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Survival Guide for those Who Want to Live on the Ground

I want to start this section with an accusation, which might be hard to believe for some of the readers of this book. The accusation goes like this: no scholar of human evolution has seriously asked whether there are any notable differences for animal species between living in the trees and living on the ground.

The situation is quite amazing. On one hand, there is a full and equivocal scholarly agreement about the crucial importance of descending from the trees to the ground of our primate ancestors for the evolution of Homo sapiens. I wholeheartedly join scholars of human evolution on this point. On the other hand, it is difficult for me to comprehend why none of the scholars of human evolution, or even broader, the evolution of animal species, ever researched the existing differences in living circumstances in these two vastly different environments.

So, arguably for the first time in writings on evolution, on the next few pages I will try to demonstrate that there are enormous differences between living and surviving predators in tree branches on one hand, and on the ground on the other hand. I believe that understanding these differences are crucial for understanding most of the morphological and behavioural changes that lead our primate ancestors to the road towards humanity.

So let us try to analyze what kind of differences are we talking about when we discuss the terrestrial (living on the ground) and the arboreal (living in tree branches) lifestyles.

(1) Two-dimensional environment vs. three-dimensional environment. Animal species living on the ground live in a two-dimensional world, and animal species living in the trees live in a three-dimensional world. This difference is similar to the difference between the two forms of art: painting and sculpture, and is profound in its essence. This third dimension – vertical, which is present in a tree-living environment and is absent in a ground living environment, makes a marked difference in the survival strategies against predators. As we shall soon see, the discussion of this neglected issue is particularly important in this context to the interaction of our primate ancestors with the ancestors of big cats.

(2) Safety standards on the ground vs. safety standards on the trees. Possibly the most important difference between living in tree branches and on the ground is safety standards. Of course, we can be sure that our primate ancestors were well aware of the prowling ground predators while they were still living up in the trees, like contemporary tree-living monkeys are. What is important for us is that avoiding and surviving these predators was much easier for our primate ancestors while they lived in the trees. All that was needed from our ancestors in order to avoid predators

was to stay on the trees' higher branches. They could live and even sleep on higher the branches without much fear of almost all predators.

"Well, I agree living up in the trees is effective in order to secure yourself from predators like lions or tigers who do not climb trees," a reader might object, "but what about tree-climbing big cats, like leopards. How can you secure yourself from them in tree branches?"

An excellent and timely question. Leopards, like most of the cats, and unlike heavy lions and tigers, are amazing masters of climbing tree branches. Some man-eating leopards were known to attack (and eat) hunters who were concealed in tree branches to shoot them. And still, I am maintaining that even graceful leopards could not do any harm to our primate ancestors while they were sitting or even sleeping on high tree branches. For one simple reason: in trees, in a three-dimensional environment, you live according to your weight. So, if you are lighter, you can climb higher up the tree than other, heavier animals. Leopards are several times heavier than most of the tree-living monkeys. For this reason, 50-60 kilo leopards simply cannot climb high enough up trees to reach a place where 10-20 kilo monkeys are spending their time. The same is true for our distant primate ancestors, small-bodied primates. They were out of reach of not only big cats, who lived on the ground, but also out of reach of the tree-climbing predators like leopards. So today tree branches cannot give us safety against leopards, as after descending tree branches we became much heavier, but our tree-living ancestors were several times lighter. Here is the importance of the third – vertical dimension – in action: the lighter you are, the higher you climb, the higher you climb, the safer you are. It is well documented that when a group of tree-living monkeys prepares for sleep, the younger generation as a rule climbs higher and sleeps on thinner branches. It is safer up there.

So, let us remember, because of the morphology of most of the trees, which have thicker branches closer to the ground, and thinner branches higher up, tree-living animal species live there according to their weight on different "floors". Lighter animals can climb and spend time higher on the trees, as thinner branches can withstand their weight, but the same branches cannot withstand the weight of heavier animals. By the way, the same tree-climbing leopard, to secure his kill from the prowling lions or hyenas, usually drags his kill up in the tree branches, as 150 kilo lions cannot climb trees as high as leopards can, and hyenas do not climb trees at all.

Living on the ground is a totally different story. The ground has only two dimensions, and irrespective of your weight, you still live in the same territory, the same "ground floor" as all other ground-living species. One kilo rabbits, 150 kilo lions, one tone buffaloes and four tone elephants all share the same territory all their lives. So, unlike the light monkeys who can sleep safe from predators high up in three branches, ground-living rabbits and antelopes are never safe. Their physical existence is under a constant, 24/7 threat from predators.

(3) Fear of falling vs. fear of predators. Well, everything comes with a price, and living in trees creates other problems. Of course, in high tree branches you are

safe from most of predators, but you may fall to your death. What would you prefer? Considering both sides of the coin, it is clear that those animal species that live high in tree branches opted for the safety from predators instead of safety from the fall.

As usual, Natural Selection, the best and fairest ally of all living species, provided some means of securing sleep against a fall from the trees for tree-living species, including our primate ancestors. Even today, after many millions of the years of leaving trees for good, humans still possess an ancient mechanism, reflex, which most likely secured our primate ancestors from falling from trees. This is the so-called Moro Reflex, the first and possibly the only unlearned reflex that human children have at birth. This reflex is a response to a feeling of a sudden fall. The origin of this reflex (as well as the recurring frightening dream of free falling) can most likely be traced back to our evolutionary heritage from the millions of years spent by our primate ancestors in tree branches.

Another price for having a small and lighter body is that although you are mostly safe from bigger predators, you may easily become a target for formidable birds of prey, like the ancestors of the powerful crowned eagle from sub-Saharan Africa. And still, it would be fair to say that the predator risk is much lower in tree branches than it is on the ground.

Another well-known fact that proves the relative safety of being up in the trees is what humans usually do at night when they are lost in the jungle – as a rule, in order to feel safer from prowling jungle predators in the dark, they climb trees. So the fear of falling is dwarfed by the dominant fear of becoming dinner for mighty ground predators at night.

So let us agree that while our distant primate ancestors stayed up on the thinner branches of trees they were relatively safe from most of the predators, including the ancestors of the mighty big cats.

So why did they decide to go down to the ground in the first place?

Animals rarely stay all their lives in the same environment, even if it is safer for them. All species, constantly and instinctively, try to push their existing boundaries and widen their living space. We know, for example, that many tree-living animals sometimes search for food on the ground. After all, most of the fruit and seeds eventually end up on the ground. Monkeys and birds, who do not live on the ground, sometimes visit the ground, usually in order to collect food. Most likely the first visits of our primate ancestors were similarly just to collect some fallen food from the ground.

And of course, there was a price for this risky endeavor, a big price. It is well known that the risk of getting killed and eaten for tree-living animals is much higher on the ground than in the trees. Natural selection has an unwritten rule for those who want to visit the ground for feeding. The rule is ominously simple and fair:

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"Welcome, if you are visiting the ground for food. There is a plenty of food on the ground, but remember, while you are feeding, you may also become food for someone else."

In this context it is becoming clear that the first meetings of our primate ancestors with bigger ground predators, including the ancestors of the future big cats, were very one-sided: any time our ancestors were caught unaware on the ground, they were as good as dead. So, during the arboreal (or tree living) period in the evolution of our ancestors, the policy of dealing with bigger predators was very strict: avoid any direct meetings with them in order to avoid a catastrophe. At this stage, interaction between the two species was very simple: they were predators, and we were prey. They ate us.

Well, those who were still brave enough to visit the ground were keenly aware of another important rule for surviving the ground visit. This rule sounds like this:

"If you want to visit the ground and survive the visit, keep as silent as you can. Being totally silent is the best option."

Some readers of this book might ask me why keeping silent is so important for your safety if you want to visit ground. OK, they would say, it is obvious that if you suddenly start making loud sounds, then you are asking for trouble as your voice attracts predators. But why the ground only? What about trees? To answer this question you must recall our discussion a few paragraphs above. Trees, unlike the ground, have a third, vertical dimension, and different animals live there according to their weight. Therefore, if you are high in the tree branches, in your "safety zone", you would not be afraid of bigger predators, as they could not climb where you are, simply because of their weight. I propose this is the chief reason why tree-living species are much noisier than ground-living species. There is no other place where the old saying "silence is golden" is as true and appropriate as on the ground.

If we all agree on this point, then I want to make another statement: the fact that tree-living species are much noisier and "talkative" than ground-living species has so far been totally neglected in the scholarly literature. As far as I am aware, this issue was discussed for the first time in my 2006 book. Let us discuss this fascinating issue a bit longer.

Singing Lovers are Invited to the Tree Branches

Have you noticed that when you walk in a park in a forest, virtually all the sounds that you hear come from the tree-living and flying species (mostly birds and insects)? Considering that tree-living species can feel safe when they are high on

tree branches, in their "safety zone" (unlike ground-living species), it is hardly surprising, that there are many more singers among those species who live in trees, then among those who live on the ground. To be more precise, let us consult numbers. Currently there are about 5400 species who sing. Most of all singing species live in trees (mostly birds and primates). There are a few singing species, like whales, dolphins, seals and sea lions, living in the water as well. What about ground-living species? Well, apart from the Australian flightless lyre-bird (still a bird!), amazingly, there is only a single singing species which lives on the ground and sings. That's us, humans. To my knowledge this unique fact of human musicality has also been so far neglected despite the staggering current interest in the origins of human musical behaviour. We will recall this fact later when we start discussing the reasons when and why our ancestors started developing their singing abilities.

Let us now come back to the second rule for tree-living animals when they decide to visit ground. This rule, as we may remember, strongly advises all ground visitors to stay silent. So not only the species who live on the ground must remain silent, but even the tree-living species, usually noisy habitual singers, when they come to the ground for a short visit, should change their habits and become silent. Let us now have a look at the tree-living birds and monkeys. Do they really become silent when they visit the ground?

When Silence is Golden

I remember, when I became interested in the singing behaviour of tree- and ground-living animals, and came to the conclusion that singing in trees is much safer than on the ground, I first of all checked if information on this could be found anywhere in the vast reserves of the internet and JSTORE libraries. Amazingly, my search yielded no results. There was no research done on this potentially very important topic. So I decided to check this out for myself.

I started checking bird behaviour in the nearby "Margaret Walker Reserve" in Preston, Melbourne. Not the best place to conduct a scholarly experiment, of course, but still OK for the preliminary observations of this new intriguing idea. Several Australian magpies, magnificent singers, were living (and still live) in this park, and for several weeks during the 2007-2008 Australian hot Summer my wife and I silently watched their behaviour. Magpies are amazing singers with a vocal range of up to four octaves, a yodeling technique, the ability to mimic dozens of other species, sometimes including horses, dogs, and humans (Kaplan, 2004). We were struck from the very first day to see how these large black-and-white birds, exquisite singers, became virtually mute as soon as they stood on the ground. When they were stood even a little bit above the ground, say, on a table or a garden chair, they would start making their famous yodeling sounds. But as soon as they stood on the ground, all their desire for singing and making other sounds disappeared. After several weeks of observations I came to the preliminary conclusion that my initial idea was correct,

and magpies did not sing and make other sounds while they were on a ground. After this I contacted one of the world's leading experts on bird singing behaviour, Peter Slater from the St Andrews University, and asked him if the silence of birds on the ground could be connected to the fear of predators. Peter confirmed that birds do stop singing while they on the ground, and that bird experts consider this is primarily for the reason of sound transmission (this idea is well represented in publications), although he also confirmed that one of the reasons for this might be the fear of predators (letter from March 3rd, 2008).

So, most likely for the reasons of safety, tree-living species become silent when they descend to the ground. Let us formulate the third rule for those who want to visit the ground:

"If you feel like singing, quickly fly or climb to the higher tree branches and start singing there. The ground is not for singing lovers."

Let us repeat again this phrase several times like a mantra: the ground is not for singing lovers. The ground is not for singing lovers... We will need to recall these words later, when we discuss the potentially very important issue of why our closest relatives, chimpanzees and gorillas, do not sing and why they are so silent in their everyday lives.

Animals that live on the ground or visit the ground sometimes naturally follow this rule, or they run a high risk of being attacked and killed by predators. That's why there are overwhelmingly more sounds coming from the animal species populating tree branches, than the species populating the ground. If you still have any doubts about this idea, I suggest when you go walking in a forest or a park next time, pay attention to the sounds you hear. You will quickly realize that almost all the animal sounds in nature are coming from above, from the tree-living and flying species. These noisy species are predominantly birds and also tree-living monkeys in the tropical forests. You will be very lucky to hear any sound from any ground-living animals either in our forests and parks, or tropical rainforests. Of course, in the parks you can also hear the barking of dogs, but you must remember that dogs are domesticated animals, and the behaviour of domesticated animals is very different from the behaviour of their free-living relatives. Barking itself, for example, is virtually absent in free-living relatives of the domestic dog. In the same way mewing, so widespread among domestic cats, is not present in adult wild cats. These widespread sounds from our canine and feline friends are a late development, the result of domestication, and aimed at their human friends and masters. We know today that barking can naturally appear in domesticated animals. For example, in a truly amazing several-decade experiment, undertaken in Russian Siberia, and reported in 2011 by National Geographic, domesticated Siberian foxes started barking and wagging their tails very much like dogs.

Therefore, ground-living domestic animals make many more sounds that their wild relatives. This is primarily because after domesticating them, their human

masters provided them with better security and also with food. Security from predators and food provision are the two main reasons that encourage both prey and predator species to keep silence in the wild. Apart from this factor, of course, growing up in the extremely noisy environment of a human society also makes our four-legged domesticated friends more vocally active.

We are so used to hearing ubiquitous bird sounds in different environments that we often fail to notice them. You can hear birds chattering and singing not only in forest and parks, but, with a bit of luck, in some urban parts of contemporary western cities as well. At the moment, for example, as I am writing these words at the Mercy College, Coburg, apart from the sound of a lone saxophone coming from the next room and traffic noise from the street, I can clearly hear bird chatter through the open window. Out of these three sounds, two are recent human inventions, but the sound of the birds has been our constant companion for millions of the years. If you are reading this book during daytime, there is a fair chance that you might be also hearing this ancient calming sound, sound that accompanied our ancestors' daily existence for many millions of years.

"So We Are Moving!" Excitement and Fear of the New Environment

There is always a mixture of several feelings when a family moves to a new suburb. If you decide to move to a different city, the feelings are understandably more intense. If you are moving from a mountainous village to the city (or vice versa), the changes and associated feelings might be quite profound. What about moving to a new country with a different language, religion and social norms? Well, as a migrant, I know firsthand the extent of the cultural shock that a person suffers in a new country, even if the new country is as relaxed and happy as Australia, with remarkably welcoming people.

Now, let us go further and try to imagine how it might feel if you are moving to a completely new environment. I mean a **really** new environment. For example, moving from the ground to a completely new life in the water, or moving from the ground to live in trees. Can you imagine the extent of the "cultural shock" from such a different environment and completely new neighbours?

By the way, very much like trees, water is also a three-dimensional environment, and very much like tree branches, there are also several "floors" in the water. Of course, each of these "floors" occupies a much bigger vertical space in the water than in the trees. This is chiefly because unlike trees, which hardly grow higher than 100 meters, the vertical dimension of the water can reach kilometers. Water, as an environment, should be actually compared to the sky, not trees. Trees represent quite a unique environment, although I believe there are still certain parallels between living in trees and living in the water.

As I have already mentioned, in the water, like trees, there are species who sing (although many times less than in trees). Water-singing animals are mainly mammals – seals, dolphins, whales, sea lions. But in this book we are not going to discuss the environmental challenges that water puts on animals. So let us go back to our primate ancestors who were anxious about their move from the trees to the welcoming but dangerous ground.

Moving to the ground must be one of the biggest challenges for every living organism, coming either from the water, or from trees. As a two-dimensional-only environment, the ground offers a very constrained living space with the most intense competition for survival among all three major environments (trees, water, and ground).

To assist aspiring migrants to overcome the challenges of the new difficult environment, there is one important positive factor. This factor is time. All these kinds of "environmental migrations", from the trees to the ground, or from the water to the ground, take thousands, hundreds of thousands, and sometimes millions of years. Evolution is never in a rush. This does not mean that the moving process is rather static and unnoticeable. On the contrary, the whole process of adjusting to the new environment is very dynamic, filled with thousands of daily experiments, miraculous escapes, small successes, big tragedies, and, most importantly, a gradual accumulation of myriads of invisible mutations and small genetic changes in morphology and behaviour. The grand process of natural selection, the driving force behind the evolution of all species, thrives on the advent of such big challenges, as every living species is given an opportunity to change itself in order to increase its fitness and the chances of survival in the changing environment. But if you did not manage to change yourself to meet the new needs, well, you will most likely join the countless species that went extinct in the mists of evolutionary history.

After this general introduction to the challenges of living on the ground we can move now to the concrete strategies that ground-living species use to avoid predators. We are gradually coming closer to the initial interaction between the big cats and our distant ancestors about 5-7 million years ago.

Surviving Predators: Animal and Human Defence Strategies

Humans often complain about the rise of crime in big cities, pollution of the environment, financial and job market uncertainty, and many other hazards of contemporary life. Well, all that is true, but ask yourself a question: how many of our 7 billion human fellows expect every single day of their lives to be killed and eaten? Not many. Well, that's exactly how each member of most of the animal species feels. So let us keep in mind that the notions of "safety" and "security" have dramatically different meaning for animals and for contemporary humans. For most of us contemporary humans, who live in the safety of the 21st century civilization, it is not

easy to imagine the dangers that each member of the animal species is experiencing every day of their lives.

A few million years ago the life of our ancestors was no different from the life of any other animals. As other animals, our ancestors had to divide their everyday lives between several crucially important activities: **(1)** finding food, **(2)** finding mates, **(3)** raising new generations, and **(4)** avoiding predators. The last task was of particular importance. The reason for this is that most of the other activities are undertaken only sometimes during the day, or according to a specific season. For example, you look for food when you are hungry, or you look for a mate when your biological time is right, and you raise a new generation when you have one. Unlike these activities, surviving predators is a full time, 24/7 job, as a predator can attack and end your and your offspring's life any minute of the day or night. So, most of the animal species have to carry out all the activities constantly keeping in the front of their minds the primary necessity of looking out for potential predators. As I wrote in my 2006 book 'Who Asked the First Question?', 'We all can agree, I hope, that it is much more important not to make mistakes in searching for predators than in searching for food. Of course, it might be frustrating if you have not noticed a good stack of bananas, but if you have not noticed a crouching lion, well, you may never need a banana anymore.' The Swiss biologist, known as the father of Zoo [zoological??] biology, Heini Hediger expressed the importance of predation-avoidance more directly: "...hunger and love can take only second place. The satisfaction of hunger and sexual appetite can be postponed; not so escape from a dangerous enemy, and all animals, even the biggest and fiercest, have enemies. As far as higher animals are concerned, escape must thus at any rate be considered as the most important behaviour biologically" (Hediger, 1955).

If you are annoyed by my perseverance in repeating again and again the importance of defence from the predators in animal lives, think of this fact:

Virtually no scholar of human evolution has ever discussed seriously how our distant ancestors survived the threat of predators after they descended from the relatively safe environment of tree branches to the dangerous ground.

To present a more precise picture of the existing suggestions that scholars have made about defence strategies in human evolution, let us discuss some of these suggested strategies in rough chronological order. Not all of these authors discussed the issue of defence from predators, but if their suggestions imply any improvement of the defence capabilities of our ancestors, I have included them as well. So let's have a look:

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Human Defence Strategies: The Short Survey

• 1871. Charles Darwin, in his groundbreaking book on human origins, gave this important issue only a passing mention, suggesting, that our ancestors were defending themselves from predators in groups, using stones and clubs (Darwin, 2004: 72, 628), and that bipedalism was a means to allowing our ancestors to use their hand to operate with tools. Darwin gave so little consideration to the problem of defence from predators that he was even considering whether humans evolved somewhere on an isolated island without predators around them.

• 1923, 1949. Raymond Dart initially thought that human ancestors were small-time scavengers, who struggled to survive, but by the 1950s Dart had changed his approach, and suggested that humans were active hunters, vicious killers and cannibals of their own fellows. The "Man the hunter" model was mostly formulated by Dart. In the absence of stone tools Dart suggested that hominids used bones as their hunting tools. As in this model human ancestors were top hunters, the need for defence from predators was not applicable. As one of the means that could be considered as a defence strategy, Dart suggested that standing upright in open habitats was adaptive and helped our hominid ancestors to scan the surroundings in order to see prey and avoid predators. Author and anthropologist Robert Audrey widely publicized Dart's idea of the "killer ape" in his several books.

• From 1942 onwards, several proponents of the "aquatic ape" theory (initially Max Westenhofer, followed by Elaine Morgan and Alister Hardy to name a few of the other more contemporary scholars) suggested that human ancestors lived on the river banks, in shallow water. For some reason living in this environment itself was considered as a very good predator-avoiding strategy. As a matter of fact, the river bank is possibly one of the most dangerous environments in which to avoid predators, both from terrestrial predators like big cats, who often stalk prey on the river bank, to aquatic predators like crocodiles. Most of the predators ambush their prey on the river bank and most of the killing takes place on the river bank. So I suggest that living on the river bank would actually worsen the predator-avoiding chances of our ancestors.

• 1953. George Bartholomew and Joseph Birdsell based their idea on Darwin's suggestion that carrying tools and weapons (for defence and attack) was an important element for the survival of early hominids. According to their suggestions, carrying weapons was one of the key actions that led to the origin of bipedal locomotion. It is now widely accepted that bipedalism pre-dated the use of stone tools by millions of years.

• 1954. Kenneth Oakley (and Raymond Dart in 1959) suggested that the need to look over tall grass was an important defence/attack strategy that eventually led to bipedalism. It is true that you can see more when you are standing taller on your hind legs, but in this posture you are also more visible to predators as well, particularly if you cannot run fast to escape them. For this reason most animals use a bipedal posture for several seconds only, and after scanning the surroundings they

quickly return to a more secure four-legged posture to conceal themselves from predators (or prey).

• 1962. Frank Livingston (also Roger Wescott in 1967, Nina Jablonski and George Chaplin in 1993) suggested that our hominid ancestors used a bipedal posture to look taller in order to intimidate their enemies and competitors. We know that plenty of animal species use bipedal threat displays to look taller in order to avoid an undesirable fight or to intimidate antagonists during a confrontation. Bipedal posture is certainly a popular strategy for many animal species during inter- and extra-species confrontation, although in animal species this does not lead to habitual bipedalism as happened in our human ancestors. As in the case of scanning their surroundings, after a successful intimidating display animals as a rule quickly return to their usual four-legged posture, unlike humans. We will look at this strategy in much more detail later in the book.

