pleistocene would be present in all humans today. From Sommer and Summit's work, we understand individuals around the globe have the same basic tree preferences. Those preferences provided protection and safety to our early forbearers (Sommer and Summit, 1996).

Richard Coss and Michael Moore studied the tree shape preferences of children from Israel, Japan and the United States (Coss and Moore, 2002). They hypothesized preschool children would exhibit inherited knowledge of suitable refuge among different tree forms and they might also see traces of sexual dinichism. In ethological studies, dinichism refers to the fact that, during our early evolution, males tended to be much larger than females. A consequence of this differential was that females were more agile tree climbers than males. On the scales for "climb to hide", "tree to sleep in" and "feel safe from lion" the researchers found 60% of the children from all three nations favored the unbrowsed Umbrella Thorn (*Acacia tortilis*) over the three other tree species. On the scale "prettiest tree" the Umbrella Thorn came in second behind the Christmas tree-like Austrian Pine (*Pinus nigra*). On the questions regarding dinichism, it was found that young girls were more likely to seek refuge in trees than boys and that in climbing, girls were more likely to venture farther out on branch ends.

Photo Credit: Natascha Kaukora/Shutterstock.com

Fig. 3. An unbrowsed Acacia tortilis.



Used with permission of author

Fig. 4. Pictures are from the study by Virginia Lohr and Caroline Pearson-Mims used in their questionnaire (2006).

Virginia Lohr and Caroline Pearson-Mims published their research in a paper titled "Responses to Scenes with Spreading, Rounded and Conical Tree Forms (Lohr and Pearson-Mims, 2006)". They queried 206 participants from Washington State University and found individuals preferred scenes with trees to scenes with inanimate objects. They found people preferred spreading trees to rounded or columnar forms. Most interesting, they found respondents were happier viewing spreading trees than other forms (Fig. 4).

In "Cultural and Developmental Comparisons of Landscape Perceptions and Preferences" Thomas Herzog, Eugene Herbert, Rachael Kaplan and C. Crooks compared preferences for differing Australian landscapes among 384 Australians and 250 Americans (Herzog et al., 2000). The Americans were all college students. The Australians were, primary, secondary, college and adult individuals. Photographic scenes were not close-ups but broad scenes of the following categories: vegetated, open smooth, open coarse, river, agrarian and structured. The results showed a high similarity of landscape preferences between the Americans and Australians. An unexpected preference among both groups was for willow trees. Regardless of the background landscape, when willows were included in the photograph, that particular scene

Photo Credit: Carine06
https://www.flickr.com/photos/43555660@N00/15682320844/

Fig. 5. A baby squirrel monkey showing Palmars Grasp Reflex as it clings to mom's fur.

was given high preference. Is it possible that the very climbable nature of the willow differentiated those scenes from the willowless scenes?

The preceding short research summaries point to the fact that humans across the globe find broad spreading tree form beautiful. This form recalls the trees of the ancient African savanna where our species evolved. Evolutionary psychology suggests a behavior common to most humanity probably has an adaptive basis.

4.5. Tree related behaviors and preferences from our primate past

4.5.1. Palmars grasp reflex

Parents of newborns are often surprised to discover the strong grip of their child even at birth. Early childhood clinging is referred to as Palmars Grasp Reflex. That strong grasp represents the need to hold onto the mother's fur as she travels through the tree canopy. Childhood studies suggest the toddler's propensity to climb fits into the same category (Figs. 5 and 6).

4.5.2. Brachiation

Life in the jungle tree canopy produced adaptations peculiar to primates. Brachiation, a method of mobility dependent on specific shoulder structure and the strength to hang from overhead tree limbs, was important to our ancestors and is still used by children and gymnasts today (Figs. 7 and 8).

Photo Credit: LADYING/Shutterstock.com

Fig. 6. A human infant showing Palmars Grasp Reflex as it clings to an adult's baby finger.