• 1965. Adriaan Kortlandt conducted a series of widely known experiments to find out how our distant ancestors could possibly defend themselves from formidable predators like big cats. He presented a stuffed leopard to the group of chimpanzees, and documented that chimpanzees attacked the stuffed leopard with sticks, accompanying their attack with loud screaming and hooting. These experiments and observations of the behaviour of wild chimpanzees suggested that our ancestors could defend themselves with the use of different objects, like sticks and rocks, and to attack their enemies in groups.

• 1980. Adriaan Kortlandt conducted another interesting experiment to check the possible defence strategy of early small-posture hominids. In experiment he used lions from the new generation of the "Born Free" Elsa lioness's family, and after experiments suggested that thorny branches could have been the earliest defence weapon against big cats. According to Kortlandt, small stature early hominids were too weak to throw rocks at predators, as chimpanzees are able to do in the wild, therefore living in a big group by itself would not provide an effective defence against predation, but would instead lead to a "massacre".

• 1981. Charles Brain published a book, based on analyses of the cave remains of early hominids. He did not pay any attention to early hominid defence strategies as the main theme of the book was to argue against the dominating theory "Man the hunter". Brain argued that in most cases, including some of the classical cases when hominids were seen as hunters and killers, they were actually the prey, hunted by the carnivores of the day. His approach became popular as the "Man the hunted" theory.

• 1982, 1983 and 1992. William Calvin in several publications proposed and elaborated the idea that throwing objects was one of the central means of early hominid hunting success and the development of human cognitive capabilities. Although throwing among primates (and apes) is mostly used as a defence strategy, Calvin considered throwing primarily as a tool for hunting by early hominids. Later in the book we will analyze throwing stones as both the means of hunting and defence.

• 1987. Felix Fifer in his only publication, and independently from him Barbara Isaac in the same year, suggested that our hominid ancestors were actively using throwing of stones (and possibly different missiles) as the earliest means of defence. Barbara Isaac provided a useful review of historical sources and cross-cultural accounts of different tribes using stone-throwing as an effective means of the defence and attack. This suggestion was further developed by Holly Dunsworth, John Challis, and Alan Walker in 2003. This potentially very important suggestion will receive special attention later in this book.

• 2005 (second edition 2009). Donna Hart and Robert Sussman, in a monograph dedicated to the model "man the hunted" put a highly persuasive argument that pressure from predation was a central force in the evolution of all primate species, including early humans. They proposed a whole set of possible strategies of defence from predation: living in larger groups with several males, a bipedal posture to increase the body size and throwing rocks and sticks at predators. At the same time, according to the Hart-Sussman model, our ancestors were still a prey species, and the ultimate strategy for their survival was climbing trees. Therefore their model did not propose a potent defence mechanism that could enable our human ancestors to successfully colonize open grasslands and savannah, and to allow them to travel into the vastly different environments of the world of at least two million years ago.

This short survey, as any such survey, is incomplete as you would expect, but can give the reader a general view of the subject. I hope we can agree that the important topic of defence strategies has not received adequate attention from the researchers of human evolution. Apart from original experiments by Adriaan Kortlandt and the book by Hart and Sussman the issue of hominid anti-predatory strategies were discussed at best as passing mentions. This cannot do justice to this crucial issue. We will see later, for example, that the list of scholarly works and ideas dedicated to the problem of human bipedalism is several times longer than the list of defence strategies of our distant ancestors after they descended to the ground.

The lack of works and ideas dedicated to the defence strategies and mechanisms in human evolution has several reasons. One of the most likely reasons is that arguably still the most popular hypothesis "Man the hunter" does not require any defence mechanisms from predators, as according to this hypothesis, it was other animal species that needed defence from our blood-thirsty ancestors. On the other hand, the more cautious "Man the hunted" model concentrated on fighting against the "man the hunter" hypothesis and on proving that instead of being vicious hunters, our distant ancestors were in fact included in the diet of the carnivores of the day. Because of this proponents of "Man the hunted" hypothesis often neglected the issues of defence as well. Also, in several cases the issue of anti-predatory behaviour was hidden behind the general statement that in every species the most intense competition goes on between individuals of the same species, not between different species.

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Well, I hope we can all agree that competition between the members of the same species does not cancel out the necessity for surviving predators in the first place. It is difficult to argue against the simple fact that members of the same species can only compete with each other if they have valid defence strategies and are able to survive predators in the first place.

Hunter, Hunted or Scavenger?

It is fascinating how much emotion is involved in discussions about the lifestyle of our ancestors. It is understandable that we should look at our evolutionary past with fear and hope, trying to explain our strengths and weaknesses. We are a cooperative species, but we also wage wars against each other. We can love to the point of sacrificing our lives, but at the same time we can participate in mass murders[1]. How can such conflicting behaviours exist in a same creature? Who are we, a loving and cooperative species, or selfish egomaniacs who use moments of altruistic behaviour only to further our selfish interests? We are interested in the evolutionary story of our distant ancestors a bit like a foster child who wants to find out about his or her biological parents. So the question of who were our ancestors and how they survived the relentless everyday struggle of natural selection is a very emotionally charged question.

To summarize the general strategies of early hominid survival, we can say that the current understanding of early hominid survival strategies are based on three main models: **(1)** Man the hunter, **(2)** Man the hunted, and **(3)** Man the scavenger. These three models treat the issue of anti-predatory defence very differently.

(1) The "Man the hunter" model, as we have already discussed above, has been possibly the most influential in popular imagination throughout the 20th century. Raymond Dart, discoverer of the first australopithecine (later confirmed as a Homo erectus) proposed, that our human ancestors were themselves top predators, bloodthirsty killers, raining terror on other species (including their own species). According to this model our ancestors had nothing to fear, and as a result, the mechanisms of defence against predators were virtually not applicable. "Killer ape" and "Man the hunter" models of early human evolution created a very strong stereotype of human evolutionary prehistory, and this stereotype seemed particularly pertinent to the nature of humankind after the devastating Second World War with tens of millions of humans killed.

From the 1970s the belief in the hunting prowess of our distant ancestors started to crumble. Charles Brain and Elizabeth Vrba were instrumental in this process. The South African paleontologist Bob Brain analyzed the fossil remains from

[1] J. Glenn Grays philosophical meditation on what warfare does to humans ends up with the following words 'War reveals dimensions of human nature both above and below the acceptable standards for humanity' (Gray, 1959).

early archaeological and paleoanthropological sites and came to the conclusion that early human ancestors were not hunters, but were instead a prey species. According to Brain, among many other carnivores of the day, early humans were particularly actively hunted by the ancestors of big cats (Brain, 1981). One of the most influential archaeologists of the 20th century, Louis Binford, added his own arguments to the demise of the "Man the hunter" hypothesis, suggesting that the main source of the early hominid meat diet was scavenging, not hunting (Binford, 1986).

Despite increasing criticism, the "Man the hunter" hypothesis is a tenacious one, and even after revealing many caveats it still attracts scholars and particularly modern minds. To conclude a discussion of predator-avoiding strategies, we may say that the "Man the hunter" hypothesis virtually neglected the problem of predation, turning the early human ancestors into powerful alpha hunters, or scientifically speaking, into "apex predators" who had nothing and no one to fear.

(2) "Man the hunted" model. While discussing the first model, known as "Man the hunter" model, we have already partly discussed the alternative model, often referred as the "Man the hunted" hypothesis. Bob Brain was possibly the earliest most important proponent of this model. This model is gradually coming into prominence. In the first decade of the 21st century two St Louis-based anthropologists, Donna Hart and Robert Sussman, combined the information on predation on primates with the existing critique of the "Man the hunter" model. The Bob Brain-coined phrase "Man the hunted" became the title of the Hart-Sussman book. Today the "Man the hunted" hypothesis is becoming an important, if not mainstream, model of human evolution. An important feature of this model is that it takes into account the tremendous pressure put on our distant ancestors from the many predators that shared Africa during the last five millions of the years. In a way this approach is radically different from Darwin's approach to predation. Darwin did not take much notice of this problem, musing whether early hominids lived in total isolation from predators. Hart-Sussman, on the contrary, proposed that predation was the central force that shaped humans. This approach also explains much better the existing fossil record with plenty of marks on the hominid fossil remains made by a killer bite of big cats, fearsome lion-sized extinct hyenas, and other carnivores of the day. The weak point of this approach is that concentrating mostly on the role of early hominids as prey, this approach does not offer a viable explanation of how this slow-breeding, slow-walking and ground-living prey species became the most widespread large mammal during the Pleistocene era, overshadowing even the mighty big cats.

(3) "Man the scavenger" model. After the reign of the "Man the hunter" hypothesis, two alternative hypotheses, the "Man the hunted" and the "Man the scavenger" appeared almost simultaneously. They are closer to each other than to the "Man the hunter" hypothesis. Both of the new hypotheses acknowledge the pressure that predator species put on early hominids. The difference between them is basically in the degree of the predation on hominids, and the degree of meat eating among early hominids. If according to the "Man the hunted" model hominids were mostly a hunted species who only occasionally had access to protein-rich meat, according to the "Man the scavenger" hypothesis hominids were not killing their meat, but

instead were using scavenging opportunities, chasing competitors from the kill. This model is possibly the most widely shared today by anthropologists. Louis Binford was one of the key figures in establishing this hypothesis among leading paleoanthropologists today.

The survival of our species throughout evolution and the widest distribution of humans all over the world in prehistoric times is hard evidence in itself, proving that our ancestors did have highly effective survival strategies. The problem is that we do not know what kind of survival strategies they were using.

To work out this problem, I suggest checking what kind of survival strategies are in the storehouse of Natural Selection, and then check which of these strategies could be applied by our distant relatives. Plenty of animal species run away from predators, and the predator-prey running competition develops amazing running abilities; many animal species can skillfully conceal themselves with matching colours; some have a wonderful sense of smell with which to scent the presence of predators, and some, even non-carnivorous species, develop large canines and horns to fight back against predators and competitors. All these are very popular means of defence from predators, and plenty of animal species use these strategies, often combining them. Some more unique survival strategies include, for example, spraying the predator with an awful-smelling liquid, like the skunk does, and of course, some non-mammalian species also use venom, electric shock charges and other more rare and exotic means.

On the next pages we shall discuss different strategies that our primate ancestors could have used in order to save their lives after they descended from the trees to the ground and met the ancestors of the big cats, who ruled the ground for millions of the years.

Hide, Run, Fight, Bite: Survival Strategies in Animals

It is a somewhat sad fact of life that to stay alive many animal species have to eat each other. Well, another fact is that no individual animal accepts this fact of life as inevitable. So there is a perpetual struggle between predators and prey. This struggle is the very basis of the grand process of Natural Selection. As a result, predators are continually getting better at finding and killing their prey, and prey are getting continually better at escaping predators. In this perennial struggle both prey and predators change their behaviour and morphology to better suit their own survival needs.

Let us start from a brief survey of basic animal defence strategies (for a more complete list of animal survival strategies see Ruxton at al., 2004). After this survey we will have a better understanding of the defence systems that our ancestors could

employ, and then we will check which of these defence strategies were in fact used by our primate ancestors.

Here are some of the most popular and time-tested strategies for defence from predators.

1. If you cannot see me, you cannot eat me!

This is the very first line of defence of many animal species. If you can manage to stay out of sight of predators, you will have a good chance of surviving, reaching adulthood and leaving offspring. This strategy is known by the scholarly term "crypsis". This strategy is so widely known that some consider that all animals are naturally cryptic (as we will see later, this is not correct). Myriads of animal species try to cover their bodies with blending colours so that it is very difficult for a predator to see them. Some non-mammalian species are more ingenious in the use of crypsis than mammals. For example, chameleons can change the colour of their body according to the environment they are in at the moment, and octopuses can create a decoy, become colourless, and swim away from danger. Crypsis is widely used not only by prey species, but by predators as well. The reason behind this is not difficult to understand. Predators need to hide from their prey as much as prey need to hide from their predators. Camouflaging tiger stripes were not formed in order to survive from predators, as big cats are on the top of the food chain and have no fear of other predator species. Tiger needs stripes to be able to stalk prey animals unnoticed, the same way as lion colours are well matched with the colours of the sun-bleached Savannah.

So, let us remember, in order to stay unnoticed by prowling predators, plenty of animal species try to blend with their environment. We must also remember that many predators use the same strategy of hiding in order to be more successful in their hunt.

2. Silence is golden!

Despite the popular conception that crypsis involves only the visual channel, crypsis uses at least two other channels as well. It is obvious that being visually cryptic is only half the strategy. Even if you blend ideally with the environment, if you suddenly start making loud noises, for example, singing, your chances of escaping a predator's attention are drastically reduced. So, trying to stay silent is the second crucially important component of crypsis. We can call this "audio crypsis". Therefore, apart from visual crypsis animals need to maintain audio crypsis as well. We have already discussed the importance of staying silent, particularly for the ground-dwelling species. We may remember the important fact that when tree-dwelling birds or monkeys visit the ground, they as a rule become silent. Very much like visual crypsis, audio crypsis is widely used by predator species as well, for the same obvious reasons as visual crypsis. Most of the predators have to be silent while they are hunting their prey, although predators that hunt in groups (like lions or wolves) may make use of sounds in order to communicate with each other. Because

of different hunting tactics dogs and cats are quite different in this regard. Dogs, while hunting, do not stalk their prey, instead they run down them, so being silent is not that important for them. Unlike dogs, being silent stalkers is vitally important for all cat species. Cats, including all small and big cats, are grand masters of silent stalking. That's why it is much easier to hear when a dog comes into a room than a cat.

3. Stay clean and survive!

The third element of crypsis is getting rid of the odour of your own body. In scholarly terminology, odour is an "olfactory factor". Most humans have quite a poor sense of smell (I myself am a perfect example of this, unlike my wife). On the other hand plenty of animals, both predator and prey species, have an excellent sense of smell and use this ability widely in their everyday lives. So, an animal which is visually well blended with the environment, and is not making any sound, can still be detected by predators if its body emits a more-or-less strong odour. Therefore, in order to stay unnoticed, animals should also control the odour of their bodies. We could call this "olfactory crypsis". And again, this factor is as important for predators as for prey. The most specialized predators of our planet, cats, including both small and big cats, maintain their bodies in a wonderfully clean condition. Later in this book we will find numerous quotes about cats, and we will see that the cat's cleanliness entered folklore a long time ago. Dogs, hyenas and other predators, which usually run down their prey with their extraordinary running ability and group hunting tactics, are not as concerned for their personal hygiene as cats are. As a result, canines are not naturally as odourless as are cats. Many dog owners might disagree with me, and I have seen a few heated discussions on this topic in internet discussion groups. If you really want to find out the answer to this question, you should do what one of the participants of the discussion suggested, namely: allow both dogs and cats to go without washing or any other interference, and check their body odour in a few weeks' time. It will be quite obvious that dogs have much more body odour than cats. As cats hunt by stalking, it is crucially important for them to stay unnoticed, so their proverbial cleanliness is the result of the evolutionary need for their own survival.

According to this logic the cheetah should have more body odour than other big and small cats. The cheetah has superb speed that makes long stalking unnecessary, therefore long cleaning sessions, like other cats perform, evolutionarily speaking, would be a waste of time for a cheetah. On the other hand, lions might also have a bit more body odour than most of the other cats, as the lion's hunting strategy is based on group participation, and stalking unnoticed is not as important for them as, say, for solitary tigers or leopards, who hunt alone. It could be predicted that most of the solitary species, both predators and prey, would have less body odour than social species.

These three factors (visual, audio, olfactory) comprise the general defence strategy, known as crypsis. The survival logo of crypsis is very straightforward: "blend with the environment, hide, be silent and odourless and hopefully predators will fail to notice you." Crypsis is the first line of defence from predators for many prey species. If crypsis fails, and the animal is detected by a predator, it will drastically change its behaviour and other defence options start operating.

4. Run for your life!

This is by far the most popular means of escaping predators, particularly in the open spaces of the African Savannah, where our ancestors shared space with lions and other animal species for millions of years. We might remember that unlike tree-living species, which can live on "different floors" of the three-dimensional trees according to their weight, and therefore are relatively safe from bigger predators, on the two-dimensional ground the only way to escape predators is to run away from them. Predator running after prey is one of the most profoundly important scenes of the great cycle of life, and it would be natural to assume that both predators and prey are getting better at running as the centuries and millennia pass. Big cats are extremely fast runners, and although they are not built for endurance running, over shorter distances they can develop a speed of about 55-60 km hour, about the same speed as most of their prey species. The power of speed shows in the fact that the fastest running animal, the cheetah, is the most successful hunter in the African savannah, with a rate of about 7 kills out of 10 hunts. The much more powerful lion kills only 2-3 out of 10 hunts. On the other hand, built for speed, not for strength, the cheetah loses many of its kill to other, stronger carnivores (lions, hyenas and leopards), and is forced to go for another kill. Well, everything has its evolutionary price… So, let us remember: the most popular means of defence from predators when you are detected is to run away.

5. Be stronger!

The importance of being stronger for survival is so obvious that I am sure readers do not need any additional arguments. The stronger you are, the better equipped you are to defend yourself against predators and competitors. Considering the dangers of ground living (in comparison with living higher in the threes), it is not surprising that ground-living animals are usually both bigger and stronger than tree-living animals. Besides, in the tree branches a lighter weight is a more of an advantage for the safety of prey species than on the ground. It goes without saying that predators also try to become stronger, even more than prey species, as predators need to overcome the resistance of the prey species without sustaining serious injuries. Because of this universal evolutionary race to become stronger, animals of every size are as a rule extremely strong for their size. Big cats are arguably one of the strongest animals in regards to the weight/strength ratio in the animal kingdom, which allows them to bring down a much bigger prey.

Although bigger animals are usually stronger as well, we will see later that this is not always the case, and most importantly, the evolution of our own species is a good (although mostly neglected) example of this kind of contradiction. So, without going further with this discussion, let us remember as an axiom – the stronger you are, the better you are equipped to defend yourself against predators.

6. Get bigger teeth!

If you have to fight for your life against predators, professional killers, who literally "kill for a living", you need to have weapons as efficient as possible to fight for your life. Teeth, and particularly canines, are arguably the most popular weapon for fight (both for the offense and for defence) in the animal kingdom. Teeth are of particular importance for those species that live on the ground. If you have some doubts about this claim, consider this fact: most living animals have sharp teeth, but almost all flying species do not have teeth at all! Among the flying species only mammalian bats have teeth (Garfield, 1972:411). The reason why tree-living species have so few or no teeth at all must be a result of several factors: (1) in the trees animals mostly survive predators not by fighting back, but by climbing higher, so, there is less direct physical fighting among tree-living species than among ground-living species, so simply speaking, they do not need teeth, (2) lighter weight for tree-living animals is much more important than teeth as a defence mechanism, and teeth are an extra weight, which is a liability in tree branches, and last but not the least, (3) teeth can decay and create health problems (we human know this only too well!).

So, considering all these factors, it is not surprising that tree-living species gradually discarded their teeth as an unwanted baggage from their evolutionary past. According to fossil evidence, the ancestors of the contemporary birds, some 60 million years ago, also had teeth. Therefore, birds gradually lost their teeth as those individuals with smaller (or no) teeth were surviving better than those who had big teeth.

In the same milieu, if you compare the canines of tree-living monkeys with the canines of ground-living monkeys, you will see a marked difference. Ground-living primates as a rule have bigger teeth. Chacma baboon canines, for example, are bigger than lion canines. Ground-living baboons and mandrills have dog-like muzzles and scary canines which they bare to scare away leopards, and they use them very efficiently when needed in combat. I could even propose an evolutionary motto: "Tell me how much time you spend on the ground and I will tell you how big your canines are." When it comes to big and effective canines, of course, predators, and particularly big cats, are among the most fearsome canine bearers. What about humans? Let us wait a while…

7. Have a thicker and stronger hide

If you have to fight against predators that have long canines and sharp claws, a stronger hide that can withstand an attack would be very useful. Of course, your hide can do little when your throat is grabbed in the lethal vice of a big cat, but in a

predator-prey chase there are many moments when you can come out clean if you have a stronger hide. Not surprisingly, virtually all the prey species have a very tough hide. For example, the hide of a spotted deer might seem very soft to us, but this impression is deceiving. In reality, they are so strong that even a tiger needs some extra energy and time to open up the carcass in order to get to the nourishing parts of the body. Following this argument, I would expect that tree-living animals would generally have a softer skin than ground-living species. At least, we know that tree-living birds successfully use their light feather instead of animal fur, and they traded their ancient tough and heavy lizard skin for a fragile and light skin complemented with feathers. As tougher skin in most cases is heavier as well, the factor of the weight also would pressure tree-living species to get a lighter alternative instead of tough hides or lizard armours.

We discussed some of the most widely used defence strategies that ground-living animals use to secure their lives from the attacks of predators. These strategies are those of staying unnoticed by the predators, blending with the environment, staying silent and odourless, running away from a predator, and in the case of the physical confrontation to be stronger, better equipped with weapons (like canines) and be defended by a tough hide.

Apart from these strategies there is one more, completely different general strategy of surviving, and we are going to discuss this strategy now.

8. What about to try to scare away a predator?

The idea of scaring a predator might sound very silly and unrealistic to some readers, but you must realise that this is a perfectly valid option and is routinely used in animal life. If you watch documentaries about animal behaviour or have seen albums of animal photos taken in nature, you may have seen how obviously much smaller and weaker animals try to scare much bigger animals by baring their teeth, making a range of sounds, or trying to look bigger in order to avoid an attack from a deadly predator. Birds are known to make themselves look bigger (by partly opening their wings) in order to avoid being attacked by different predators, including crocodiles, some frogs try to survive against frog-eating snakes by literally inflating their bodies and making themselves look much bigger, and a fragile cheetah sometimes tries to scare away the mighty lion by making threatening gestures and movements. None of these animals could really survive a serious confrontation with the animals they are trying to scare away, but there is always a chance that the predator is not hungry and determined enough at this particular moment, so a predator might decide not to attack a prey if the prey is not running away, and instead suddenly looks bigger, shows a threatening attitude and is most likely going to fight back. We need to remember that during lethal combat predators also run the risks of injury, which can be a death warrant for them.