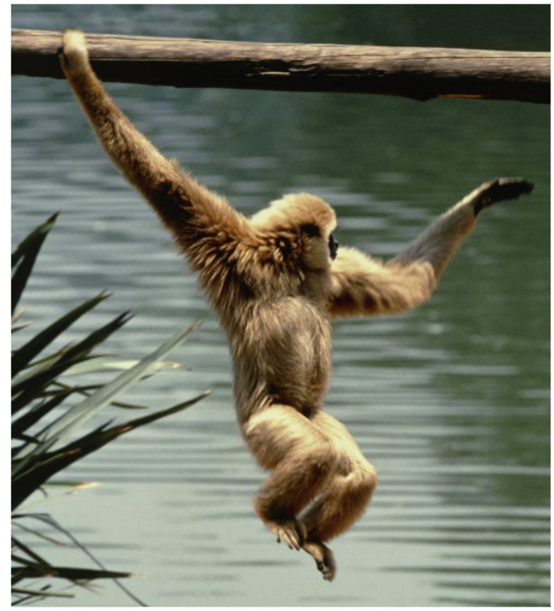


Photo Credit: TOM MCHUGH/SCIENCE PHOTO LIBRARY

Fig. 7. A white-handed gibbon brachiating at the local zoo.

Photo Credit: J.B. Townsend

Fig. 8. A child brachiating in the school yard.

4.6. Well-being and fitness

According to Frances Kuo and Andrea Taylor, "Green outdoor settings appear to reduce ADHD symptoms in children across a wide range of individual, residential, and case characteristics" (Kuo and Faber Taylor, 2004). Over a decade, Kuo and Taylor have studied the effects of natural green surroundings on children with ADD and ADHD. Their research suggests the impact of regular exposure to green is comparable to a prescription of Ritalin (Faber Taylor and Kuo, 2009). While these studies do not focus specifically on trees, they do demonstrate the power of green surroundings.

Another researcher, John Gaithright, studied the rehabilitative effect specifically of tree climbing. He sought to answer the question of how people change when they climb trees.

> They measured pulse and stress hormone levels on the ground and again in the trees. They studied pain sensitivity. Time and again, their research showed the positive effects tree climbing was having on the kids. Even more interesting, they collected the same data while climbing concrete towers and discovered the effects were not as strong — not even when the tower was in the same forest. It wasn't just the climbing. It was the trees. (Gathright et al., 2007)

Gaithright went on to found TreeHab. Since 2005, the organization has trained climbers and provided adaptive and rehabilitative climbing for individuals with special needs across the globe. For more information on this remarkable program see Gaithright's TED talk (Gaithright, 2013).

4.7. Our relationship with single trees is reflected in literature, painting and architecture

Reference to literature and painting may seem out of place in a scientific article but, following the example of Gordon Orians and Judith Heerwagen, cultural artifacts may point to the unrecognized presence of ancient preferences deep within us (1992). From Biblical times to the present, trees have been featured in literature, paintings and architecture. Trees are our ancestral home and represent safety and security. They often set the stage for human events.

In most cases trees provide the background, but in the Genesis story of the Garden of Eden, the Tree of the Knowledge of Good and Evil is a central character. When Adam and Eve eat its forbidden fruit, they are expelled from the garden. Interestingly, the tree seems to have higher status than the humans. According to the Bible, by eating its fruit they become god-like in their knowledge.

In the 5th century BCE, Siddhartha Gautama meditated under an old, very large, ficus tree (*Ficus religiosa)* for seven days in Lumbini, present day Nepal. During those seven days he achieved enlightenment. Gautama went on to become the Buddha and initiate one of the world's great religions. The tree is still referred to as the Bodhi Tree or Tree of Enlightenment for its part in shielding and guiding the Buddha. Folklore claims that one of its descendants still grows on the original site.

In relatively modern 1683, William Penn, the proprietor of Pennsylvania, signed a treaty with the Lenape Indians in Shackamaxon, PA. The painting below by Benjamin West shows the Proprietor and Chief Tamanend with Quaker Friends and Braves. They are all sheltered by a giant elm tree. Beside the tree on the right are the rough outlines of a teepee. On the left in the background is an English settlement of brick cottages. The tree encompasses under its broad canopy the peaceful transition from the primeval lifestyle to the modern. Descendants of the tree still grow at Haverford College and the Morris Arboretum of the University of Pennsylvania (Fig. 9).

Architecture makes use of our ancient connection to trees to evoke interest and positive affect. Yannick Joye has written extensively on this topic.