This factor, how hungry a predator is, is not always taken into serious account. At the same time it is absolutely crucial for predicting a predator's behaviour in any

given situation. Not-so-hungry predators can sometimes be easily dissuaded from an attack by a prey's aggressive display and might even run away from a prey species. A sad story from Canada was reported on the internet recently: a cougar ran away from a barking dog and took a refuge in a tree, where he was later shot and killed by a farmer. Cougars, as other bigger cats, are known to hunt dogs (leopards are particularly known for this), and no dog has a chance of survival in a confrontation with a cougar or even a lynx, but in this particular case the cougar most likely was not hungry and that's why he tried to avoid confrontation with the aggressively barking dog. On the other hand, if predators are very hungry, they may make an extremely risky decision and attack much bigger animals, animals that are not on their usual diet and can kill the predators. For example, lions and tigers are sometimes known to attack adult bull elephants that are about 20 times heavier than adult tigers and lions.

As we can see, it is a perfectly valid option to try to scare away a predator with an aggressive display. Later in this book we will specially discuss the intimidation of predators and competitors by different audio and visual displays, and we will see that this is an extremely important and relatively overlooked strategy in human evolutionary history.

In order to make aggressive display more effective, animals use plenty of special morphological elements and behaviours. As these techniques will play an important part in our understanding of the defensive behaviour of our primate and hominid ancestors against big cats, let us now discus some of these techniques.

9. "Bigger kids do not get bullied"

That's what we were told when we attended a school talk for parents about bullying among schoolchildren, when we took our son to a primary school in Australia in January 1996. It is highly possible you have heard about this as well, during your own school years, or later, when your kids went to school. It is quite amazing, but even in our civilized epoch, where physical strength and size does not matter that much for success in life, not only the bigger sized boys and girls can usually avoid bullying at school, but even in such a high-profile intellectual race, as the election of the President of the United States, the taller candidate often wins. Millions of years ago, when a struggle for one's own life was an everyday business, having a bigger body was much more beneficial. So, let us remember: if you are trying to avoid a predator's attack by intimidating the predator, a bigger body will help you to look stronger and more intimidating. Seeing a bigger-sized prey, a predator might think twice before starting an attack.

Everything comes with a price, and a bigger body is more difficult to hide, so it is up to your evolutionary choice, whether you will be a devoted follower of the principle of crypsis and remain a smaller bodied animal, or you will try to look bigger and try to intimidate predators with a bigger body.

Natural selection is extremely inventive. So many animal species found the ideal solution to the dilemma of positive and negative features of smaller and bigger-

sized bodies: they can quickly change the size of their bodies. So in one moment an animal might be trying to look as small and invisible as possible in order to avoid detection, but in the next moment, as soon as the predator notices the animal and expresses aggression, a smaller animal suddenly drastically changes its posture and behaviour: the hair is fluffed up, the body is often turned sideways (both of these behaviours are designed to look bigger), the teeth are clearly displayed, and the display is often accompanied by threatening sounds. The behaviour of a domestic cat when an unknown dog enters the backyard is a good example of this kind of sudden change of posture and body size.

This kind of threatening display often works. Otherwise natural selection would eliminate this display from the behavioural set of many species. But intimidating a predator does not always work. In those cases when a predator is unfortunately very hungry, it will most likely attack. In this case, you have two choices, known as "flee or fight response": you can run away, or you can fight for your life, using all your weapons and strength. Smaller-sized cats, for example, can sometimes quickly escape into the safer environment of the tree branches, demonstrating once again the life-saving power of the "third dimension".

Let us remember once again that for tree-living animals a smaller-sized body is an advantage in their struggle for survival, as a small weight allows an animal to climb higher on tree branches. But on the ground, which does not have the third, vertical dimension, a bigger-sized, heavier body with more muscles usually offers better protection from predators. It is not surprising that many ground animals have bigger bodies than their tree-living relatives. For example, ground-dwelling primates are usually bigger than their tree-living relatives, and as we have already mentioned, ground-living primates also have bigger teeth as well.

10. Stand on your hind legs

Arguably the most popular way to suddenly increase your body size is to stand on your hind legs. Many animals stand on their hind legs to drastically increase their height and to intimidate their antagonists with their size. Bears are a classical example of this tactic. If they are confronted with other potentially dangerous animals (for example, leopards or a tigers), they as a rule start displaying bipedal posture in order to look much taller. Very often this works (again, if the antagonist is not too hungry). Some predators do not even attack another animal if they are taller than the attacker. The idea that human bipedalism might have initially started from such bipedal intimidating displays was expressed almost half a century ago by Frank Livingston, and later repeated by different authors several times. We will come back to this idea later in this book.

11. Make threatening sounds

To look bigger is not the only factor that can scare away a predator and save your life. Making loud sounds is another widely known strategy. Plenty of animals, when facing aggression from a predator or a competitor, make loud sounds – cats

hiss, growl and scream, lions growl and roar, even ants make clicking sounds, snakes hiss and some of them make rattling sounds. Sometimes the sound itself might not be as loud and blood-curdling by itself, but might have specific associations. For example, many animals are afraid of venomous snakes, so the snake's defensive sound (hissing) became popular among many totally unrelated animals who could give other, much louder sounds (for example, small and big cats). This technique is known as "audio mimicry" (Gaul, 1952).

The list of animals using warning sounds can go on, but I do not think we need too many examples, as making sounds for saving life from aggression is a very well-known strategy in the animal kingdom (you can have a look at Ruxton et al., 2004). Basically, the louder the sound, the more effective it is. A lower, deeper sound makes a particularly good tool for the intimidation of opponents, as lower sounds evoke the sensation of a bigger, heavier and stronger animal.

12. "I have big eyes and I can see you!"

Another popular means of scaring away a predator it to display "big eyes". We are not talking here about the real eyes of animals. For this kind of display animals use other parts of the body with markings that look like eyes. These markings are known as "eyespots" or "ocellus". Eyespots are clearly visible, and they can be on different parts of an animal's body. The use of eyespots as a defence mechanism is particularly popular among butterflies, reptiles and birds.

There are different ideas about the function of the eyespots among scholars. Initially it was believed that eyespots were designed to scare away predators by displaying big eyes that resembles the eyes of other species that the predators are afraid of (Blest, 1957). For example, butterflies display eyespots that might resemble the eyes of the owl, and thus scare away birds who eat butterflies but are afraid of owls. The effectiveness of eyespots as defence mechanisms has been demonstrated in experiments. For, example, in one recent experiment 33 out of 34 Peacock butterflies avoided death from hungry birds by displaying eyespots. Both butterflies and hungry birds were confined to a small room, and butterflies survived continuous attacks during the 30 minutes by just displaying the eyespots (Vallin et al., 2005).

The idea of eyespots, as clearly visible marks, goes against the idea of crypsis. The ingenious power of Natural Selection made it possible for the same animals to be cryptic and to display eyespots only when the animal has been detected. For example, some butterflies have two pairs of wings, and the outer pair is cryptic, blending with the environment, and the inner pair has clearly marked eyespots. Therefore, a resting butterfly is in a "cryptic mode" and is difficult to notice, but if disturbed, a butterfly opens the outer wings and the predator gets a sudden shock with the appearance of scary Big Eyes. The above-mentioned Peacock butterflies use this switching mode from crypsis to aposematism (warning display).

Scholars also suggested that eyespots might be designed to confuse predators by diverting them to less vital parts of the body (see for example, Lonnstedt et al.,

2013). As we know, evolution is very economical, so it is possible that eyespots have several functions.

Among mammals eyespots are not as popular as among butterflies and reptiles, although very importantly for the topic of our book, many big cats have eyespots on the back of their ears. At least one of the possible functions of these markings on the back of the ears is to deceive a potential enemy who is approaching from behind into believing that the enemy has been spotted. It is widely known that cats themselves prefer to attack their prey when the prey is not aware of the cat's presence. For example, one effective means of saving human lives in the marshlands of Sundarbans, where killing villagers by man-eating tigers is a regular occurrence, was the putting of masks of human faces on the backs of the head of the villagers, in order to avoid tiger attack from behind. So, eyespots are an effective means of preventing an attack of a predator, and as a result, this strategy is employed by countless numbers of animal species from different classes and orders. Leyhausen proposed that as the eyespots on the back of the ears are prominent from the frontal view when a tiger (and a few other cats) flatten their ears in order to show aggression to the antagonist, it has the function of intimidation (Leyhausen, 1960; Schaller, 1972:264).

We are coming to the end of our brief review of animal defence mechanisms. In the next section we will start discussing the defence strategies of our ancestors. But first let us repeat one more time that the strategy to scare away predators is opposite to the strategy of crypsis. In crypsis animals try to stay unnoticed by hiding and being silent. On the contrary, when animals try to scare away predators, they try to look bigger and they make loud sounds. Also, let us remember that a large number of animal species manage to use both of these strategies by instantly shifting from one mode of behaviour to another. For obvious reasons, this shift is always from crypsis to warning display, but never vice versa.

Also, very importantly, apart from such species who use both cryptic and warning modes in different situations, there is also a number of specific species who use the principle of warning display all the time. Such **species, who use warning display as the central strategy of their defence, and who do not try to hide themselves from predators, are known as aposematic species**. The mysterious word "aposematism" means "warning display". We will discuss aposematism and aposematic species in detail later in the book.

Summary

Let us summarize the defence strategies among animal species we have already discussed.

The list of the techniques and strategies that we have just discussed is by no means exhaustive, but will give a reader the general idea of the main defence strategies that animal species use in order to avoid predation. If a reader in interested in reading a more detailed account of existing defence strategies, I would suggest

reading a recently published book on the subject "Avoiding attack. The evolutionary ecology of crypsis, warning signals, and mimicry" (published in 2004). Of course, different animal species use many more defensive strategies, but I included only those strategies that might apply to the morphology and behaviour of human (and big cat) species. There is little sense in discussing such defence strategies as using venom, electric shock, or horns, when we are discussing the interaction between human ancestors and big cats.

And at the end of this section, dedicated to basic survival strategies used by prey species against predators, I want to remind the reader once more that after our primate ancestors made the historical move from trees to the ground, they had to devote much more time and energy to safety from predators, as the risk of predation was much higher on the ground than it was in the trees.

With this thought clearly in mind, let us now have a closer look at which of the above-mentioned strategies could have been used by our distant ancestors.

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Early Hominid Defence Strategies

Here we are, trying to reconstruct the first encounters of our ancestors with ground-living big predators, primarily big cats. We already mentioned that initially the interaction between the ancestors of big cats and humans was the interaction between predators and prey, but gradually our ancestors learned to stand their ground, and to survive the kings of the forests and savannah. The crucial question is: what strategies could they use for their safety from the fearsome ground predators?

I fully agree with Hart-Sussman's thesis that predation was a crucial evolutionary force forming the future Homo sapiens. The central thesis of my model of human evolution is that it was primarily the original defence strategy that started the long chain of our morphological and behavioural transformations from primate into Homo sapiens.

Now, to find out which of the known defence strategies might have been followed by our distant ancestors, let us compare the above list of animal defence strategies with the early hominid morphology and lifestyle.

Did Our Primate Ancestors Become More Invisible to Escape Predators?

As we recall hiding (crypsis) is the initial defence strategy for many animal species. They try to stay unnoticed most of the time. We may also remember that hiding from others is very popular not only among prey species, but among predators as well for obvious reasons. Basically, both predators and prey try to stay unnoticed from each other.

What about our ancestors? It seems to me that, according to their upright bipedal posture, it would be logical to conclude that our distant ancestors did not try to hide from predators. Or at least, if they tried, they were not good at it. Some readers might suggest that contrary to my assertion the bipedal posture was not too bad a tool against predators. For example, Dart suggested in 1925 that a bipedal posture might have helped our ancestors to notice stalking predators. This idea was repeated a few times later by several scholars as well. It is generally true that, if you are taller and your eyes are positioned at a higher point, you can see your surroundings better. On the other hand, the proponents of this idea sometimes do not pay attention to another obvious fact, that in an upright posture your body is also seen better by all other animals as well, including prospective predators. What to do? As is often the case, the genius of Natural Selection found a brilliant solution to make use of both postures: many animal species (both predators and prey) use a bipedal posture for several seconds only. They rise on their hind legs just to scan the territory, and after receiving this visual information they quickly return to their usual four-legged posture to stay out of sight.

In contrast with this very sensible strategy, our ancestors shifted to full-time bipedal locomotion, which was very visible, particularly in the open grasslands of the African savannah. It must be natural to conclude that our ancestors did not try to conceal themselves from the eyes of predators.

And by the way, their highly visible bipedal posture indicates that our ancestors were visible not only to prospective predators, but to prospective prey as well.

Did Our Ancestors Become Silent After They Descended to the Ground?

We may remember that ground-living species are much more silent, than tree-living ones. We may also remember that when tree-living species visit the ground, they as a rule also become silent. So what about our ancestors? In answering this question we can be quite sure that our ancestors were not a silent species. As I have already mentioned earlier, humans are virtually the only species who live on the ground and sing. All other 5400 singing species live away from the ground, on the safer tree branches, or in the water. So we can definitely say that our ancestors did not try to be silent. As a matter of fact it is virtually impossible to find a noisier animal species than humans.

What about Escaping Predators with Running?

As you remember, running away from lethal predator danger is the most widespread means of avoiding predation, particularly in such an open place as the African savannah. As we know, humans can run, and watching how some of the best athletes run is a great pleasure. The amazing human ability to run was studied and glorified by two American scholars Dennis Bramble and Daniel Lieberman. The reader can easily find on the internet the fascinating 2004 article "Born to run" about their research into human running ability. Bramble and Lieberman studied the importance of running in human prehistory and evolution for a long time. They argue that humans are the best endurance runners among all animals, beating even horses, wolves and antelopes. So it might seem that running was the key factor in how our ancestors survived deadly ground predators in Africa.

Well, I must say that such claims about the effectiveness of human running are not widely shared by scholars, and there are good reasons for this.

Consider several facts. Most importantly humans are not fast runners (this fact is shared by Bramble and Lieberman as well), and that is what counts when it comes to saving yourself from a charging predator. The fastest speed ever to be achieved by the fastest running human, the legendary Jamaican athlete Usain Bolt, was under 45 km per hour for a couple of seconds only. Basically, anyone who can run 100 meters in 10 seconds (10 meters a second), will be most likely participating in the Olympic

games as a professional sportsman. So the top speed in human running is about 36 km/h.

If we compare this speed with the speed of other animal species, which live in the open territories of the African savannah, we can see how slow humans are. The minimum speed of most predators and prey on the African savannah is approximately 55-60 km per hour. Even if we forget the amazing cheetah, which can run with a lightning speed of over 90 km/h for several seconds, much heavier lions also can run with a speed of 60km/h. The same is true for most of the prey species, for example, the antelope species. A slow-running antelope is a dead antelope.

So what is the conclusion? Not very positive for running humans and hominids: even if you can beat Usain Bolt on the track, your speed still would not be enough to save your life from a charging lion, or to catch a running antelope on the African savannah for your diner. There is more. Forget about the lightning speed of the big cats and antelopes. Even our closest relatives, the funny chimpanzees, with their awkward knuckle-walking and running style, can run faster than the slim and spectacular elite of human athletes. Embarrassing for humans, but a fact.

Actually, if humans were as fast as the best runners of the African savannah, we would need to redesign some of our sporting games and gear. For example, in order to play soccer, the soccer federation would need to change the texture of the playing ball, as the currently used soccer ball flies over big distances slower than the running speed of the African savannah animals. So a player with such an "animal" speed would be able to kick the corner and then score himself...

"Wait a minute," a reader might ask, "Dennis Bramble and Daniel Lieberman agree that humans are not sprinters, but they argue that humans are the best endurance runners! What about this?" We will discuss the human long-distance running ability in an evolutionary light later in the book, when discussing the ways our distant ancestors obtained food. Here we are discussing **running as a means of avoiding predation**, and we can all agree that running away was not an option for our ancestors to escape predators if their speed could not match the speed of the attacking predator.

Possibly It Was Sheer Physical Strength?

As you will recall, physical strength is another crucial factor that helps a species in a struggle for survival against deadly predators. How strong are humans and how strong were our hominid ancestors? We look at the muscular bodies of the best human athletes in admiration and awe, but how strong are they compared to animals? The answer to this question is another disappointment for humans. Even the best human athletes are hopelessly weak in comparison with even much smaller animals. For example, when you look at the photos of the huge muscular bodies of the guys like Arnold Schwarzenegger on one side, and a photo of a funny-looking chimpanzee on the other side, it is very difficult to believe that the much smaller chimpanzee is several times stronger than the seven times Mr. Olympia. By the way,

Schwarzenegger not "only looks" strong as some might think. He is extremely strong, and in 1967 he even won the traditional strongman competition in Munich after lifting 253 kg stone. Some might argue that our hominid ancestors were very different from us, that their physical strength was closer to animal strength. This is most likely true, but it is also true that during the millions of years human physical strength gradually declined during the process of sapienization (or becoming human). So although our bodies were becoming gradually bigger, our "animal" physical strength was gradually disappearing. So our ancestors could not save their lives relying on their physical strength against the ancestors of the big cats.

What about Teeth?

If we needed at least several sentences to discuss the human inadequate abilities in running and physical strength in comparison with animals, here, discussing teeth, we do not need this, as it is too obvious that canine teeth, the most important defence (and offense) evolutionary tool of many animal species, is totally absent in humans and in known hominid ancestors. Teeth have the strongest bone structure of all human bones and can survive better than other bones, so the paleontological evidence on the evolution of hominid teeth is as rich as it can be. The evidence shows that human canines were disappearing for several million years, from the very beginning of the long road to humanity, starting from out very first known ancestor "Toumai," who lived about seven million years ago. So it is clear that our ancestors were unable to defend themselves from predators by fearsome canines, as many other ground-living primates, like baboons or mandrills, could and still can do. Darwin was probably the first to point out that the decrease of canines in human evolution must have been connected to the adoption of tools as weapons, relieving teeth of the function of physical defence. A century later Ralph Holloway suggested that the reduction of canines followed changes in the social organization of our ancestors and was a selection against aggressiveness (Holloway, 1967). Richard Wrangham recently suggested that it was the invention of cooking, not tools, that played the key role in the decrease in the size and number of hominid teeth (Wrangham, 2006). Whatever the reason, it is clear that teeth could not serve ad an adequate weapon to defend our ancestors from the attacks of the big African predators.

Hide Behind the Thick and Tough Hide

Disappointment again. Humans have one of the softest skins in the animal kingdom, and arguably the gentlest and softest skin among the savannah-living animals. So it is clear that our ancestors were devoid of any possibility of protecting themselves with the last resort of defence – a tough hide, one that both prey and predator species use to endure the rough physical contest against each other for survival.

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Summary

This brief review of possible hominid defence mechanisms looks like a total strategic disaster. None of the usual popular means of the defence from predators were used by our hominid ancestors! Our ancestors were not hiding from predators, they were not keeping themselves silent, they could not run fast, they were physically very weak, had no teeth, and had no tough skin to defend them against charging predators. And such defenseless creatures were living millions of the years on the open grasslands of the African savannah, both day and nighttime, sharing territories with lions, saber-toothed tigers, lion-sized hyenas and wild dogs, to name a few of the predators of the day. It might seem a miracle that primate-hunting big cats did not eliminate the strange groups of primates, living on the ground and virtually without any defence mechanism.

But of course, our ancestors were not defenseless after all. Louis Leakey once famously said "We were not cat food". Well, we actually were a cat food for a long time, but we gradually developed strategies to become exempt from the diet of the big cats and later even challenged them for the domination of the animal world. We are living proof of this. So what was the key of our success?

We have not yet discussed all the defence mechanisms that animals use to save their lives against predators. Now we need to discuss the totally different strategies that animals use in order to survive the struggle for existence. This strategy is to **intimidate and scare away** predators. We will be pleasantly surprised to learn how efficient our ancestors were at intimidating all predators and competitors. Our ancestors possibly were the best intimidators that the world has even seen. But this unique ability did not come suddenly. It was developed during a long and painful process of selection and elimination through natural selection and the gradual accumulation of new morphological and behavioural characteristics in our species. We shall next discuss this survival strategy.

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CHAPTER TWO

Aposematism: When the Interests of Prey and Predator Species Coincide

In two words, "aposematism" is a strategy of intimidation of the opponent by different means – looks, sounds, smells, behaviours. Literally, "apo" means "stay away", and "sematic" means "sign" or a "symbol." So we can translate this term in plain English as "warning display." Contrary to popular belief, the use of aposematic (warning) display is not connected to prey species only. As a matter of fact, there is hardly an animal species that does not use at least some aposematic strategies. Even the strongest of all predators, the mighty big cats use aposematic display in their everyday life, as they often growl and show their fearsome canines in order to be left alone. We all possibly have seen a situation when a big dog corners a cat: the cat arches its back, turns its body partly sideways, erects every hair on its body, bares its teeth, and makes hissing sounds. All these elements are designed to communicate to the dog that, if it comes closer, the cat will fight back. By arching its back, positioning its body sideways and erecting its hair, the cat tries to look as big as possible. The importance of showing teeth is clear without explanation. In regards of hissing, it is an "international" (or interspecies) signal, kind of a "stay away" sign to everyone. We will discuss later the possible reason for such popularity of hissing among various species, as diverse as snakes, geese, cockroaches and tigers.

Apart from intimidating an opponent, many aposematic features were designed by evolutionary forces to enable easy recognition of the species. "Remember me?!" is a very import message communicated by colours, sounds, smells and behaviours. This is an extremely important part of aposematic display. If the cryptic strategy is based on staying as low as possible and surviving predators by avoiding detection, an aposematic strategy, on the contrary, is based on advertising the animal's presence by all means, and scaring predators by looks, sounds, smells, and fearless behaviour, or advertising their unprofitability with the same audio-visual-olfactory signals.

A very important point that distinguishes aposematic from cryptic characteristics is that by its very nature individuals in cryptic species try to be less individualistic. They try to blend, to look and behave as others, try to be as ordinary as possible. Individuals in cryptic species thrive when they stay unnoticed. On the contrary, aposematic strategy thrives on constantly pushing existing boundaries (colours, shapes, behaviours) and an animal who is a bit more aposematic, more brilliantly coloured, more visible, will have better chances of survival. So for example, if a species have a big-sized body those individuals who are bigger will have an advantage in surviving attacks by predators and finding mates, and will leave more offspring. The same happens with the colours of a body, with louder and lower sounds, with the smell of the body, and with the elements of aposematic behaviour. In short, an aposematic strategy thrives on exaggerated features and

constant expansion of the existing elements of warning display, whereas the strategy of crypsis is more conservative in its nature and just tries to blend better with the environment.

Another crucial feature of the strategy of aposematic display is that most of the species use aposematism only sometimes, at the times they need to warn or intimidate their opponents, like bears who stand up only if confronted by a predator or competitor. On the other hand, there are also some very interesting species of animals which use aposematism constantly, as their everyday survival strategy. **These species are known as "aposematic species"**.

Let me here explain the differences between an aposematic display by non-aposematic species, and the use of aposematism by so-called "aposematic species."

As we already know, aposematic display is a means of warning antagonists to stay away. Virtually any animal can use an aposematic display in an appropriate situation when they are harassed or confronted by a competitor or a predator. For example, when dogs or lions growl and bare their teeth while eating, they are communicating (by audio and visual signals) to everyone around that they want to be left alone. Bears and scores of other animal species stand on their hind legs to seem higher and more imposing to their competitors. Lions and many other animals erect all the existing hair on their body and head, in order to seem bigger and to better intimidate their competitors and enemies.

At the same time it is very important to remember that none of the predator species use aposematic display during hunting: lions do not roar, and bears do not stand on their hind legs when they are hunting, on the contrary, they try to stay as unnoticed, silent and swift as possible, and aposematic display is always connected to losing both speed and the factor or surprise. Of course, in the movies attacking lions and tigers always make fearsome roars, but this is because it is human nature to make loud sounds when engaged in combat (we will see why later). Hunting predators do not try to scare away their potential food; on the contrary, they are silent and swift.

What is it that animals, particularly powerful beasts like lions, try to intimidate each other? Why do they not just fight? We may remember from the early evolutionary models that the evolutionary struggle for existence is a relentless and continuous fight by an animal with everyone, from their conspecifics to the members of other species. Here are some famous words from Huxley: "From the point of view of the moralist the animal world is on about the same level as a gladiator's show. The creatures are fairly well treated, and set to fight–whereby the strongest, the swiftest, and the cunningest live to fight another day. The spectator has no need to turn his thumbs down, as no quarter is given. He must admit that the skill and training displayed are wonderful. But he must shut his eyes if he would not see that more or less enduring suffering is the meed of both vanquished and victor. And since the great game is going on in every corner of the world, thousands of times a minute" (Huxley, 1888, pg. 199-200).

Well, this initial bloody model of struggle for existence is not very accurate. In fact, **representatives of the animal kingdom are much more sensible that many scholars give them credit for. Most of the animal species try to avoid unnecessary violence wherever and whenever this is possible**. The reason for this avoidance of violence is not altruism, it is purely practical: if an animal tries to kill another animal, the aggressor should accept that the other animal will be as determined to kill the aggressor, or at least inflict injury to the aggressor. So even if one of the combatants is stronger and can kill the antagonist, there is always a chance that the fight will still result in an injury to the winner. And injury often means loss of fitness, and eventually might cost a life. Therefore, if animals want to avoid injuries, they must avoid physical violence. So, if the opposed animals can avoid physical all-out fight to a lethal ending, figuratively speaking, they are both winners. Although many think that animals use "the rule of tooth and claw" in every encounter with other animals, those who study animal behaviour seriously know that all-out fight to the total destruction of the opponent (and particularly an opponent of the same species) is much less frequent than most would imagine.

Edward O. Wilson formulated the key question in this regards, asking why do animals prefer pacifism and bluff to escalated fighting. The answer is that direct violence potentially carries very high costs, including possible injury and death. Wilson suggested that for each species there exists some optimal level of aggressiveness above which individual fitness is lowered (Wilson, 2009). The only exception, where there is no way of avoiding fatal violence is hunting, when one animal must kill another for food.

But how can animals resolve the conflict if they do not fight? For example, who decides who the master of the territory is? Or to whom this particular female belongs? These are conflicting situations that somehow must be resolved, but desirably without serious injury to either side. And this is where the power of aposematism steps in.

Instead of starting an all-out fight, animals try to intimidate each other by several means: showing the size of their body, the size of their canines, the power of their voices, and other possible non-violent means of display. This kind of display is usually known as ritualized fight, an ingenious aposematic tactic to avoid real, non-ritualized fighting (see, for example, Lorenz, 1964, 1966). Ritualized fights as a rule also contain a few non-lethal blows to each other, and the animal which is smaller, or has a softer voice, concedes defeat after a couple of slaps, long before the fight can seriously injure either of the combatants.

When male lions, famous for their fighting abilities and short temper, face each other, they as a rule do not start an all-out fight from the very beginning of a confrontation. In fact, in most case they do not start a real fight at all. For some time they face each other, roar at each other, display their canines, the size of their manes and body, and if neither of the participants in the confrontation backs down, only then do they start their physical conflict. The physical conflict at this stage, as a rule, is still not serious and is only a continuation of the strategy of intimidation. So, although they might seem to human observers to be terrible lethal blows (their blows

seem to us lethal as they would certainly be lethal to us), lions still avoid the real "killer" blows and bites that they can certainly deliver.

Let us hear what George Schaller says about lion conflicts and fights in his groundbreaking book "Serengeti Lion" (1972):

"Fights as a rule are short – a slap or two accompanied by much vocalizing and baring of teeth – and biting is infrequent" (pg. 132)… This was characteristic of intra-pride interactions, but the following words describe the violent interactions with the non-pride members, including territorial disputes: "Even though interactions are at times seemingly violent, with the animals growling, slapping, and so forth, injuries, if any, consist of minor cuts. In fact, the combatants give the impression that they avoid physical contact. When a lion pursues a stranger it usually maintains a certain distance, at least 10m, adjusting its speed to that of the intruder; even if it catches the other, actual contact is usually limited to a slap or two. Serious fights do occur but are rare (pg. 55)… "In over two years of observation on lions in Manyara Park, which has a higher lion density than Nairobi Park, no serious fights were seen…" (pg. 47). This does not mean serious fights and fatal violence is totally absent among lions (see, for example, Schaller, 1972:189), but it is clear that apparently serious fights and all-out violence is much more rare than is popularly believed.

Brian Bertram, another scholar who studied lion behaviour at the same time as Schaller, and published a book in the same year, also wrote that lions try "if possible, to avoid physical conflict…" "In a sense, many threats are a combination of warning and bluff" (Bertram, 1972: 63).

"Warning and bluff" are potent words to describe the essence of aposematic display. So, although it is popularly believed that lion fights are very violent and often lethal, in fact lions try to avoid serious violence between each other. My long search for a lethal lion fight among YOUTUBE videos also had no result, although there are quite a few lion fights on the internet, and some video titles even claim a fight was lethal.

So, let us remember: the central aim of aposematic display is to avoid physical violence by substituting violence with the ritualized display of the size and sounds of the conflicting parties. Audio-Visual-Olfactory Intimidating Display (or AVOID) is very appropriately used to **avoid** unnecessary violence and injuries. No predator uses aposematic display, or AVOID, while hunting. Lions do not roar and erect their mane when they are pursuing prey. Bears do not stand on their hind legs while hunting and cats do not hiss and erect their hair when hunting mice either.

Ritualized behaviour in many animal species, or as Darwin called them, "antiques", are as a rule aposematic displays, designed to get the needed result without physical violence. With a warning (aposematic) display animals can chase a competitor away from their territories, chase rivals away from desired females, etc. Predators, on the other hand, do not chase away prey species. But prey species, when pursued, try to intimidate predators by showing their size, voice, teeth and horns, clearly indicating that they are ready to fight back with all the means they have. The

predator-prey relationship is a relationship that understandably has the highest rate of fatal encounters. No kill – no meal.

No doubt, aposematic display is one of the greatest inventions of Natural Selection. Skillfully designed to minimize unnecessary violent confrontation that could lead to unwanted injuries in the animal kingdom, aposematic display made a strong and still mostly neglected appearance throughout human evolutionary history, from the early hominids' life to the big international politics of contemporary states today.

I hope most of the readers will agree that the central aim of state military powers with many billions of dollars of financial backing is to communicate to everyone that their military forces can answer to any aggressive move toward their interests. Many agree that the most powerful military weapon of humanity, the dreaded nuclear bomb, acts primarily as a potent warning signal, or aposematic symbol, as hardly any of the owners of this weapon are ready to deploy it for affirming their own political interests. A successful test of a nuclear weapon by a country has the same aposematic symbolic meaning, as standing on hind legs for bears, or a growl from the bushes for an irritated tiger: "Leave me alone!"

We have just discussed the fact that most of the animal species have critical moments when they employ aposematic warning displays in order to avoid unnecessary violence. Apart from them we already mentioned that there are also animal species who took the notion of aposematism to the extreme. The whole existence of these animal species, including their morphology and behaviour, are directly connected to the principles of aposematic display. So, if other species use warning signals in some stressful moments of their lives in order to avoid confrontation, aposematic species display warning signals continuously, at every moment of their daily life (and often during sleep as well). They never try to blend with the environment in order to hide themselves; they do not try to be silent, or to be free of the body odour. On the contrary, with all the possible means they try to be seen, heard, and smelt. Through the millions of the years of adherence to the strategy of warning display, their morphology and behaviour have adapted appropriately to their aposematic lifestyle. Their morphology developed in the way that they are easily seen, easily heard, and easily smelt. This is the central reason why aposematic species are often coloured in bright colours, and why they have ostensibly unnecessary and highly visible morphological additions. For the same reason they often produce lots of noise while walking, and their body also often has a strong (and often unpleasant) odour. Aposematic species also developed two behavioural characteristics, signaling to the would-be predators to stay clear of them: (1) they usually walk very slowly and awkwardly, as if to communicate to the would-be predators that they do not need to run for their lives. And also, (2) they often congregate in larger groups. And when they are in large groups, they are becoming virtually impossible to miss as a bunch of highly visible, noisy and smelly individuals.

So let us remember, such species are known as **aposematic species**.

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Not all aposematic animals fulfill entirely the whole arsenal of these aposematic characteristics. For example, skunks, classic aposematic mammalian species, do not live in large groups, and some colourful and slowly moving venomous snakes do not have body odour, but there are quite a few aposematic animal species whose morphology and behaviour is entirely dominated by strive towards aposematism.

Bluffing Is Not Enough!

When prey animals communicate the "stay away" signal to predators, they need to have some other, more "real" means of defence (known as secondary defence[2]). We all know that continuous bluffing can lead to disastrous results. Many aposematic species have venom and can sting their attacker (venomous snakes, spiders and wasps are all prime examples), some are highly toxic even to touch (for example, some brightly coloured frogs), some can retaliate via electric charges (such as electric catfish and electric eels), and some are extremely unpleasant or poisonous to ingest (this is particularly popular among insects).

As a matter of fact, bluffing may actually go on for generations. We know that many totally defenceless species have successfully learned the complex game of bluffing. They copy the appearance and even the behaviour of "true" aposematic species (i.e. ones which have potent secondary defences such as poison and non-palatability). This bluffing game is known as "Batesian Mimicry", and the great number of species utilizing this set of principles suggests that bluffing has been used in the animal kingdom for millions of years before humans fine-tuned it as one of their most powerful tools for political games.

It is very important to distinguish the **'aposematic behaviour** of non-aposematic species**'** from outright **'aposematic species'**. Any species of animals can behave aposematically in moments when it is beneficial for them to avoid harm or physical violence, but only certain species can ultimately be labeled as true 'aposematic species'. For example, a domesticated cat might behave aposematically in a critical moment (e.g. hiss and arch its back), but this does not make it an aposematic species. The skunk, on the other hand, is an aposematic species, as it follows the rules of an aposematic lifestyle constantly, having morphology to match its behaviour.

In the next chapter we will discuss the history of the phenomenon of aposematism, and review the prevalence of aposematism in today's animal world – Prepare yourself for some unexpected discoveries.

[2] Quite confusingly, some scholars call "primary defense" the "real" means of the defense (like venom or teeth), and the crypsis and warning display as "secondary defenses". In terms of relative effectiveness, venom is arguably more important than hissing and a colourful body, but from the procedural point of view, crypsis and aposematism are the first line of defense for these prey animals, therefore I follow the "timeline" classification of "primary" and "secondary" defenses, given in the Ruxton at al., 2004, and consider crypsis and aposematism as the primary defense, and venom and teeth as the secondary defense.

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Short History of the idea of Aposematism

Every idea has its history, consisting of a birth, early growth and a coming of age. The death of ideas can also happen. Sometimes an idea is stillborn, but an image of successful life is given by caretakers. In other cases a healthy idea is considered stillborn, until someone later manages to revive it and gives it new life. Apart from a biological parent (or parents if it is collaboration), ideas may also have godparents, individuals who will adopt an early idea and raise it into something more widespread. Sometimes the identity of the parent or godparent of an idea is lost in the mists of history, or in the depths of scholarly intrigue. The idea of the warning display, later coined as aposematism, has the most glorious biological parents that the history of evolutionary study can provide: the famed co-discoverers of the theory of natural selection: Charles Darwin and Alfred Wallace. The idea of a warning display, or "warning flags" was born in February 1867, during the communication of these two great scholars. Despite these glorious parents the idea of warning display for some reason never really received its "coming of age", the attention it deserved.

1867 was the year when Darwin was busy writing his second big book, "The Descent of Man." The full title of this book reads as "The Descent of Man, and Selection in Relation to Sex." You can already anticipate from the title of the book that Darwin will attribute sexual selection as having crucial importance in human evolution. The book indeed argues that sexual selection was the driving force in the evolution of humans as well as many other species. Because of this, Darwin's book was criticized both by his contemporaries and following generations of scholars. More precisely, Darwin was criticized for two reasons, (1) that his book was more about sexual selection than about human origins and evolution, and more importantly, (2) that Darwin overrated the importance of sexual selection in human evolution (and in evolution in general).

Scholars still remain divided about the importance of sexual selection in evolution, and in particular in human evolution.

It is true that Darwin was attributing the large diversity of animal species to the forces of sexual selection. Virtually everything that could not be explained by the forces of natural selection through the ubiquitous "struggle for survival", Darwin attributed to the forces of sexual selection. All the exaggerated morphological features of animal bodies such as the bright colours of insects to the tail of the peacock (known as its "train"), plus all the strange behaviours ("antics") and sounds of many animal species, were stated by Darwin to be the result of the work of sexual selection.

By its potential, the model of sexual selection was about as potent and the model of Creation. The main difference between them is that instead of God's will and desire as the creative power behind all changes, sexual selection puts in the centre of the evolution the will and desire of our female counterparts. Male behaviour and morphology, according to the proponents of sexual selection, totally depended on females' arbitrary choices. This idea is clearly expressed in the

following phrase from an American scholar from the University of New Mexico, Geoffrey Miller, one of the most ardent contemporary proponents of sexual selection: "for the most part adult male hominids must have been rather peripheral characters in human evolution, except as bearers of traits sexually selected by females for their amusement value or utility" (Miler, 1998: 109-110).

All was going well for Darwin, as he could find plenty of difference in the shapes, sizes, colours, sounds and behaviours between the different sexes of a vast array of animals. But suddenly he hit a brick wall. It was when he was trying to explain the brilliant colours of several species of caterpillars. You may be thinking that he would not have hesitated to attribute their brilliant colour schemes to the power of sexual selection, but there was one huge problem - caterpillars were not yet sexually active, so sexual selection was theoretically and ultimately ruled out, at least for caterpillars. So what then was the reason for their beauty? As a staunch evolutionist, Darwin was sure that such brilliant colours could not have been developed without a practical reason to do so. He would not accept the dominating theological explanation at the time, suggesting that the existence of beauty was proof of the existence of an almighty and conscious Creator. According to the creationist view, the beauty has no utility other than to give aesthetic pleasure, and that humans (God's 'highest' creatures) are the only creatures who can truly appreciate such beauty.

Finding himself in a troubling situation and unable to use his favourite model of sexual selection to explain this discovery, Darwin wrote to Wallace on February 23, explaining his predicament and asking if his friend had a solution to this problem.

Wallace's answer, written the next day on February 24th, to Darwin is one of the most important letters written in the history of biology. Wallace had noticed that the animal species which had good secondary defences (for example stingers, poison, or an unpalatable/noxious body texture), were also the ones with visible colours, seemingly a warning to predators that it was advisable to refrain from attacking them. Wallace wrote:

> "*The animals in question are possessors of some deadly weapons, as stings of poison fangs, or they are uneatable, and are thus so disagreeable to the usual enemies of their kind that they are never attacked when their peculiar powers or properties are known. It is therefore, important that they should not be mistaken for defenseless or eatable species of the same class or order since they might suffer injury, or even death, before their enemies discovered the danger or uselessness of their attack. They require some signal or danger flag which shall serve as a warning to would-be enemies not to attack them, and they have usually obtained this in the form of conspicuous or brilliant colouration, very distinct from the protective tints of the defenseless animals allied to them*" (Wallace, 1889:232).

Continuing this idea, Wallace also suggested that birds and other predators would reject the conspicuously looking prey, and would rather chose the more cryptic (built for concealment), non-conspicuous looking prey or food items. After learning about Wallace's ideas, John Weir from the Entomological Society of London conducted experiments with caterpillars and birds in his aviary, and after a few years in 1869, he reported the first experimental evidence of the effectiveness of warning colouration in animals.

Wallace's letter to Darwin contained two brilliant ideas, (1) the idea of a "warning display," later developed by Sir Edward Poulton into the idea of aposematism (Poulton also coined the term "aposematism"), and (2) the suggestion that predators would reject colourful and unknown preys, developed later into the idea of neophobia among predators (avoidance of new and unusually flamboyant-looking animals).

Darwin's reaction to Wallace's letter was overtly positive. He was very pleased that the dilemma of the conspicuous-looking caterpillars was settled, and he wrote in reply to Wallace's letter: "I have never heard anything more ingenious than your suggestion, and I hope that you may be able to prove it true." Receiving Darwin's letter must have been one of the happiest moments of Wallace's scholarly life.

Here we are closing in on a crucial idea, so far mostly neglected in scholarly literature: animal species can develop distinctive colours, hard-to-explain morphological structures and strange behaviours in order to attract mates on one hand, but on the other hand, animal species can develop exactly the same kind of distinctive colours, sounds, morphological structure and strange behaviours in order to ward off predators and competitors, thereby avoiding unnecessary and violent confrontations. This idea was implicit in Wallace's letter to Darwin, but was unfortunately dismissed by Darwin, as Charles was at the moment still overwhelmed at finding such an abundance of "evidence" of the importance of sexual selection. For Darwin, Wallace's idea was only there to explain the cases of bright colours that did not already fit the model of sexual selection.

Quite amazingly, Wallace himself did not grasp the implicit importance of his suggestion regarding the animal kingdom. Just a couple of years later Wallace and Darwin had a discussion about the peacock's amazingly beautiful train. Darwin was sure that the power of sexual selection was at work here. Wallace had another idea, but instead of suggesting that the peacock train could have had a function of scaring away competitors and predators (we will discuss this idea later), Wallace instead came up with a very implausible suggestion that the bright colours and long tails of the peacock were not adaptive in any way. According to him, bright colouration could have been the result from non-adaptive physiological mechanisms. For example, he argued, the internal organs of animals that are impossible to see are often still brightly coloured.

Therefore, we have a very sensitive situation for scholars interested in the mechanisms of both sexual selection and aposematism. Sexual selection and the warning display (aposematism) work using the exact same elements: bright colours, sounds, smells and behaviours, but with totally different driving mechanisms: sexual

selection is driven through the female choice (which can be arbitrary) leading to mating success, but aposematism is driven by the mechanisms of natural selection through the warning display, leading to survival from predators and avoidance of unnecessary violent conflicts. *Attracting* in one case, and *intimidating* in other case.

Of course, there is no good reason why these two forces, aposematism and sexual selection, could not work together. Essentially, females may find attraction the same traits that help their male counterparts avoid violence and survive, particularly as these traits are more colourful, noisier, and generally more attention-grabbing. But here comes the crucial question: Which of these two forces is the primary and which of them is secondary? Proponents of sexual selection of course would suggest that sexual selection is the primary reason, to the extent that certain traits are not only unnecessary for survival, but actually detrimental to it. The idea of this "handicap principle," suggested by the celebrated Israeli evolutionary biologist Amotz Zahavi, proposes that the true ("honest") signal for the mate's choice must in theory be detrimental to survival. A peacock's amazingly beautiful train is the best proof available for this line of thinking and was featured on the cover of Zahavi's book. We will discuss the possible reasons for the beauty of a peacock's train later in the book, but I would like to propose that, in the case of the shared responsibilities of sexual selection and aposematism which are carried by bright colours, loud sounds and exaggerated shapes, the aposematic warning display is most likely the primary force, thereby making sexual selection a secondary objective of these traits. As we are going to discuss this issue in detail a bit later, let us go back to Darwin-Wallace communication about the idea of a warning display.

Unfortunately, whilst reading Wallace's letter, Darwin was too engrossed in the power of sexual selection to be able to appreciate the wider explanatory potential of Wallace's new and brilliant idea. For him the idea of a "warning display" was a good enough explanation for the sexually-immature caterpillar's brilliant colour schemes, and after solving this troubling problem Darwin never looked back to Wallace's idea of warning displays. This is why Darwin did not go any further in considering the importance of warning displays in the evolution of the morphology and behaviour of a large array of conspicuously looking animal species. It was through this process that the big chance for early appreciation of the principle of warning displays was lost.

Here is more evidence that Darwin did not even consider the possibility that brilliant colours, exaggerated morphology and different behavioural displays of males could serve as anything else but as a means for successful sexual selection through a possibly arbitrary female choice. Arguing for the importance of sexual selection, Darwin famously wrote: 'To suppose that the females do not appreciate the beauty of the males, is to admit that their splendid decorations, all their pomp and display, are useless; and this is incredible' (Darwin, 2004:557). We can all certainly agree with the great scholar that all the 'splendid decorations' and 'all their pomp and display' were definitely created by the forces of evolution for a good reason. This reason was definitely to impress, but to impress who? Were they created to impress females for better mating opportunities, or to impress predators and rivals for better survival chances through avoiding unnecessary violence? Darwin did not even

mention the survival benefits of bright colours and unusual behaviours, which means that he never looked at the alternative explanation of brilliant colours. If he did, possibly his book on human origins might have had a different title and quite different content.