> In neurological terms, we believe that biophilic architecture can activate the specific neural mechanisms that are specialized in processing information about natural entities. Because of the clear survival value of quickly recognizing and categorizing biological entities, it is probable that such representations will also activate the neural correlates of affective responding. (Joye, 2007)

Public Domain

Fig. 9. Penn's Treaty with the Lenape at Shackamaxon. Notice the large elm, back left, complementing the scene.

Public Domain

Fig. 10. Fan vaulting in Kings College Chapel, Cambridge. The building was started in 1446. The lines of the stonework recall tree trunks and branching.

Photo Credit: Bobo Boom Permissions: CC BY 2.0

Fig. 11. Similar to the fan vaulting at Kings College, this train station canopy was designed by Santiago Calatrava in 1995 for the Gare do Oriente station in Lisbon.

The message from both these architectural masterpieces is that the lines depicting our most ancient home, tree canopy, foster in us a sense of safety and wellbeing (Figs. 10 and 11).

A book work by Michael Perlman, *The Power of Trees, the reforesting of the soul*, (1994), is especially relevant to this article. Perlman was an ecologist, university lecturer and imaginal psychologist. He believed, much like ancient polytheists, that the human soul is made up of images or reflections of the world in which we live. Our relationship to trees is one of those reflections. "Trees speak with uncanny exactitude to our biographical lives–their sufferings, their joys, how certain things are done and left undone and come undone, and the leafings and branchings of our dawns and our dooms" (Ibid.,38). Perlman spotlights our tree myths by interviewing a series of modern individuals about their experiences with trees. Hurricanes Hugo and Andrew are the backdrop for the interviews.

David, a former military man, and his family hid in a closet during Hurricane Andrew. The house was severely damaged and the only trees that remained were blown over and leafless. He cried with joy when local contractors were able to salvage some of the trees by pulling them up and re-planting their roots (23).

Ted, a South Carolina biology teacher said of the live oaks damaged by Hurricane Hugo in his neighborhood: "They each have a personality…it feels like a friend's been injured" (26).

Will, a sawmill operator from South Carolina, lived on a property that took a serious blow from Hurricane Hugo and many of his trees remained on the verge of dying from the damage they had suffered. But he respected their woundedness: "My wife asked me, 'Will, these trees are leanin', are you going to cut those out?' And I said, 'No. Those trees lived through Hugo. 50 years from now I want to be able to sit right here and say, "That crooked tree right there lived through it."' You know– the trees that lived through it, to me are sacred. They stood up… a whole lot better'n a lot of us did" (32).

Perlman suggests that we do not project human qualities onto trees rather it is the trees that animate our souls. After all, tree canopy was the nursery of all primate species. Ancient life in the trees fashioned both our body design and workings of our minds. "Before we were human, we were intimate with trees" (77).

4.8. Predictions on behaviors and preferences related to tree canopy

Behavioral adaptations from our EEA have not remained static over time. Evolution has a way of adding to and modifying our physical and behavioral components. Genetic variation does not invent new behaviors; it tweaks what is already encoded. Over time a module dedicated to finding safety in tree canopy will "become accessible to a wider range of inputs" (Shettleworth, 2010, p. 550). Reading and writing are examples of behavior that has been sculpted from our most primitive need to communicate (Ibid., 551). It is reasonable to assume that unexpected aspects of modern behavior have origins in our relationship to tree canopy.

Stairs may be an example of our ancient reliance on tree limbs. Tree limbs are a sort of stairway into the canopy. For ancient hominins canopy was home. Even today, most primates nest in the canopy. Due to its height and difficulty to reach, canopy was a safe place to be. Like tree limbs, stairs allow us to climb up to that safe spot. We often use hands and feet as we climb stairs. For many, the upstairs is the safest place in the house ("Why do we Sleep Upstairs?, 2015) (Fig. 12).

Photo Credit: The Canopy Stair Used with Permission

Fig. 12. Stairs instead of branches provide canopy access.