It was Poulton who proved Wallace's idea to be true in 1887. And still, even after 130 years, the idea of the warning display remains in the shadow of the bigger idea of sexual selection. The unique position and extremely high authority that Darwin commanded must have been one of the central catalysts to the popularity of the idea of sexual selection on one hand, and also to the neglect of aposematism on the other hand.

Certain progress was definitely made in the subsequent decades, but the idea and notion of aposematism is still very much on the periphery of contemporary biological science. According to my observation, some scholars do not even know what the term "aposematism" means (I have also discovered through my writing that Microsoft Word also does not recognise this term). For a long time even the origin of aposematism itself was considered a puzzle as, according to R. A. Fisher (Fisher, 1930), aposematic individuals have more issues with survival from predators than cryptic ones. It was only by the beginning of the 21st century that scholars came to the more realistic conclusion that aposematic prey individuals might have good chances of survival because of the natural aversion shown by many predators when introduced to new and unusual food. This phenomenon is known as "neophobia."

"There is evidence that predators are particularly cautious in dealing with potential prey having bright colour patterns" suggests the 2008 edition of an Australian Biology textbook (Campbell, 2008: 1223). Furthermore, even in this grandiose book, aposematism is mentioned only once in connection to colours, without mentioning sounds, smells, or behaviours as other important elements of an aposematic display.

Also, it was only in the 21st century that scholars started appreciating the idea of aposematism among plants (see: Lev-Yadun, 2009). Scholars started finding more and more aposematic species not only among insects and reptiles, but among plenty of mammalian species as well. For a long time only the skunk and zorilla (striped polecat) were considered as rare examples of aposematic mammalian species, later studies suggested that the list of the aposematic mammalian species can be indeed rather large (see, for example, Caro, 2009). When discussing the reasons for contrasting colouration, under the categories "aposematism likely" and "aposematism very likely" Tim Caro lists the following animal groups: echidnas, tenrecs, hedgehogs, possums, wolves, foxes, raccoons, enotes, skunks, civets, moonrats, porcupines, weasels, and mongooses. If we remember that in his article Caro is discussing **only** black-and-white coloured species (hence "contrasting colouration"), we can start to get an idea of how large the list of species using aposematic colouration can really be.

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A Few Facts and Ideas about Aposematism

As I have already mentioned, aposematism is gradually gaining scholarly recognition despite still being very far from its dues. From personal experience, I can testify that the term "aposematism" is rarely mentioned even by scholars of evolution. The term "warning colouration" is routinely used instead of aposematism. Alternatively, "warning signals" or "warning display" would both be better substitutes for aposematism than "warning colouration", as aposematism definitely involves more elements than colouration. The Wikipedia article on aposematism, for example, starts the article with the words "Aposematism (from *apo-* away, and *sematic* sign/meaning), perhaps most commonly known in the context of warning colouration...". Another Wikipedia article, this time on the skunk, a classically obvious aposematic animal, still did not even contain the word "aposematic" when I last checked in June 2012. Even the title of the most recent book on animal defence strategies, in which you can learn plenty of things about aposematism, reads like this: "Avoiding attack: The evolutionary ecology of crypsis, warning signals, and mimicry". If the term "aposematism" was better known, I guess the book would be titled a more fluent "Avoiding attack: The evolutionary ecology of crypsis, aposematism, and mimicry."

By now we already know that aposematism is not only colouration. We know that when aposematic animals try to get attention, they mostly do this by using warning flags in several modalities simultaneously. Apart from colouration, aposematic animals try to look tall and wide, they make various sounds, and they also often emit a body odour. Together with these morphological signals, they also use behavioural signals such as moving slowly and awkwardly, as if signaling to the predator their confidence in that they have no need to run for their lives.

Here is for example a description of the behaviour of a threatened skunk from Wikipedia: "black and white warning colour aside, threatened skunks will go through an elaborate routine of hisses, foot stamping, and tail-high threat postures before resorting to the spray."

As we can see, there is definitely "more than meets the eye".

The aim of this chapter is to give the reader more information about this fascinating and still not-so-well-known evolutionary strategy.

So let us first of all try to classify aposematic warning signals. As the first attempt of this kind, my suggested classification cannot be exhaustive; however I do hope it will encourage scholars to put some energy and time into creating a more refined classification scheme for aposematic signals.

So, aposematic signals can be:

(1) Visual
(2) Audio
(3) Olfactory (smell)
(4) Behavioural

Each of these modalities can be divided further on several sub-types:

(1) Visual signals can be based on use of

(1.1) Bright colours, where the message is "I do not need to hide from anyone!"

(1.2) Contrasting colours (with the same message "I do not need to hide from anyone").

(1.3) Display of size ("Do not assume I am easy to kill! See how big I can get?").

(1.4) Display of weapons – spikes, fangs, etc. ("See what I got? If you attack, I **will** use them!").

(1.5) Display of eyespots (differences in pigmentation that try to simulate the look of open eyes), being preferably bigger ones ("I am always alert!").

A display of special morphological additions adds several advantages: it can be effective for the increase of the size of animal (see 1.3), it often makes animal more colourful (see 1.1), and also sometimes eyespots are also displayed on these extensive morphological additions to further their overall believability in the eyes of a predator (see 1.5).

(2) Audio signals can also be based on several different components, namely:

(2.1) Making as loud as possible sounds ("I am as strong as I am loud, and I am not giving up!").

(2.2) Making as low/deep as possible sounds ("I am bigger and stronger than you think!").

(2.3) Making hissing sounds ("I have venom!" – mimicry of the warning sound of a venomous snake).

(2.4) Making sound in groups ("If you attack, we will all fight together!");

(2.5) Group sounds made deliberately at different pitches, particularly on dissonant intervals, giving any listener the impression of a bigger group, the so called Beau Geste effect ("We are more than you think!").

(2.6) A wide range of sounds, for example, foot stomping, drumming on external subjects, chest beating, can be made without one's voice. The most popular threatening sound across the wide range of animal species, hissing, also does not need a voice.

(3) Olfactory signals are often quite linear in their range and use and do not seem to be as varied as visual or audio signals are, but can still send a strong aposematic message:

(3.1) A Strong smell is designed to signal the non-palatability of an animal. The smells often get stronger in danger or excitement ("you could and would not eat me, so why waste your time and energy killing me?").

(3.2) A not so strong smell is designed simply to advertise the presence of the creator and trigger the predator's memory of an unsuccessful prior meeting. ("Remember me?").

(4) Behavioural signals can take on arguably the widest variety of different forms:

(4.1) Slow walking pace, even when confronted by predator, or even stopping ("You don't represent much of a challenge to me, so why would I avoid you?!").

(4.2) A demonstratively sluggish style of walking ("I can just take my time, I have no need for running away from you at all!").

(4.3) Displays of overtly aggressive behaviour ("I am ready and willing to fight you, so you'd better be absolutely sure!").

(4.4) Congregating in a big groups ("We will fight together against you if you decide to attack!").

(4.5) Mobbing ("you don't have a chance when we are united against you!") .

(4.6) Strange movements, designed to confuse and dazzle the opponent ("You have no knowledge of my fighting techniques! But you will know them first-hand if you come closer!").

Although we've already distinguished several types and sub-types of aposematic signals, I must say that virtually every sub-type of the above mentioned list of aposematic signals can be divided further into categories, for example, according to the **factor of time**. Some display signals are constant (such as colouration or eyespots) and some are temporary (appear briefly only when needed, such as a skunk's smell). Caro mentions them as "permanent" and "facultative" signals (Caro, 2004: 261). We will now have a quick look at these categories, as their differences are of great importance.

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Constant and Temporary Aposematic Signals

Visual signals

(1) Visual signals are so numerous and abundant that, for a long time, the overall warning display was mostly known as "warning colouration." Visual signals form the following groups and sub-groups:

(1.1) Bright colours – this signal may at first seem to be constant, but there are still some animals that change their colours according to the situations they find themselves in. Apart from well-known examples such as the chameleon or the squid, plenty of animals can intensify the colours on their body or face when they are excited or angry (the colourful face of a mandrill is a good example, as it becomes brighter when it is excited or in danger). Here we should also note that human faces can also change colours when we are excited, afraid, or angry (a common example is blushing, another one being turning pale when extremely afraid).

(1.2) Contrasting colours – possibly the most constant factor in the appearance of many creatures, however there are very few that are able to achieve a sudden transformation into contrasting colours (sailfish is one such rare species, and can change its colours to become light blue with yellowish stripes).

(1.3) Display of size – Although size may also seem as a constant, there are a number of tricks to make your appearance much more impressive in a critical moment. The presence of a large number of morphological and behavioural tricks of quick size change strongly suggests that in the evolutionary game for survival, size truly matters. Animal species can drastically increase their visual representation with the help of a number of special display patterns. Here are several means with which to reach this the sudden size increase:

(1.3.1) Stand on your hind legs – This behaviour allows the most drastic increase of an animal's size. Plenty of animals stand on their hind legs when they are confronted by competitors or predators. This posture is appropriately labelled as "threat display." A few animals, like bears or some primates, can even move on their hind legs for periods of time without losing balance. It seems that height is arguably the most important measurement of size when an animal wants to impress or intimidate a competitor with its body size. The drastic increase that the visual effect has on the animal's size can be seen clearly in some animal shows. For example, although we know that lions and tigers are heavier and bigger than humans, we only truly appreciate their size and power when they stand on their hind legs and put their paws on the shoulders of their suddenly dwarfed human trainers or friends.

(1.3.2) Raise any mobile part of your body above your head – This behaviour is not as potent and popular as standing on the hind legs, but is still used by a large number of species. A common example to observe is cats and dogs walking with their tails up in the air when they feel confident and want to be seen. On the contrary, if they are frightened (for example, after sighting a bigger and potentially dangerous animal) they often drop their tails under their legs in an attempt to become as invisible as possible.

(1.3.3) Erect the hair on your body and head – This is possibly one of the most widespread means in the increase of body size in a moment of threat or confrontation. Some animals achieve a noticeably bigger effect with their hair erect. A classic example is the male lion, who erects his long mane when threatened (as if the view of his canines and loud roaring were not already enough for intimidation). Even the fine hairs on a human body instinctively rise in moment of fear or other strong emotions, although the visual effect this has is quite negligible considering the amount of hair on a human body relative to creatures with fur coating.

(1.3.4) Stand sideways – strike a pose in order to look bigger. This is a well-known trick known widely among fish, mammals, reptiles and insects. Many fish will readjust in order appear sideways to their opponents, and many species of birds partly open their wings to increase the size of their body. You may have also noticed how conflicting cats approach each other: also sideways. As the frontal view of many animals does not show their true size, walking at a sideways angle is often the preferred way to approach an opponent.

(1.3.5) Erect, open, raise or display any available morphological structure of your body in order to seem higher and bigger – Even elephants open their huge ears as if their size was not already a sufficient deterrent. Many animal species (for example, many bird species) have seemingly random additional morphological structures that may seem totally useless at first or even a hindrance in the everyday survival game. Darwin explained the presence of such morphological additions as the result of the power of sexual selection. We should not forget though, that such "useless" visual artifacts might play an important role in intimidating competitors with a bigger body size and colours, *particularly* when suddenly displayed in a moment of confrontation, as if to suggest to their opponent that the feature is, or relates to, a defence mechanism rather than simply being a 'bluff'. So for example, if you are suddenly confronted by a potentially dangerous and aggressively behaving animal, and by chance you happen to have an umbrella with you, I suggest that instead of using it as a club, just open it and raise it above your head. You will be surprised with the outcome.

(1.4) Display of weapons – Showing the opponent your available weapons such as spikes, fangs, or antlers can also be saved for the moment of confrontation (both for defence or offense). Some weapons, like antlers, are carried around permanently in the same "display mood", but other weapons are only consciously displayed in a moment of need. Baring the teeth is possibly the most popular and easily understood gesture of threat across a wide range of species. Showing your canines is a strong warning message, particularly if the canines are of good proportions like in most carnivores, and also in ground-dwelling primates such as baboons or mandrills. Showing the teeth in a smile or laughter among humans and some primates as a sign of *good* intentions is a very interesting phenomenon, and must be used with caution in order to not to be misunderstood by some animals as a sign of threat (van Hooff, 1972; see also Gregory, 1924; Black, 1984; Harris, 1999). Display of spikes is also very popular among those who are lucky to be endowed with them (e.g. hedgehogs, porcupines). Spikes are usually raised, often shaken and often coloured in easy to see patterns, and can also accompanied with sounds.

(1.5) Display of eyespots – It is not easy to be sure about the precise function of eyespots, but one of possible functions is definitely the intimidation of competitors and predators. Some eyespots are carried around constantly, like eyespots on the backs of the ears of many big cats, however eyespots of many other species of animals are displayed only in a moment of danger or confrontation. A classic example is several species of butterflies who do not always display eyespots on their wings as their eyespots are placed on the second pair of the wings, which are covered by the first pair of wings. What is the point of having eyespots if you do not display them? Eyespots are hidden when a butterfly is sitting undisturbed. But when disturbed, butterflies suddenly open their top layer of wings (without flying away!), clearly displaying the big eyespots to their attacker (mostly to birds who prey on them). Therefore, a butterfly with such a function can instantly go from a cryptic mode of defence into an aposematic mode of defence (a double primary defence!).

(1.6) Display of morphological additions – Some morphological additions are carried around constantly, like the huge antlers of some species of deer; however, the majority of morphological additions among animals are only displayed in a moment of threat. Insects, reptiles and birds will open (or raise) the usually-hidden morphological additions of their bodies when they face predators or competitors.

(1.7) I propose one more aposematic category which, unlike any other signal, is displaced in time and territory. I am referring to markings that animals leave on different objects, which are on display constantly without requiring the actual presence of the displaying animal. Examples of such aposematic signals are the marks of clawing that big cats leave on the trees, or faeces and urine markings left in strategically important places. I call them "displaced aposematic signals." These signals are addressed to other animals (and usually to the same species) and are aimed to notify them that the territory is occupied.

Displaced aposematic signals are an important part of an animal's claim on territory. This kind of displaced aposematic signals can exist only in visual and olfactory modalities, but not in audio and behavioural modalities.

Audio signals

(2) Now we move to audio signals, and see if they too can be categorised as constant or temporary. Because of its nature, audio signals are as a rule used only in a moment of confrontation. Snakes do not hiss, rattlesnakes do not make rattling sounds and lions do not growl in a peaceful, undisturbed moment. At the same time we should remember that producing constant sound (if somehow kept at a low level) can also be a big part of animal behaviour. For example, porcupines are constantly making "booming" sounds when they are on the move. Other species also have a specific 'careless' moving pattern which creates plenty of accompanying sounds. Such careless locomotion creates a noisy aposematic message to everyone that they are formidable and, as a result, have no need to conceal themselves.

(2.1) Making as loud as possible sounds – Making loud sounds requires strong effort and energy, and this is why loud sounds in most animals are reserved for very specific occasions only. Apart from the use of loud vocalization in a moment of confrontation, a number of animal species also use occasional loud calls to make sure that competitors are aware of their presence and to keep them clear from their territory. It must be said that making loud sounds is a double-edge sword: on the one hand it warns competitors, but on the other hand the noise can work as an invitation for possible predators. Stags making loud calls during a mating season (to simultaneously find mates and scare away competitors) can make them vulnerable, as their call may also invite hungry tigers to the location of the romantically attuned male. As we have established, loud vocalization among animals that live on the ground always carries an inherent risk factor. Birds on the other hand can advertise their territory and their presence largely without fear of predators, and this is why bird sounds are the most constant of calls heard throughout nature.

(2.2) Making as low (or deep) as possible sounds – also connected to specific critical situations. Bigger animals, as a rule, produce deeper sounds, and emitting such a sound can give the impression that the threatened animal creating the sound is not as small as it may seem. Elephant herds are known to produce low frequency sounds, and apart from keeping in touch with each other, these sounds are used to communicate their presence to everyone, particularly when they cannot be seen in some of their thick forest habitats. Humans (particularly males) produce very low sounds for their relative body size, and we will discuss the possible function of this later in the book.

(2.3) Making hissing sounds – We already mentioned that hissing is used by a wide range of animals, even those whose image does not seem to fit this relatively soft sound (such as big cats). Hissing is a technique employed only when the necessity to scare away competitors and enemies arises. As vocal chords and "true voice" is a relatively late evolutionary product, for many tens or even hundreds of millions years hissing, which does not need vocal chords, must have been the most popular component of an audio warning display. This must be reason that such a wide range of animal species such as geese, tigers and even some cockroaches all hiss when disturbed.

(2.4) Making sounds together in groups – So far we have been discussing sound production by individuals, but it is obvious that making threatening sounds in groups would also be a very effective way to warn (or intimidate) your enemies or competitors. When a lion pride roars together, they give a powerful message to all the roaming lions in the vicinity that the territory is occupied. Wolves are doing the same with their coordinated howling. The Gibbon family often sings together, very likely to signal that the territory is occupied and also that the resident family has a high level of coherence and unity. In this case the quality of singing communicates the quality of coalition (see on this topic the enlightening paper by Hagen & Bryant, 2003). Making sounds together can be organised for a special occasion, or as a response to a challenge (for example, when a lion pride hears other lions roaring). Kortlandt wrote that chimpanzees sometimes organize a loud evening "concert," most likely to scare away any potential predators from the vicinity (Kortlandt, 1973). On the other hand, bees and many related insects produce constant a group sound around their dwelling place, which gives a strong message of their famous cooperative defence to all prospective aggressors.

(2.5) Group sounds made deliberately in different pitches – This is a very interesting audio phenomenon, and particularly interesting for musicians. If you have a group of several animals, singing together in unison, on the same pitch, and another group of the same animals, singing at different pitches, you will hear the difference. The overall sound in the latter, multi-pitch case will be much more impressive. This phenomenon is known as the "Beau Geste" effect. Hearing the sounds of a wolf pack is a good example, as sometimes two or three wolves can create the audio effect of a larger pack of wolves. Hearing the vocal cacophony of a frog choir is yet another example of such group vocalizing. Such sounds can be made in a critical moment of confrontation, or as a warning to a yet-unseen opponent.

(2.6) A wide range of sounds can be made without the voice. Do not forget that voice is a relatively late evolutionary product, and definitely much younger than hearing. The earliest warning audio signals (like hissing) were definitely made before the emergence of voice. Foot stomping, drumming on external subjects, or chest beating are other examples of such non-vocal sounds. Most of these sounds are produced when animals are confronted by competitors or

predators, but these sounds can also be produced to give a preliminary warning message to everyone in the vicinity (such as the aforementioned chimpanzee evening gala).

Olfactory signals

(3) We need to discuss olfactory signals as well. As we have already established, these signals are not as diverse as visual and audio signals. The question is whether they are produced constantly or in the moment of confrontation.

(3.1) Strong body odour – Strong body odour gives two warning signals, (1) that the animal is not hiding away, and (2) that the animal body might not be an ideal food source for the predator. As we remember, some animals' body odour can give a predator the impression that the body has been dead for a long time and that it is actually already gone off. Importantly for the temporary factor we are discussing, in several animals a pre-existing smell intensifies in a moment of critical confrontation. Huge and strong Gorillas also produce strong body door in moments when they are facing the possibility of a physical challenge. This behaviour is known, among others, in two related species: gorillas and humans. Human sweating, as we know all too well, also intensifies in moments of danger. In some animal species (including gorillas and humans) sudden and strong life threatening stress can also induce instant defecation, which is possibly another innate function to increase the strength of smell.

(3.2) The presence of a not-so-strong smell is possibly designed to trigger memories within the mind of a predator, and this feature is most likely a more constant one. Of course we should remember that not all animals react similarly to the same odours, and that the same odour might be disgusting to some predators but quite acceptable (and even considered a delicacy) to others. Some predators have a bad sense of smell, and this is very bad news for the animals that rely on their faulty odour for protection. Even the legendary skunk is commonly attacked, killed and eaten by the Great Horned Owl which, as scholars have suggested, hardly has any sense of smell at all. This suggestion must be correct, as skunks are avoided by most of other predators exactly because of their powerful odour, and that the Great Horned Owl is possibly the only predator that a skunk will desperately try to flee from.

(3.3) Olfactory modality also offers the relatively rare possibility to create "displaced aposematic signals", where the signal is displayed permanently without requiring the displaying animal to be present. This type of displaced warning signal is widely used by territorial animals in order to notify others that the territory belongs to them. Cats, dogs, lemurs and wildebeest all mark their territories by either spraying or leaving faeces in prominent locations, or by

rubbing their body parts which contain scent glands against prominent objects (mostly tree branches and leaves). As we may remember, displaced warning signals can be used only in visual and olfactory modalities but not in audio or behavioural modalities. In some cases an olfactory channel can be more effective than any other channel. For example, hyena pups which have never seen lions do not react fearfully upon seeing them, but react fearfully upon detecting their scent.

Behavioural Signals

(4) Now we will discuss behavioural warning signals. They can also be divided into the temporary and constant categories. Certain behaviours appear only in a moment of need, but others are present at all times, or at least most of the time. Behavioural warning signals can compete in popularity and variety with visual and audio signals.

(4.1) Slow walking pace – Possibly the most characteristic feature of many animal species that have strong secondary defences. Most venomous snakes and spiders move very slowly. Most of us who have seen hedgehogs and turtles would know that most quill and armour-covered animals also walk very slowly. Even when confronted by a predator, they do not attempt to move any faster. This feature (slow walking speed), as a rule, is mainly found in more physically-threatening creatures, largely as these slow-moving animals are actually unable to move as fast as other animals whose survival depends on fast legs and more defence-minded mechanisms rather than having their strengths lie in the course of an actual physical confrontation. Slow walking animals have another drastic means of warning signal: stopping. When confronted by predators, many slow walking animals stop moving altogether. In this tense moment they usually face their opponent and express their disgust with aggressive sounds, visual gestures, and any other aposematic features at their disposal. Many predators prefer their prey to run away – this is because the instinct of freezing is the initial defensive reflex in the more fearsome predators, therefore they can actually become confused if their prey does not initially run away, forcing them to contemplate the chance that what initially seemed as prey may be stronger than initially thought due to its "predator-esque" reaction to them.

(4.2) Sluggish style of walking – In the same vein as slow walking and the freezing instinct, a demonstratively sluggish style of walking is another potent signal to other creatures that the animal has strong secondary defences. This feature also seems to be fairly constant rather than being employed only in confrontations. At the same time, at least in theory, there is the possibility that an animal

would be able to walk normally and quite fast, then only adopt the awkward sluggish to in a display of strength when confronted by a predator.

(4.3) Overtly aggressive behaviour – As many politicians and teenagers know, pretending to be aggressive and adopting threatening behaviour is sometimes (only sometimes!) a potent means to avoid further aggression from others. Most such aggressively-behaving animals are gentle and cooperative and friendly with their family group and kin, but can also suddenly become overtly aggressive towards predators and competitors. This overtly aggressive behaviour is more a temporary feature of aposematic display than a constant one.

(4.4) Being in groups – The advantages of having strength in numbers are well known both to animals and in particular humans, but is this feature constant or temporary? This may initially seem like more of a constant feature, as social animals such as lions and many primate species do spend 'relaxed' time together and do not really come together from different parts of the jungle or savannah for a single moment of need. On the other hand, many social animals (especially humans) demonstrate an increase in group density and coherence as the necessity arises. Humans demonstrate a strong tendency of bunching together in moments of perceived strong danger (natural disasters, wars and even protests).

(4.5) Mobbing – Aposematic animals do not only passively aggregate in large groups. Often when there is a danger from a predator, they actively attack the predator simultaneously to drive it away. Mobbing can only work if none of the animals attempt to escape the predator, but instead behave fearlessly and together harass and try to injure the mortal enemy. Of course, mobbing is solely a temporary function which occurs only in critical moments of survival where there is a need to defend young offspring or the group in general.

(4.6) Strange, obscure movements – Unusual behaviours in a moment of confrontation are designed to confuse and dazzle an opponent. Darwin extensively wrote about such behaviours in his "Descent of man" (he called them "antics"). Unfortunately, Darwin was explaining such behaviours as merely the means to attract the attention of the opposite sex. Today we know very well that strange movements can also be a potent weapon in a confrontation. These movements are integral to ritualized fights, and can be designed in to avoid a scenario of all-out violence.

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Conclusions

I hope I did not bore the readers of this book too much with the differing descriptions of a vast array of visual, audio, olfactory and behavioural warning signals. I myself find them extremely fascinating. When animals of the same species are scaring each other with their looks, sounds, and other ritualized behaviours, or when prey animals try to impress their predator using the same means, the central function of all these strategies is the same: to get the required result without the costly all-out fight and associated physical harm.

Aposematism seems to be an integral factor of natural selection for many different classes of animal species for several, sometimes varying reasons:

(1) For predators aposematism is convenient as it allows them to distinguish well defended prey animals from the undefended ones (undefended animals most likely will try to run away, as running away is a popular means of avoiding predation);

(2) For the prey species aposematism is good as it allows them to demonstrate (or merely remind) to predators that they should not be wasting their time hunting them. For example, if a tiger is approaching a venomous snake, the possibility of both of them getting killed in a lethal confrontation can be avoided once famous audio signal "sssss" is sounded (most likely from *both* snake and tiger). As a result, they have avoided a dangerous violent confrontation, quite possibly lethal for both.

(3) For conflicting animals of the same species aposematism allows them to avoid an all-out fight and possible death, and instead substitutes real fights with a ritualized means of aposematic display. These displays are known as "ritualized fights" (or as agonistic behaviour, see Scott & Fredericson 1951). This "ritualized fight" is the primary deterrent and reason why many animals do not use their other, possibly lethal means of offense when they are fighting their fellow creatures (even when males are fighting for the attention of females). Most animals use aposematism when dealing with their counterparts and prefer to settle disputes without costly fighting and the associated injuries.

(4) The same is true for some conflicting animals of different species: a ritualized display, in most cases, is enough for the participants to clearly state their interests to each other, and also for them to assess each-other based on the aposematic signals they perceive (this exact process is also prevalent in human street fights and confrontations). As a result the competing animals can usually settle the dispute without having to resort to a physical fight. Therefore, contrary to popular perception, animal life is not only one where the tooth, claw and fang rules. In the animal kingdom body size, colours, shapes, sounds, smells and behaviours also play a fundamental role in the survival of many creatures.

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The Importance of Being Earnest

Animal determination and the readiness to fight is a crucial factor of any confrontation. When two animals are displaying their body size and exchanging warning signals, it is not always the bigger and louder one who wins the confrontation. By some subtle, harder-to-notice elements of behaviour, conflicting animals can feel which of them is more determined to fight. As a result, the less determined animal usually backs down, avoiding the confrontation from descending into physical violence. This does not always mean that the lenient animal is weaker; this only means that in this situation the animal was less ready or less willing to fight than the more determined competitor. A classic situation to illustrate this point is when a huge male backs down when up against the aggressive behaviour of a smaller mother animal that is ready to die defending her young.

And here comes the question: what are the factors that make animals more determined?

These are possibly the two most important factors: hunger and parental instinct.

Hunger is possibly the most widespread factor. This factor is particularly clear in such ubiquitous situations such as confrontations over a recently killed prey animal. For example, when lions (or a single lion) come across feeding hyenas, the outcome can depend immensely on how long the hyenas have been feeding and how hungry the lions are. Sometimes a single lion can be enough to chase away a large group of hyenas, but on the other hand a small pack of hyenas can chase away not only a single lion, but several of them. Most interestingly, those animals that are pushed away by competing animals do not usually go away completely. Instead they wait nearby, allowing time for their stronger (or hungrier) competitors to feast on the kill. After a period of waiting, the waiting animals make a comeback. By this point the second side, who has now been feeding for a while, is not as hungry as before. Therefore, they are now not as ready to fight for a food as they were before, and as a result the side that was originally defeated comes back and reclaims the kill.

When predators are not hungry, they may avoid confrontations with aggressively behaving animals that they could otherwise easily kill. There have been cases of pumas being chased up a tree by a single barking dog. No dog can survive a confrontation against a puma or even a lynx, but when pumas aren't in need of food they will usually try to avoid any confrontation, even if this means running from an attacking (yet weaker) competitor. On the other end of this spectrum, if predators are desperate for food then there is almost nothing that can stop them. Skunks are sometimes killed and eaten (despite their famously smelly defence glands), not only by Great Horned Owls (who do not have a sense of smell), but also by very hungry dogs and coyotes as well, who would normally be disgusted by the skunk's odour. In much the same way, porcupines are also occasionally hunted despite their long and

sharp quills. In such cases no display can divert a predator's will, and they attack determined to either kill or to be killed. Hungry lions have even been known to tackle adult African elephants. This is why the only fully guaranteed defence from a predator is to kill the predator (Ruxton et al., 2004). We can now agree that relative hunger and desperation are both crucial factors in the precarious equation that is a confrontation between two animals.

Defending the young - Another important element that strongly affects animal warning displays and confrontations is parental instinct. Animals (usually mothers with most species) that are defending their young form can go into an all-out-battle without reservations and with total neglect to any warning displays used by the opposing side. The silver lining to this kind of attack (if you are attacked) is that the attack usually remains solely as a defence mechanism aimed at protecting their young, so if you have a chance to retreat you will be safe. The inherent negative factor to add is that even if you are not endangering their young and you came close only by mistake, you may not have enough time to demonstrate your good will to the enraged parent. Out of these two factors (hunger and defending the young) the latter seems to me a more potent reason for animals to enter into unprovoked fights without reservations and without any care for their own health.

Apart from hunger and parenting instinct, there are other factors also affecting the determination of conflicting animals. Fighting for mates is one obvious factor, and fighting for territory is another such important factor. Therefore, when there are two animals in a confrontation (for food, territory, defending their young, or for mates) their size, strength and variety of display patterns are not the only signs to observe. Other psychological and physiological factors (offspring located in the vicinity, animal in heat, starving animal) must be taken into consideration if one is to have a true idea of the challenge they are likely to face. Similar to many of the world's human political landscapes, determination and confidence play an undoubtedly integral role in all success.

A true fight to the death is actually a very rare occurrence in animal everyday life (this of course does not include regular hunting undertaken by prey, in which there is no real "stand-off" as such), and a wise strategy of aposematism is a central factor in avoiding unnecessary and damaging confrontations. Huxley was wrong – the battle for survival is **not** the continuous combat of every single animal all other animals of both other and its own species. On the contrary, the battle for survival in the animal kingdom seems to be more about utilising psychology and morphology in avoiding such combat and fruitless violence.

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Conclusion: Aposematism, Cold War and Peace

We come to a somehow surprising conclusion: Aposematism (warning display) is in fact a strategy for peace. A possibly better way to say this is that it allows conflicting animals to avoid physical confrontations and all-out fights, replacing them with ritualized displays of size and power. An aposematic confrontation might seem like a serious fight brewing, with lots of intimidating gestures being thrown around, but in reality none or little serious physical violence actually eventuates.

This strategy from the animal kingdom is somehow close to the international political strategies employed in the notorious "Cold War" between the USSR and the USA, where conflicting parties were often engaged in different (usually bluffing for the most part) displays of their weapons and readiness to engage in combat, yet at the same time both sides would desperately attempt to avoid any real all-out physical engagement in the event that such a confrontation seemed imminent. It is no coincidence that, after the creation of the most devastating weapon, the nuclear bomb, there has been no large-scale all-out wars between any major world powers. The successful detonation of the nuclear bombs above Hiroshima and Nagasaki instantly became the most powerful aposematic tool ever employed by humans. The idea that the emergence of nuclear-powered weapons helped to establish a peace between major world powers (although at the same time increased the danger of catastrophic terrorist attacks) is coined under the term "nuclear peace" and is almost as old as the weapons themselves.

Throughout history we have been shown that if we have to have a conflict with other parties, it is much better to have a ritualized display of strength rather than an all-out fight to a point of mutual destruction. Politicians only realized this during the last half-century. The forces of natural selection realized this many hundreds of millions of years ago.

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Can a Predator Be an Aposematic Species?

Predators come in different sizes, shapes and exhibit many different behaviours. If you ask a person in a street to name five species of predators from the top of their heads, most people would probably name the big predators, such as lions, tigers, bears, wolves, sharks and crocodiles among others. Very few would recall that there are in fact many more different forms of predators, with a vast array of sizes, behaviours and types of prey. For example, not many would recall that virtually all birds (not only eagles and falcons) are also predators, which prey upon insects in prodigious quantities.

Predators differ from each other largely by the prey they hunt (from flies to giraffes and baby blue whales), by their method of getting to their prey (some run or fly after them over large distances, some use stalking, some lure them, some just wait), and also by their method of killing (some use a killer bite in the nap, others suffocate their prey, some tear the prey apart, and some swallow their prey alive). I have only mentioned the most well-known methods of predator behaviour, but in specialized books you can find many more means used for obtaining prey. We are not going into the subtleties details of different methods of predation. We need to discuss another, more important and relevant question – can predators in general actually be classified as aposematic species?

The reason I am asking this question is that aposematic species, as we remember, do not try to hide and instead try to demonstrate their presence at all times. It is not too difficult to notice that that the basic strategy of aposematism is in direct contrast with what many predators are trying to do: conceal themselves from the prey animals in order to hunt them with a greater success rate. A lion or a tiger who advertises their presence by walking openly and roaring will starve to death as all their potential prey will be aware of their presence. On the other hand, virtually any animal can use an aposematic display in certain situations, mostly to avoid unwanted violent confrontation. Tigers and lions are no exception, and express their desire to be left alone with growling, as do bears by standing on hind legs and cats by raising their back and hissing and raising their body hair, however these behaviours alone do not necessarily mean that these animals are aposematic species. Aposematic species are those who use a whole system of aposematic signals virtually all the time, seemingly in an orchestral and organised nature. As a rule these are the generally weaker species that have their bodies covered in bright, often contrasting colours, make loud sounds, often emit smells and move slowly and awkwardly. By this definition it is evident that neither lions nor tigers are aposematic species.

The most famous predators of all, the family of big cats, and their domestic descendants are a perfect illustration of the demands survival has put on predator species. They often have camouflaging body colours, they are masters of natural disguise and can stay unnoticed, they can move without making a sound and do not have body odour (herein lies the evolutionary source of domestic cats' legendary cleanliness).

But not all predators have all these heavy demands. Wolves, for example, and the big group of their relatives, known as "canidae," hunt their prey using a different strategy. The hunting method of a canine tribe does not depend on silent stalking and a surprise attack. Instead it is a test of endurance and speed. They run after their prey over long distances, wearing them down, and attack the now-tired prey as a group, leaving virtually no chance for survival. As a result, dogs do not care too much if they are seen by their prey before the chase begins, or if they emit body odour. This is why at least some of their domestic counterparts are coloured in contrastive colours, and also why they do not pay as much attention to their personal hygiene as domestic cats do. Therefore it would be more common for dogs to have more constant aposematic features, such as clearly seen colours or a strong body odour. We must remember that canine predators cannot afford to use certain aposematic features such as a slow and awkward movement style.

There are many other predators that can maintain aposematic features while remaining skilled in hunting. Many birds, for example, hunt insects and therefore qualify as predators, however they do not care if they are seen by their prey. Another important point to include at this time is that many animal species can be both predators and prey at the same time.

So we come to the conclusion that some aposematic display features are unacceptable for the lifestyles of certain predators, but are acceptable for others. For example, features such as contrastive body colouring or body odour are acceptable for 'cursorial' predators such as wolves, but not for stalking predators.

I do not want to delve too deep in discussing the presence of aposematic features in a wider range of animals, but I would like to remind the reader that most animals have at least some arsenal of temporary warning display and they use them primarily in order to avoid violent confrontation. We must remember that temporary displays are those which are not permanently present in the apparent morphology or behaviour of an animal. Temporary warning signals can also be used by cryptic species as well, who initiate their aposematic display only after they have been spotted by a predator (for example, certain cryptic butterflies open their first layer of wings to display the second layer of wings with eyespots to attacking predators).

It would be a grand mistake to attribute the use of aposematism to prey species only. Aposematism has a much larger role in natural selection. It had the crucial evolutionary function of avoiding rampant and endemic physical violence. It was the neglect of the importance of warning displays in natural selection that brought some earlier evolutionists to the erroneous picture of the struggle for existence as a constant physical ("gladiatorial") battle.

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A Few Words on Sexual Selection from the Point of View of Natural Selection

Before we continue our discussion on aposematism, I would like to briefly mention several elements of sexual selection which seem to me very important to include.

Firstly let us recall that sexual selection operates via two very different mechanisms: (1) male competition, or *intrasexual competition*, and (2) female choice, or *intersexual competition*.

Secondly, male combat itself also contains two different forms of competition (1) intimidation, which is based on a wide set of elements of ritualized display, and (2) physical combat aiming to defeat (or even kill) an opponent.

The differences between these two forms of male combat are too important to view them as simply two elements of the same mechanism. The intimidation tactics of rival males involve the display of aposematic elements and a ritualized showcase of size, colours, smells, behaviours. This display is identical to the other main use of aposematism, which is to avoid predation. The primary aim of the ritualized display in both cases is to avoid violence, and to substitute violence with the ritualized displays. While on the topic of physical combat between males, we need to remember that physical combat in most species as a general rule is very short, and violence very rarely escalates into a real all-out fight. Relatively minor elements of a violent clash in male competition must be understood as a part of intimidation strategy. During a ritualized display of size, colours, sounds, smells and behaviours the bigger and louder animal gradually pushes the smaller opponent towards conceding defeat, and as soon as any actual physical confrontation starts to develop, the smaller male as a rule will retreat backwards. As a result of this, both males will have avoided unnecessary violence and injuries.

I therefore suggest that *intrasexual selection* (competition between males) and aposematism are often directly intertwined. They have the same morphological and behavioural elements, and the same internal forces. Without an aposematic ritualized display, any encounter between confrontational males would lead to the injuries and deaths of participating animals, and this kind of constant in-fighting between the conflicting males would be disastrous for the species, even more so in today's world where human expansion has pushed wildlife into more confined and condensed areas.

On the other hand, there is a considerable difference between aposematism and *intersexual selection*. This is when males try to impress females via the mechanism of female choice, as opposed to merely competing with each-other via the *intrasexual* model. These two mechanisms, natural selection via aposematism and sexual selection via female choice have confusingly similar morphological and behavioural features, but they are driven by two very different internal forces: beauty (or display of healthy genes) on one hand, and the intimidation of an opponent on the other.

Which of these two forces is the primary evolutionary agent for the development of these characteristics? This is a tricky question, and to have a chance

at answering it we will need to find cases where natural selection through aposematism and sexual selection through female choice have had conflicting interests. We will now look at two possible scenarios:

> (1) In the first scenario it should be possible to demonstrate that a clear and unique visible (or audible) characteristic is very effective for attracting mates, but at the same time the very same feature is harmful for the displaying animal's chances of survival against predation;
>
> (2) In the second scenario it should be possible to demonstrate that an exclusively aposematic feature does not attract females and does not therefore contribute to more offspring.

The first scenario above was proposed by Charles Darwin. As a matter of fact, his entire theory of sexual selection was almost entirely based on the idea of unnecessary (and even harmful) beauty that is favoured by females and leads to more offspring. This intriguing idea was later developed into the well-known notions of the "honest signal" and "handicap principle" (see Zahavi, 1975; Zahavi & Zahavi, 1997). According to this principle, in order to be "honest" the signal has to be costly for the survival of the bearer. The famed peacock's tail is the best known example of this and a true symbol of this evolutionary principle.

The second scenario can be called true aposematism, or the warning display without any indications of any involvement of female choice. The best examples of this scenario were provided also by Charles Darwin, when he found cases of brilliant colours used by sexually inactive larvae. Darwin himself could not explain this phenomenon, but an effective and elegant explanation was suggested by Wallace.

As the author of this book is clearly fascinated by the power and many faces of aposematism, the readers can guess that I believe that, in the complex interaction between the principles of sexual selection via female choice and the aposematism, the latter must be a much more potent evolutionary force than the former. It seems to me logical to propose that females who happen to develop a passion for mates who exhibit traits and behaviours harmful to their survival would be themselves doomed by the forces of natural selection. My suggestion is in direct contradiction with the idea of the "handicap principle" and I want to assure readers that I will soon discuss the "handicap principle" on the example of the best known and the most iconic example of the power of sexual selection via female choice – the famed peacock train.

At the same time, I have to admit that even if we accept the primary power of natural selection as the formation of aposematic signals, we should not exclude the possibility that sexual selection might also be a factor in forming (and particularly intensifying) certain aposematic signals. For example, there is an interesting case study on the strawberry poison frog, and the authors of the study suggest that the power of sexual selection is behind the existing colour differences of local varieties of this frog (Maan & Cummings, 2009). Although it is difficult to be sure whether the existing local sexual preferences are the primary driving force behind these colour

differences, the possibility that sexual selection can provide the pressure to form or to intensify aposematic features should not be ignored. As a precautionary tale I would remind the readers the similar interpretation provided by Charles Darwin on the differences in skin colour of different human populations. Very much like the researchers on the study of strawberry poison frog, Darwin was also sure that the differences in skin colour of different human populations were a result of female choice, not of natural selection via adaptation to the differences in solar intensity. Today the idea of sexual selection determining human skin colour has lost most of its supporters (although see Frost, 2009).

Here I would like to suggest a few concrete suggestions in order to distinguish which of the two central primary forces are behind traits in animals as bright colours, sounds, smells, and behaviours: (1) sexual selection via female choice, or (2) natural selection via aposematism. Here are the suggestions:

> **(1)** As sexual selection is mostly arbitrary, a single trait (for example, bright colours) can be present in isolation, and it does not have to be intertwined with the other signals (sound, smell and behaviour); Natural selection, on the contrary, is not arbitrary, and if the trait was designed by the forces of natural selection as a warning signal, these signals will very likely involve other accompaniments as well, as a wide-ranging aposematic display in several modalities is much more potent than a linear one. Therefore, if the presence of bright colours is the single distinguishable feature of an animal, this is most likely a case of sexual selection, but if bright colours are accompanied by other forms of display: loud sounds, strong (and particularly unpleasant) smells and unusual behaviours, then the primary function of this multi-modal signalling is most likely to be aposematism.
>
> **(2)** If males of the same species are engaged in direct male-to-male competition for the females, the stronger males win females via this competition and there can be little to no real female choice of the males involved. In such cases a female is more like a "trophy for the winner", than a picky beauty queen with the right of the last decisive word. The factor of female choice in sexual selection in such species must be considered close to nil;
>
> **(3)** If males and females of the same species both have the same traits such as colours, sounds, smells or behaviours, and particularly if these signals are presented simultaneously, then aposematism must be the preferred logical explanation;

In the next section we will discuss the possibility of measuring the amount of aposematism in particular animal species.

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How to Distinguish Aposematic Species: Aposematic Index

In order to introduce a methodology to measure the presence of aposematism in an animal species, and to see if there is an objective way to qualify different animal species as "aposematic species" I would like to introduce the **"aposematism index."** What is an aposematic index? Aposematic Index (AI) is a numerical expression of the relative importance of aposematic warning signals used by any given animal (both constantly and in specific situations). This functions on a percentage medium, thereby making the maximum AI 100%.

As there are four basic modalities (visual, audio, olfactory, behavioural) I propose to give each of these modalities an equal maximum 'impact' share of 25% to reach a maximum total 100%. If an aposematic element is present only in specific situations and only briefly (like a dog's growl for the defence of a bone, or a cat arching its back to avoid a conflict), this temporary signal will have the value of 5% in any given modality. On the other hand, if an aposematic signal is constantly displayed (like the contrastive colours of a skunk or the spikes of a hedgehog) this will be equivalent to the value of 20%. The presence of both constant and temporary signals in a given modality will result in the maximum of 25%. 100% AI means that a given species is constantly displaying aposematic signals in all four modalities, and that in critical situations it also displays stronger additional signals in all four modalities.

In order to qualify a given species as an "aposematic species", without any doubt the AI should be 100%. This high requirement for qualification derives from the strict demands of natural selection: if a species follows the aposematic lifestyle as a survival strategy for thousands of generations, it will naturally and gradually develop the means to advertise warning signals through all four modalities. Therefore it is very likely that any true aposematic species will be advertising aposematic signals constantly in all modalities, and they will also have ability to increase the intensity and possibly variety of warning signals in critical situations.