4.8.1. Arboriculture

Does the work of arborists relate to evolutionary landscape preference? After all, arborists are the only fulltime tree-climbing professionals. There is little data to answer this question, but we can make some relevant suggestions. The evolutionary account that tree canopy is a source of pleasure, is a strong one. Adrina Bardekjian in her Vimeo clip, "Limbwalkers", speaks of a certain vibe all climbers feel when climbing big trees (Bardekjian, 2013). Tree climbing has a lot in common with rock climbing and gymnastics. It is a challenging process that requires integration of mental acuity and physical coordination (Everett-Haynes and Berkley, 2017). For the challenging aspect, every time a climber ascends a tree there is a moment of satisfaction and confirmation one is doing just exactly what this body is designed to do. Christopher Bergland speculates in *Psychology Today* that activities like tree and rock climbing have a unique salutary effect on our mind. "An educated guess is that dynamic physical activities which engage all four brain hemispheres … optimize brain structure, function, and working memory" (Bergland, 2015). Anecdotal accounts suggest that arborists have a particularly enthusiastic opinion of their profession. Could this be related to the deep evolutionary history of tree climbing?

4.8.2. Landscape design

Trees evoke both fear and sense of safety in the landscape. It is curious that both feelings can be present at the same time – an example of modularity at work. From an evolutionary point of view, dense canopy is suspicious because it can harbor evil doers. We often hear this complaint in reference to proposed street tree installations. Robbers and drug dealers might hide in the trees (Donovan and Prestemon, 2010). On the other hand, repeated surveys of resident opinions on installed street trees confirm that trees provide residents a sense of wellbeing and safety (Kuo and Sullivan, 2001; Townsend, 2014). Is the positive affect trees provide related to their adaptive signals of escape from danger and nesting? Is there an unrecognized component of fear and safety even in the most commonplace landscape?

4.8.3. The predictive power of evolutionary psychology

In the spirit of Stephen Kaplan's 1995 paper, *The restorative benefits of nature: Toward an integrative framework,* it is incumbent on us to demonstrate how the discipline of environmental psychology "should provide insight into matters not illuminated by previous theory" (1995). The following predictions demonstrate the broad nature of

Photo Credit: J.B. Townsend

Fig. 13. An intimidating tree canopy over a street in San Juan.

Photo Credit: J.B. Townsend

Fig. 14. An alluring street scene from Wilmington, DE.

potential studies using evolutionary psychology to study tree form preferences (Figs. 13 and 14).

1 Evolutionary psychology suggests that children are more cognizant of climbing clues in the landscape than adults because they are more in tune with inherited tree preferences.
2 It explains why broad tree canopy provides positive affect because the most likely tree refuge in our EEA was the broad spreading legume, *Acacia tortilis*.
3 It suggests that our contemporary human hand size may be proportional to tree branch size capable of bearing human weight during climbing.
4 It suggests that humans prefer sleeping on the second story, elevated off the ground, because we associate elevation off the ground with safety.
5 It suggests that humans prefer enmeshed multiple tree canopy as opposed to stand alone trees because connected canopy allows movement within the canopy from one tree to the next.
6 It explains why humans prefer short boles on trees because low branching allows entrance from the ground into the canopy.
7 It explains why humans prefer horizontal branching rather than ascending or descending patterns because horizontal branching makes climbing easier.

5. Conclusion

There is strong evidence that modern humans have a specific connection to tree canopy inherited from our environment of evolutionary adaptation. That connection informs our attitudes about the landscape today. The discipline of evolutionary psychology contributes to the understanding of the story and provides an explanatory theory. One aspect, the theory of modularity, describes how preferences for specific habitats were established by evolutionary forces over the past several million years and are still with us today. We have specific neural wiring dedicated to appraising tree canopy and climbability. Our contemporary sense of landscape beauty could owe as much to proximal tree form as to the distal arrangement of landscape features. There is much still to be learned from studying how tree canopy appraisal from ancient times resonates in our minds today.

The study of the contemporary human preference for branching and tree canopy has practical application in landscape design, urban forestry and medical settings. More importantly, understanding our own human history and how the components of the modern mind developed provides insight into human nature. Even as human societies hurtle into a digital world of ubiquitous urbanization we still have a mind molded in the Pleistocene. Our ancient mind is not just a relic of the past. It influences our health, sense of beauty, and sense of safety today.

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