Let me present some examples of this AI system with brief comments:

For example, when using **visual** signals, an aposematic animal should have a constantly visible body (ideally a large, colourful one). Additionally, in the time of need, an animal should be able to increase its body size more drastically (by changing its body posture, erecting hair, or extending various parts of the body to seem taller or wider). The constant feature on its own gives the animal 20% AI in this modality ("visual"), and the temporary feature gives 5%. The presence of both constant and temporarily features together will give the total 25% in a given modality. According to my observation, animal species that have constant aposematic signals as a general rule will have means to further increase their size (and even colour) in a moment of need. Therefore when a constant visual signal is present it is most likely that a temporary signal is also available. On the other hand there are many species that have temporary visual signals, but do not possess constant warning signals (for example, cats raising their back and fluffing their hair). Aposematic animals as a rule have highly visible bodies, often coloured in bright or

contrasting colours and sometimes sporting unique patterns or features over prominent areas such as the head or the body.

When using the **audio** modality an aposematic animal is expected to be making some kind of constant noise to advertise its presence. Much in the same way as visual signals, an animal will be able to increase the sound level and make additional, stronger sounds when in a critical moment. There are many animals that remain mostly silent and only make noise when disturbed (for example many different cat species that can walk with incredible silence but can make various sounds when irritated) will only score a 5% in this modality, while animals that exert noise constantly in addition to doing so in critical situations will score the full 25%. Porcupines, for example, most of the times produce a specific booming sound, and if disturbed, add the rattle of quills and other sounds from the rich repertoire of their sounds, ranging from high-pitched whistles to whines, grunts and snuffles. As a rule, aposematic species are more vocal and noisy than non-aposematic species.

When talking about the **olfactory** modality in an aposematic species, we are looking for a constant body odour that the animal's body produces. As the absence of odour is important for hiding from a wide array of predators, the mere presence of a clearly detectable body odour will itself indicate the aposematic nature of that odour. Unlike visual and audio signals that can produce a strong intimidating impression, body odour is a more subtle signal. Porcupine and skunk body odours (without the deadly skunk gland) can illustrate this state. While maintaining a constant body odour, aposematic species often increase their odour production in moments of need, commonly resulting from increased sweat production through excitement. It is theoretically more difficult to produce a strong temporary odour for an animal which does not already have a constant odour in place. We can essentially conclude that body odour can be present either constantly, or both constantly and temporarily (with the stronger smell produced in critical situations).

While discussing the principles of aposematic display and aposematic index (AI), I would like to make a short list - effectively a summary of the most widely used designing features used by the cryptic and aposematic strategies. This list of features is based on binary opposition; with one set belonging to the cryptic strategy of staying unnoticed, and the other belong to the aposematic display of advertising one's presence with all possible means[3]:

Cryptic	**Aposematic**
Dull colours, matching environment;	Bright, contrastive colours
Staying close to the ground;	Rising on hind legs;
Lowered tail;	Raised tail;
Being silent;	Being noisy;
Absence of body odour;	Presence of body odour;
Swift movements;	Slow movements;
Running away from danger;	Aggressive response to danger;

[3]Darwin was probably the first who wrote about the principle of antithesis of intentions on the example of play signalling in dogs (Darwin, 1873).

We are now approaching the most interesting part of our discussion, as we are going to analyse several examples of evaluating AI in different species. We will start from very well-known species whose aposematic nature by this point has been established, and then we will move on to more unexpected cases.

Skunk – Classic Case of Aposematism

The aposematic nature of a skunk's defence is quite well known, albeit the full arsenal of skunk aposematic possibilities is often understated, meaning that only the black & white colour scheme and the notorious odour are widely known. In reality, the skunk uses array of aposematic signals via each four of the above-mentioned modalities, and what is particularly important is that skunks advertise their warning signals constantly. These signals may also be intensified in critical moments, as per the general rule of aposematism.

Visual signals - Skunk body colours consist of a highly visual and contrastive black-and-white pattern. The skunk also raises its tail when walking (a) to be better seen (b) to look bigger and (c) to look confident (skunks do not lower their tail even when confronted by a predator). In critical moments they cycle through the whole repertoire of visual signals including bipedal posture, raising their tail and stomping their feet. Interestingly, a skunk's bipedal posture is very different from ours in that stand on their front feet (like some humans who can stand on their hands). Skunks do this in order to gain more impressive height by extending their tail upwards rather than having it sweep at the ground. If they were standing on their hind legs, most of their tail length and potential would be not in clear view and essentially wasted.

Audio signals of the skunk consist of the sounds they make to accompany themselves while walking. Apart from this constant sound, skunks can also hiss (the oldest and the most universal aggressive sound), growl and tap their feet – all these audio signals are employed before the skunk's last resort, when turns its back and raises its tail in preparation to use its deadliest weapon.

Olfactory signals - Do we really need to discuss this factor? Apart from the famous spray used in critical situations, skunks also produce a constant musky smell. A skunk's deadly spray is actually a combination of its primary and secondary defences.

Behavioural signals consist of demonstratively slow walking with a raised tail and not running away from predators. Instead of running away, skunks gain an arrogant and aggressive confidence in response to many predator advances. The only behavioural feature that does not fit the typical aposematic framework is that skunks do not aggregate in large groups. Why don't they aggregate? I propose their defence is so relatively potent that they need not rely on "safety in numbers".

Therefore, the morphology and behaviour of skunk clearly defines their constant dependence on the strategy of aposematism. When measured on the

Aposematic Index, the skunk scores a full 100%, therefore skunk can be clearly classified as an "aposematic species". Airborne predators (and particularly the Great Horned Owl), catastrophically for the skunk, have zero or minimal sense of smell and are therefore only predators that are largely invulnerable to the skunk's defences. When sighting an avian predator a skunk quickly forgets about all of its aposematic talents and tries to run away as quick as it can with its not-so-swift feet.

Porcupine – Another Classic Case

Porcupine is another species with an obviously very high Aposematic Index (AI). Let us have a quick look at all four modalities.

Visual signals - consist of long and usually contrastive coloured spikes, which the porcupine can raise and rattle for a better visual and audio effect in a time of critical need. Rising quilts also makes the porcupine seem bigger to opponents.

Audio signals - while moving, porcupines and their close relatives often make a constant "booming" sound and are basically quite noisy while going about their day-to-day business. The stomping of feet, chattering of teeth and particularly the rattling of the quills of porcupine family members in critical moments are other audio reminders of the deadly power of their quills, which can even seriously injure animals as ferocious as tigers.

Olfactory signal - Porcupines constantly emit a smell which is reminiscent of the odour of sweaty human armpits. Apart from this, when disturbed they also produce a strong noxious odour (used in conjunction with the raising of their quills and chattering of their teeth as warning signs).

Behavioural signals are also clearly present: all members of this family walk slowly and awkwardly, clearly advertising that they do not need to run for their lives. Also, when seeing a predator they usually stop moving altogether. By raising their spikes they also warn predators of their weapon, as well as the raised spikes making their body seem bigger. In a critical situation they will often move threateningly towards the predator, displaying an aggressive character. Very much like skunks, porcupines also do not aggregate in groups, and the same explanation of the potency of their defences can be used as the explanation of this fact.

The conclusion is clear: porcupine AI also reaches the maximum 100% mark, clearly identifying the porcupine as a member of the group of truly aposematic species.

Let us now discuss a relatively unknown case.

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Norwegian Lemming – Unknown Classic

This species is definitely not as universally well known as the skunk or the porcupine, but it shows a remarkably high AI. Malte Anderson published a special article in 1976 on the possible aposematic character of the colouration and behaviour of this species (Anderson, 1976).

Unlike all other rodents from the Scandinavian region, who are cryptically coloured and try to conceal themselves from their predators, Lemmings on the contrary are conspicuously coloured with contrasting bright yellow, reddish brown, white and jet black hues. They are also very noisy, making different sounds which include loud calls. Their behaviour is very aggressive towards their usual predator bird of prey, the long-tailed Jaeger. Lemmings are aggressive even towards approaching human observers, first by turning towards the approaching humans and sounding a call. If approached further their call will grow louder, they will rise on their hind legs, leap and try to bite the intruder. Anderson observed lemmings and another local rodent, the vole (which is not aposematic), and specially studied their survival strategies in their encounters with their mutual natural predators, Long-tailed Jaegers, in the wild. The cryptic vole was killed and eaten in 10 cases out of 12 encounters while the aggressively behaving Lemming was killed only once out of 6 cases. The Jaeger never hesitated to attack a vole, but was always wary of approaching the aggressively behaving lemming. Other important characteristics are that, compared to voles, lemmings are also slower in running, and also that lemmings constantly produce a strong body odour (which resembles sour milk) from a special dorsal skin gland.

The Norwegian Lemming has all the attributes of an aposematic species: its body is colourful and highly visible; it makes loud noises and calls, has a strong body odour, runs slower than its relatives, and behaves explicitly aggressively towards possible predators and enemies. Conclusion: Norwegian Lemming has a 100% AI.

After the examination of two well-known species whose aposematic qualities are quite widely known (skunk and porcupine), and one of a relatively unknown species who apparently is also a clear example of aposematic morphology and behaviour, I am going now to surprise readers and discuss a couple of animal species whose morphology and behaviour has never been discussed in relation to aposematism.

Is There an Elephant In the Room?

Is it possible that the elephant is an aposematic species that has never had all of its characteristics and features fully identified? I have never heard of anyone proposing that elephants use an aposematic strategy, and if you do a Google search for "elephant" and "aposematism", you will most likely find only references for an

aposematically coloured frog which has so much poison that it could kill an elephant. Well, we need to remember that aposematism is still a "rare guest" in biological and ethological thinking and publications, so there are potentially thousands of aposematic animals have not been yet been identified as such in scholarly literature. A closer look at elephant morphology and behaviour reveals a very interesting picture.

Visual signals - An elephant body does not have any conspicuous colours, but there is hardly a need for this, as the elephant body is one of the most visually recognizable symbols in the natural world as it is simply the largest land animal on earth. Apart from their extraordinary body size, in critical moments elephants can also open their ears and raise their trunks, making their size even more impressive, particularly when accompanied by their trumpet-like loud calls while running towards an opponent.

Audio signals - Although elephants can walk silently, when moving around they usually make plenty of noises and are easy to locate. They hardly need to hide their presence as it is, and of course they are able to produce loud and piercing sounds on command when required.

Olfactory signals - Elephants have a quite a strong constant body odour, clearly recognizable even by such smell-deprived species as humans. In a specific season (known as "musth"), when male elephants become highly aggressive and dangerous, they activate a smell-producing gland so that the strong smell emitted clearly notifies everyone to stay away from them.

Behavioural signals - An elephant's behavioural strategy also fits very well within the aposematic model of defence. They are slow moving animals and they rarely run away from any other animals. On the contrary, they often charge aggressively towards lions and other possible enemies in order to scare them away with their impressive presence and loud sounds.

Therefore we can make a conclusion that elephants actively and constantly use aposematic warning signals, and as a result, they should be categorised as aposematic species with an AI of 100%. As aposematic characteristics work according to a principle of "the more the better", the growth of the body size alone could become a factor of permanent selective pressure (unless the size itself becomes problematic for survival). The massive size of an elephant, apart from securing them from predator attacks, is a decisive factor in intimidating bouts between rival males, which as a rule consists of bluffing display of size and sounds and rarely leads to physical injuries.

In regards to aposematism, we can say that there are a few more elephants in the room.

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Gorilla – The Scary Gentle Giant

Gorilla, the biggest and strongest of the primates, also exhibits a number of aposematic characteristics. Since these characteristics are not enough to reach the 100% AI level (as it was in the case of elephants), I would not include the gorilla in a definitive list of aposematic species. Let us examine:

Visual signals - Gorillas are not as visible as elephants, of course, but their size (and particularly the size of a silverback adult gorilla) can definitely be intimidating for predators and competitors alike. Apart from their constant big size, in a moment of confrontation gorillas will rise on their feet, making themselves seem taller. They also shake their arms, beat their chest, and break branches around in what is essentially a display of strength, determination and physical aptitude.

Audio signals - Gorillas are usually silent, so we cannot say that they are advertising their presence constantly, however in critical moments male gorillas do make plenty of sounds which include roaring, beating their chest and breaking tree branches and foliage in their vicinity. Together with the fierce looks and body size, this display is extremely impressive, generating unfounded legends of gorillas' incredible fierceness and lethality. Being strict vegetarians, gorillas are basically gentle giants, and are much more peaceful than the more 'approachable' chimpanzees, who have been known to exhibit quite violent behaviour, including hunting and killing (not for food) other chimpanzees. I must add that the notion of a "gentle giant" is very aposematic by nature, as animals (and also humans) with large and intimidating bodies often do not need to be fierce in order to be respected, and are left mostly undisturbed.

Olfactory signals - Gorillas do have a specific body odour, however they do instantly produce a very strong and pungent smell in sudden moments of confrontation.

Behavioural signals - Gorillas walk slowly and awkwardly. In moments of confrontation with predators and rivals they do not run away from danger, instead standing their ground to face the threat. Their behaviour in such moments seems very aggressive, albeit their aggression largely consists sound and sight, rarely reaching the stage of physical violence.

We can conclude that gorillas do exhibit a number of strong aposematic signals, but at least one of these signals (audio) are of a temporary use only. Another important characteristic when taking into consideration the AI among gorillas is that males are definitely more aposematic than females. This kind of sexual dimorphism in the use of aposematic features is quite common among a wide range of animal species in which males and females differ in size, colours and behaviours. For example, in comparison to males, female gorillas do not engage in audio-visual-olfactory intimidating display, do not beat their chest, do not break branches, and do not produce a strong smell in critical situations. Despite of this it must be remembered that female gorillas are still incredibly strong and can do plenty of damage to any predator if need be. In a gorilla clan it is the male's duty to provide security for the family, and although a male gorilla may sometimes fall prey to a

leopard (usually while sleeping) or a lion, they perform their task admirably. They are able to do so without usually having to resort to violence due to their fierce size, look and their array of effective aposematic signals.

Peacock – The Rise and Fall of a Symbol?

For many readers who strongly believe in the evolutionary power of sexual selection, the discussion of a peacock's aposematic features will be of crucial importance as the peacock train has been an enduring symbol of sexual selection.

Readers should note from the beginning that the term "peacock" refers only to a male. Females of the same species are known by the name "peahen", and the overall species name is "peafowl". Therefore a peacock is a male peafowl, and in this section we will be predominantly discussing the evolutionary importance of the peacock's tail (correct terminology for their tail is "train").

Through the works of Charles Darwin, the amazing size and dazzling colours of the peacock train became the most prominent symbol of the power of sexual selection. The peacock's visual features were considered so unnecessary for survival, even harmful, that it was believed that the only reason for the peacock sporting the huge train was to entice the female peahens with their beauty. According to this model, a more impressive train ensures the better chances of its bearer in having many offspring. Amotz Zahavi famously dedicated a book to the "handicap principle", where he argued that for a signal of sexual selection to be "honest", it must actually be a hindrance to the bearer. Zahavi placed a picture of a peacock on the cover of the book as the best and undisputed example of a beautiful but harmful morphological addition to a male body.

Before we discuss the possible aposematic nature of some of the peacock's features, we must recall that the morphological and behavioural elements that are routinely discussed as the designing features of sexual selection via female choice (colourful and big sized body, exaggerated morphological additions, various sounds, smells, strange behaviours), are absolutely identical to the designing features used by the aposematic warning display. Therefore **any scholar dealing with animal species with colourful bodies, ostensibly unnecessary morphological additions or strange behaviours and smells should always take into account that both sexual selection and aposematic strategy use the same visual, audio, olfactory and behavioural signals**.

Unfortunately, as aposematism and warning display have never been properly acknowledged in biological science, plenty of aposematic signals from a vast array of species have never been properly studied. As a result, the model of sexual selection via female choice is virtually reigning unchallenged in discussions on the evolution of the colours, sounds, smells and behaviours of thousands of species, ranging from insects to humans.

This disregard toward the aposematic strategy of natural selection flowered from Charles Darwin. When writing about the amazingly beautiful display of colours and additional morphological features on many animal species, Charles famously wrote: 'To suppose that the females do not appreciate the beauty of the males, is to admit that their splendid decorations, all their pomp and display, are useless; and this is incredible' (Darwin, 2004:557). It is clear from these words that the great scholar did not even consider the possibility that the "beauty and splendid decorations" could all be potent tools to scare away predators and competing rival males.

Because of his one-sided approach, Darwin was sometimes puzzled by the strange features of sexual selection in some species. For example – why, in some species, are females just as distinctly coloured as their male counterparts? Or – why, in species where a male can win a female's affection by physically defeating a competing male, do males still retain these beautiful colours and unusual features that hinder their fighting abilities? The answers to these questions start to become clearer if we take into account that the appearance of colours, morphological additions and strange behaviours may instead be to intimidate rivals and predators. For example, the presence of distinct colouring on both sexes most likely means that their colours are primarily to scare away predators and competitors, avoiding unnecessary physical violence and injuries. The initial notion of natural selection as a total and all out struggle of each living organism against all other living organisms, of different and the same species, is hopelessly out-dated. We need to acknowledge that **avoiding physical conflict is a crucially important strategy in the survival of most animal species**. A complex system of ritual fights with elaborate and intimidating displays serves this strategy in an integral manner. This was the crucial point neglected in the writings of Darwin, and the same point is still absent in the writings of most of his contemporary proponents on the sexual selection model.

Now let us return to the discussion of peacocks and their unique look, asking ourselves the crucial question: Was it developed to garner female attention or to scare away rivals and predators? Or was it possibly formed to serve both purposes?

Before proceeding further, let us first assess the peacock's AI (Aposematic Index).

Visual signals - A peacock (the male peafowl) with an opened tail is one of the most spectacular sights of the natural world. First of all it is huge, reaching a height of 1.5 meters and three meters in width, making peacock one of the largest birds of our planet. The colours of the peacock's body and tail are also possibly one of the most visually impressive sights of our world. Even with a closed tail, a peacock's colourful body and crowned head are amazingly impressive. As if this were not enough, a peacock's opened tail has plenty of eyespots. Eyespots, as we remember, are often used for intimidating predators and competitors. Visually, peacocks are one of the most potent aposematic species on the planet.

Audio signals – When peacock's beauty is discussed, it is often overlooked that apart from their visually-screaming attire peacocks also make a huge, literally 'screaming' call as well. The volume and persona of a peacock's call are very far from

the beauty of its tail, reminding one more of the screaming of some alien species from a horror movie. This call is often described as a negative side to having a peacock as a pet, as the call is much stronger than a rooster's call and can easily disturb the peace of a whole neighbourhood. Their most common calls are a loud *pia-ow* or *may-awe*. The frequency of calling increases before the Monsoon season and may be delivered in alarm or when disturbed by loud noises. In forests, their calls often indicate the presence of predators such as the tiger (Whistler, 1949:401-410; Ali & Ripley, 1980:123-126). Apart from these loud calls, peacocks also make rattling sounds when displaying their train.

Olfactory signals – I have not found any information indicating that peacocks have any constant body odour, but when grabbed by humans (and we could assume, by predators as well) they defecate on them, and according to people lucky enough to have of these beautiful birds the smell of peacock droppings is quite strong. I have never had the pleasure of having this magnificent bird as a pet, but we can read the testimony of a person who has some first-hand experience. When he took the peacock for the first time in his hands, the peacock defecated on his clothes, and according to him: "…the smell of peacock shit is the worst of all the shits I've ever smelled, cats included. It's true! Peacock poo is bad to match the sound..." Such a strong smell from a mostly non-predatory bird, together with the habit of defecation when constrained against its will, suggests that peacocks also use an olfactory aposematic signal.

Behavioural signals – Aposematic species usually walk slowly, and do not run upon seeing a predator. They instead often behave aggressively, even moving towards an antagonist that is bigger and stronger. Peacocks also walk slowly and are not easily frightened to run away or fly away. They often come close to humans and are sometimes known to follow them, which can actually be intimidating considering their size. Peacocks in the wild are not even frightened by the sight of tigers. George Schaller wrote: "The peafowl at Kanha [National Park in India] were not greatly alarmed by the proximity of a tiger. One cock walked past a tigress at a distance of thirty-five feet; on another occasion, when a tigress suddenly stood up in the grass thirty feet from a cock, the bird merely looked up, then continued to forage" (Schaller, 1984:279). These are typical aposematic behavioural signals. Females (peahens) also actively use their (albeit much smaller) tail to scare away competitors or predators.

Darwin noticed how peacocks open their tails when pigs entered the yard but made, in my opinion, the wrong conclusion: "evidently [peacock] wishes for a spectator of some kind, and, as I have often seen, will show off his finery before poultry, or even pigs' (Darwin, 2004:444). Well, if I was to choose out of these two reasons as to why peacocks open their tail when a pig enters the same yard, (1) to show off the beauty of their colourful tail to a pig, or (2) to defend his territory from the intruder - I would choose the latter option.

So, contrary to the opinion (or even the belief) of the long list of distinguished scholars from Darwin to Zahavi, who were/are sure that the peacock's legendarily

impressive tail was designed by the forces of sexual selection, I am coming to the conclusion that the **primary force behind the beauty and size of the peacock was natural selection trough the mechanism of warning display (aposematism)**.

Of course, as I have already mentioned several times, these two forces of evolutionary change are not necessarily mutually exclusive. On the contrary, the same signals that can scare away predators and rivals can also attract mates. However, when choosing the primary force behind these signals I opt for natural selection – scaring away rival males and predators and replacing violent fights with ritualized display must essentially be the primary reason behind the dazzling beauty of a peacock.

Unfortunately we cannot ask the peacocks and peahens about the main reason behind their beauty, but there are other ways to check the relative importance of these two evolutionary forces. Why do scholars need to be guessing whether the peacock train is for sexual selection of for some other reason? Scholars should merely observe peafowl behaviour and see if the males with more beautiful trains have more success with the females!

Sexual selection in peafowl: studies – Amazingly, scholars were so sure about the sexual nature of the attractiveness of a peacock's dazzling display that they did not even consider it necessary to test this tacitly agreed idea with an objective and solid field study. It was only in the beginning of the 1990s that Marion Petrie, Tim Halliday and Carolyn Sanders published the results of their study on peacocks' mating behaviour. According to their results, as it was expected, females were choosing males with bigger trains and with the biggest number of eyespots. Unfortunately the study was not large enough (researchers studied only one Lek of 10 males for very limited time. A Lek is a congregation of males).

In the second half of the 1990s, a seven year-long study was conducted in Japan to verify the Petrie/Halliday/Sanders finding with a larger sample and ground the sexual nature of the peacock's attributes into popular thinking with solid field results. During seven mating seasons, observed from 1995 to 2001, researchers from the Graduate School of Arts and Sciences at the University of Tokyo, under the leadership of Mariko Takahashi, studied a free-ranging population of Indian peafowl at Izu Cactus Park in Shizuoka, Japan. They naturally expected to find confirmation of the power of sexual selection in a peacock's morphology.

Amazingly for the Japanese researchers as well as a big section of scholars, researchers came to the sensational conclusion that the female peahens were indifferent to the peacocks' tail size, and that brilliant colouring and tail condition did not correlate with the reproductive success of their bearers.

The publication of the results of this study, as expected, stirred heated debate. According to an article in Discovery News, "The feather train on male peacocks is among the most striking and beautiful physical attributes in nature, but it fails to excite, much less interest, females, according to new research. The determination throws a wrench in the long-held belief that male peacock feathers evolved in response to female mate choice. It could also indicate that certain other elaborate

features in galliformes, a group that includes turkeys, chickens, grouse, quails and pheasants, as well as peacocks, are not necessarily linked to fitness and mating success" (Viegas, 2008).

Creationists also benefited from this unexpected result, suggesting that if sexual selection was not behind the peacock's tail, then what else could be the reason for this 'unnecessary beauty' if not the will and aesthetic sense of the Creator? Petrie and her French colleagues actually wrote a rebuttal of the revealing Takahashi et al. study (Loyau et al., 2008). They suggested that, first of all, more observations were needed to come to final conclusions, and secondly they proposed that a phenomenon known as 'plasticity of female choice' can be involved. When translated into plain English, this term means that peahens possibly change their taste in choosing males much like humans do, and that contemporary peahens are not as interested in the size and beauty of the classic peacock train as their grandmothers were.

I agree with Marion Petrie and her French colleagues in that more observations are needed to come to final conclusions, but in regards to the "plasticity of female choice" I do have some doubts. It seems quite difficult to believe that, after tens and hundreds of thousands (possibly even millions) of years of female excitement for their male counterparts' trains that suddenly, before the close of the 20th century during a 4-5 year period in the 1990s (between the studies of Marion Petrie and Mariko Takahashi), that they suddenly lost interest towards the peacock's dazzling display.

I strongly suggest to those who will be studying the reasons behind the beauty of peacock tail not to discount the possibility that a peacock's tail's amazing size and beauty, with an immense number of large eyespots (over 150), together with their loud calls, smelly droppings, and fearless behaviour can be a set of warning and intimidating signals to their rivals and predators.

Academics are notoriously difficult and reluctant in accepting new ideas and even new facts. The groundbreaking Japanese study of Takahashi sometimes gets simply neglected (see, for example, a recent article by Patricia Brennan from the Department of Ecology and Evolutionary Biology, Yale University, Brennan, 2012). Proponents of sexual selection in peacocks also try to draw on a number of previous short-term studies as well: "The authors seem to ignore the fact that three previous independent studies have found relationships between mating success and train morphology. Rather than consider what is unusual about their study, they conclude that peahens in general do not prefer males with elaborate trains" declared Marion Petrie (Barras, 2008).

Well, as I can understand, the biggest difference between the previous studies that Petrie mentions and the Japanese study is evidently clear: Japanese scholars spent a much longer amount of time in observing the behaviour (seven years as opposed to one). Furthermore, unlike the previous studies, Japanese scholars did not change the peacocks' appearance by erasing their eyespots. We should be grateful that the Japanese team of scholars, despite the fact that they were confused by their

findings (they expected their results to merely confirm previous studies), still published their alarming results. It is, unfortunately, a quite common and sad practice among academics that studies with negative/undesirable results are almost never brought to a wider audience.

It would be natural to expect that a bigger study of the peacock train and its importance for sexual selection is currently under way, in an eager bid to prove the Japanese results wrong. Losing this iconic argument will take a heavy toll on the proponents of sexual selection, but will we ever hear of the outcome of such studies if the new results confirm the conclusions of the Japanese study?

Conclusion: if we take into account that to look bigger (and more colourful) is one of natural selection's favourite strategies to scare away predators and competitors and avoid unnecessary physical confrontations, the idea that the peacock train was primarily designed by the forces of natural selection in order to scare away rivals and predators seems very plausible.

Another suggestion: scholars who are interested in researching the power of sexual selection should first acquire a solid knowledge of aposematic signals and strategies, as both aposematism and sexual selection thrive on virtually the same set of morphological and behavioural features. Therefore, completely ignoring one of the two great evolutionary strategies designed by the evolutionary forces is an unwise and detrimental research strategy.

The problem is far from being resolved, as only one long-term study is not enough to settle such an important question. We can say that the old axiom is currently viewed with a healthy dose of scepticism, and for a good reason. The tail of a peacock, arguably the greatest symbol of the power of sexual selection, might in turn become the symbol of the decline of the importance of the theory of sexual selection.

Tiger: The Silent Beauty

After discussing a few cases of the use aposematic signals and aposematism as a life strategy in several animal species (some expected and some unexpected), let us now discuss what importance aposematism might have in the survival strategy of the three central species of our study, mentioned in title of the book: tigers, lions and finally – humans.

As you may recall, aposematism does not go well with a predator's lifestyle, particularly for the predators that use stalking as their central means of hunting. It is hard to imagine a stalking predator who clearly advertises its presence with visual signals, noisy behaviour, body odour, and a slow and awkward walking style. Tigers, like many other cats, are swift and silent killers. They are truly archetypal predators. Nevertheless, we will still have a point-by-point discussion on the tiger's

possible aposematic morphological and behavioural features, including an assessment of the tiger as per the 100% Aposematic Index.

Visual signals

Tigers are notoriously difficult to locate in their natural habitat. Unlike another big cat, the lion, which can be often found asleep in the shade of a tree, tigers are very difficult to spot in the wild. I myself spent several days at the Corbett National Park in 2011 and still did not manage to see a tiger during seven three-hour safari sessions, albeit knowing that many visitors had better luck. On the other hand, when I visited the Gir Forest in 2012 to see some unique Asiatic lions, during four three-hour visits to the park I saw 17 lions of all ages including males, females, and cubs. Tigers are famously coloured with black stripes on an orange-brown and white body (these colours are quite aposematic), and they might seem to not have much stealth tactics present in their visual morphology. On the contrary, as Corbett, Schaller and many tiger experts others have noted, tigers' colours and stripes work as the perfect cryptic device to help conceal themselves in the jungles. Because of the difficulty inherent in observing tigers, Schaller was in some cases transferring his knowledge of lions over to tigers (Schaller, 1984:235). Schaller sighted tigers 91 times during his whole period of his study, which lasted for 380 days (Schaller, 1984:236). Each lucky day was followed three unlucky days.

Tigers do tend to leave visual claims of their territory for all others to see, a common one being leaving claw marks on trees, but when we are discussing visual aposematic signals, we only take into account the signals that point to the physical presence of the animal, not the signals that communicate territorial claims to other animals. Therefore, territory marking with various means (scratching, urine, faeces) cannot qualify as aposematic signalling. It is clear that tigers do not advertise their presence. On the other hand, in critical situations tigers use a few very effective visually intimidating signals: they open their mouth and display their impressive canines, and when meeting with rival males (and also when in the act of fighting) they also rise on their hind legs. Therefore, tigers have only temporary visual warning signals in order to intimidate opponents, and as a result they score a low 5% in the visual category of the AI.

Audio signals

Unlike lions, who frequently advertise their right to the territory via loud roaring (and even by communal roaring), tigers are generally silent. The best chance to hear tiger sounds in the wild is to be in a tiger reserve when tigers are in their mating season. As tigers are mostly solitary animals, they need to call for each other in order to meet during the mating season, unlike lions that often meet and live their lives in a pack. Therefore tigers do not have any constant audio-aposematic signals, while lions that live in the safety of numbers do. In the event that they are disturbed, tigers can express their frustration by various sounds such as hissing and growling to thunderous roaring (their roar is almost as loud as a lion's). As they display

temporary audio signals but no any constant ones, tigers get another 5% in the audio category for their AI total.

Olfactory signal

Tigers are typical cats, and they spend plenty of time licking their body. The absence of body odour is particularly important for a predator that stalks its prey or ambushes it from a hiding place. Of course, in a zoo enclosure some tigers might acquire some body odour, but there are tigers that maintain their cat cleanliness even in inhumanely small cages. On the other hand, tigers do mark their territory by marking trees and defecating on certain spots. Although their body is as clean as possible, they do use olfactory signals to keep unwanted other tigers off their territories. Tigers use olfactory signal for marking their territory, but do not use body odour in order to announce their presence. They also do not produce any smell when in confrontation (unlike gorillas and humans). Therefore, although tigers do use scent to mark their territories, they do not have any odour present on themselves, thereby receiving 0% in the olfactory category.

Behavioural signals

In this category again we find that tigers do not have any elements of constant behavioural advertising signals. They definitely do not walk slowly and awkwardly - on the contrary, their movements are swift and graceful. On the other hand, when they need to tigers can intimidate virtually any species of animals in their environment, including humans and even elephants. Tigers receive a 5% for the behavioural AI.

In conclusion, the tiger's AI is a low 15%. Tigers arguably have no constant aposematic signals, however they do display temporary signals in three categories (visual, audio, behavioural), making them classic predators. They remain concealed, silent, clean and swift for most of their lives. Despite their non-aposematic life strategy, when required tigers have a wide range of very potent means (visual, audio, and behavioural) with which to deploy a very effective intimidation strategy. The primary importance of these temporary warning signals is to help them to avoid unnecessary physical violence during situations of conflict. We can also add here that, although there are some minor differences between the size and other elements of life of male and female tigers (for example, unlike mostly solitary males, females are spending a considerable part of their life raising their cubs), both male and female tigers generally share the same tactics and both have an equally low AI.

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Lions: When Gender Matters

Although lions and tigers are phylogenetically closely related to each other and can even produce mutual offspring, their behavioural patterns have some very interesting differences. Probably most importantly, lions are social cats, and also have the most expressed sexual dimorphism amongst all cat species (both big and small). I believe that aposematism is behind this dimorphism, and I hope that after reading this section that most readers will agree with me that male lions use the intimidating and warning power of aposematic signals much more often than females. As a result, embarrassingly for the king of the beasts, male lions are much worse hunters than their female counterparts.

Let us now assess all four modalities: visual, audio, olfactory, and behavioural, and see how both male and female lions score in their Aposematic Index assessment.

Visual signals

Only male lions have the most identifiable unique morphological feature of the species – a big mane around their neck and shoulders. Because of this huge mane, male lions are much worse in approaching a possible victim unnoticed. Female lions do not possess any unnecessary constant morphological features – they are physically slick, silent stalkers and swift killers, and as a rule they provide food for all the members of the pride, including cubs and cumbersome males. The lion mane is effectively a constant aposematic feature. Regarding temporary visual signals, lions of both sexes have plenty of intimidating signals, such as baring teeth and trying to look larger. Even with their temporary visual signals male lions possess more aposematic qualities than females - in critical situations males can also erect their mane. In conclusion, in the visual category males score the maximum 25% AI, against the modest 5% of AI in females.

Audio signals

Both males and females have huge voices which they often use to indulge in loud group roaring sessions, but most of the time remain silent as they are resting or moving. We may remember that making loud sounds on a ground is dangerous as it can attract predators, but lions hardly have any natural enemies, apart from humans. As a result of the human threat to their survival, it has been noticed that in regions where lions are hunted, they roar much less. Although lions can definitely move silently when they need to (particularly when hunting), their loud roaring sessions indicate that they like announcing their royal and dominating presence. Both genders of lions have a loud voice, although the male sound is still superior in strength and is lower in range. For their temporary audio signals both males and females use a variety of growls, hisses and roars when disturbed and when they want to achieve their goal without physical violence. Interestingly, lions never roar when they are chasing their prey. In summary I would say that although lions do not

produce a constant noise that characterizes true aposematic animals, their wide arsenal of sounds and roaring sessions during relaxed times makes it possible to give both male and female lions an arguable maximum 25% of AI in the audio modality.

Olfactory signal

Lions are cats, and cats are legendary for their cleanliness. However, according to Brian Bertram, lions are not as good in washing their faces as domestic cats are (Bertram, 1972:56) and adult male lions are less clean than females (Bertram, 1972:59). My own experience in petting lions at the zoo in Georgia during my teenage years in the 1970s also suggests that male lions are less concerned about their cleanliness than females – male lions emit a constant body odour. Apart from this, lions mark their territory with their urine and faeces, but we do not consider this as aposematic signal, as it does not point to the physical presence of the animal. In this category we can give a full 25% score to the untidy male lions and 0% to the slick and clean females.

Behavioural signals

Lions do not have constant aposematic behavioural signals, they do not walk slowly or awkwardly and they both can run fast enough to catch their prey, with females being quicker and swifter than males. As for their temporary aposematic behavioural signals, both males and females employ a large repertoire of threat signals including aggressive but bluffing attacks, baring of teeth and growling. I think that, in regards of behavioural aposematic signals, we can give a low 5% to both male and female lions.

Overall, lions use variety of temporary aposematic signals in all four modes in order to avoid unnecessary physical violence in potentially critical situations. Most importantly for our discussion, male lions have a much wider range of aposematic signals than females do, including their constant aposematic visual signal (mane) and olfactory signal (constant body odour). According to my calculations, female lion AI will be 35% (25% for audio modality, and 5% each in visual and behavioural modalities). As for the male lion AI, it will be high 80% (25% in visual, audio and olfactory modalities, and 5% in behavioural modality).

Male and female lions are quite different in their use of aposematic signals. Male lions are much more aposematic that females, and in fact more aposematic than any other cat, wild or domestic. Female lions on the other hand are quite close in behaviour to tigers, although their long roaring sessions in conjunction with the males indicate that they still use more aposematic signals than tigers. The clue to this intriguing characteristic of male lions is most likely the unique social nature of lions in general. As lions mostly live together, they divide the tasks among pride members. Females have become (or more correctly, stayed as) sleek hunters without any unnecessary hindrance from having constant visual or olfactory aposematic signals. Alternatively, male lions evolved with characteristics to enhance their fighting and intimidating capabilities for their confrontation with rival males and in

defending their pride from other serious threats. For males to be better at intimidation and fighting is more important that to be good at hunting. As a result of their higher AI, males are poor hunters and rarely hunt when they are a part of a pride. Females on the other hand cannot afford to be aposematic, as a high AI (e.g. the presence of huge mane or a constant body odour) would make their hunting strategy much less effective.

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Before we start discussing the importance of aposematism in **human** evolution, let us first summarise the idea that I am trying to bring to the attention of the readers of this book:

Aposematism is not only a strategy to avoid predation. The central function of aposematism is **to avoid physical violence and to substitute violence with ritualized forms of display**. Prey species use aposematism to advertise their unprofitability to predators and to get away without fighting for their life. However even the strongest predators, such as tigers and lions, also widely use an aposematic display in order to avoid physical confrontations with other formidable creatures. And of course, there is a big difference between the aposematic animals that use aposematic display constantly, and the non-aposematic animals that use aposematic warning display only temporarily.

If we remember these methodologically very important premises, let us now move to the discussion of the importance of aposematism in human evolution.

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CHAPTER THREE

The Descent of Men, and Selection in Relation to Aposematism

When Charles Darwin wrote a book on human evolution, the resulting volume was more about sexual selection than about human origins. Darwin was often criticized for this imbalance and for his overrated credit to the power of sexual selection. In the last couple of decades, the popularity of Darwin's ideas on sexual selection has grown considerably, and many human traits that even Darwin was not considering as being the result of sexual selection via female choice, are now considered today by proponents of sexual selection as examples of female choice.

One of the central aims of this book is to give better acknowledgement to the strategy of aposematism (warning display). In this chapter I will argue that humans, who are one of the most visible and noisiest creatures, with plenty of body odour and a slow and awkward walking style, are in fact an aposematic species. Readers will easily notice the resemblance carried in the title of this chapter to Darwin's 1871 book. The mission of this chapter is almost impossible: to prove that almost all morphological and behavioural characteristics of our species were brought on by the perennial strive to become better at aposematic/ritualized warning display. Darwin explained virtually all human evolution to be from sexual selection via female choice, and this chapter will try to explain virtually the same characteristics but via warning display.

I want to say from the very beginning that, for any scholar who believes in evolution, criticizing Darwin feels like a blasphemy to a religious person. Darwin has been my role model for all my conscious life, not only for his brilliant ideas and ability to see the widest picture of the entire world, but also for his disarming honesty and gentle and vulnerable soul. The fact that I also share my birthday with the great scholar made me feel somehow mysteriously connected to him from my teenage years. A few years ago when I first started thinking of the importance of warning display in human evolution, and noticed that warning display could be the central force behind many elements of animal and human morphology and behaviour, and that it could potentially weaken or even gradually replace the sexual selection model, I had an ambivalent feeling. This feeling was possibly something close to the feeling that Darwin himself had when he did not want to publish his own ideas on evolution. I wrote a letter to my dearest colleague and mentor about my inner conflict regarding Darwin and his legacy of human evolution through sexual selection. His response assured me that being honest and direct in presenting my ideas was the only true course of action with which Darwin himself would have approved. There has hardly been any new development in science so far that could do any damage to the unique place Darwin holds in the history of biological science.

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Any new idea takes many years, sometimes even generations to be noticed, let alone shared by academics, especially in the event that the new idea contradicts the ideas of a distinguished authority such as Charles Darwin.

After modestly suggesting in my 2011 book that humans are an aposematic species, I have not had any response to this idea from the academic community. In this book my claims are louder, and are written in the simplest language for anyone to follow my arguments. I believe that if viewed with an unbiased attitude and open mind, the aposematic nature of human morphology and behaviour is just too obvious to reject. At the same time I am well aware that most of academics and peer review journals are extremely conservative in even acknowledging the presence of new ideas, let alone accepting them.

To begin with a general introduction for this chapter let me say that, very much like in the cases of male lions, elephants and peacocks, I have never seen a discussion of the use of aposematic survival strategies in humans, and of the effects of warning displays on morphology and behaviour throughout human evolution. At the same time I must note that the idea of human groups possibly scaring away predators by shouting and throwing objects at them (both very aposematic behaviours) is already quite popular in evolutionary literature and widely accepted to be true.

In reviewing the aposematic index of our own species in the same way we have with other animal species, I will have a look at all four modalities (visual, audio, olfactory, behavioural) and check for their presence and aposematic characteristics. As the readers might guess, we will not be as brief with all human aposematic characteristics as we were with other animals like skunks, lions, tigers, and even peacocks. We will have to discuss numerous aspects of human morphology and behaviour in the next few sections, beginning with visual signals.

Visual Signals

It is often said that the first impression is the strongest. The visual impression often provides the major part of a first impression, hence the importance of visual appearance in animal species and humans. As we remember the most important requirement of a visual aposematic signal is to be clearly visible. I will argue in this section that a big part of our body's morphology was formed by the forces of natural selection with the central aim to look as tall and as visually impressive as possible.

"The taller the better" or the origins of human bipedalism

As we may remember, being tall helps on many accounts both in human and animal life. Taller kids are less likely to be bullied at school, taller presidential candidates are more likely to win the election, taller sales personnel are better at

convincing potential buyers into buying their stuff and taller boys and girls often get more attention. On the animal side of the things, taller and bigger animals are less likely to be attacked by predators than smaller animals, and taller and bigger animals are more likely to be successful in their bid to intimidate rivals and obtain territories and mates. We must remember that no trait has only positive sides, and on the negative flip-side for many species (both predators and prey), taller animals find it more difficult to stay unnoticed. Another negative aspect to being big is that predators will sometimes prefer to attack larger prey animals simply because they will 'provide' more food. Overall however, the positive aspects of distinct visual traits outweigh the negatives.

In the next few sections I will argue that human (and hominid) morphology is the direct result of our perennial evolutionary strive to become taller.

We will start our discussion with bipedalism, a trait widely accepted as arguably the first and most important step on the long evolutionary road between our primate ancestors and modern humans. The origin of bipedalism has been one of the most prominent topics of human evolution since Charles Darwin proposed his theories to explain our animal descent. After more than 140 years since the appearance of Darwin's work, the origin of bipedalism is still largely shrouded in mystery. On one hand, the skeletal adaptation to bipedalism is well documented throughout the evolution of hominids, but on the other hand scholars are still arguing on the exact reasons that could have led to this walking style (which is extremely unusual for mammals).

When discussing the origins of bipedalism, we should be aware that bipedal locomotion had (and still has) both positive and negative effects. On the positive side, for example, bipedalism frees up the hands and allows the bipedal creature to see its surroundings better. On the negative side of the coin, bipedalism uses twice the energy as mammalian quadrupedalism, and bipedalism and associated skeletal changes created several problems for our ancestors, some of which are still visible today. For example, tree climbing became more difficult, our running speed drastically declined, hiding from predators became more difficult, and human lower back and knee joints have since become plagued by osteological problems, predominantly because in bipedal posture these joints support much more weight than in the "normal" quadrupedal walking gait.

Of course we hardly require tree climbing in our contemporary life anymore, and 99% of the time we do not care if we are easily seen while walking in tall grass, but the lower back pain that many readers of this book may have experienced (and some are possibly even experiencing as they read these words) also comes from our constant bipedal posture. In this context I would like to remind readers that traces of osteological problems are apparent in the discovered skeletal remains of prehistoric hunter-gatherers (Koella & Stearns, 2008).

We have discussed how bipedalism has both positive and negative sides, but for a new locomotion model (as for any other morphological or behavioural trait) to be successful, the benefits must outweigh the disadvantages. Several million years of relentless everyday struggle for survival will eliminate an unwanted morphological

or behavioural element. With this strict evolutionary rule in mind, let us remember that none of the other terrestrial mammalian species opted to shift to constant bipedal locomotion, therefore our ancestors must have had very worthy reasons to shift to this style of locomotion, which was and is so unpopular among other terrestrial animals.

From the moment our ancestors started walking upright habitually more than 4 million years ago, the long process of transformation towards becoming a modern-day human had begun. It is universally agreed that bipedalism evolved well before the enlargement of brain and the development of stone tools. To understand what was behind this crucial change is to understand the main forces at play during the very beginning of the human evolution process - this is why bipedalism is universally accepted as one of the most important behavioural and morphological changes in the evolution of our species. It is no wonder that hardly any other topic of human evolution has received as much attention as bipedalism has.

There had been plenty of hypotheses, ideas and models to explain why and how bipedalism started and consequently established in human evolution. The different hypotheses are not necessarily mutually exclusive, as different selective forces could have acted in conjunction to lead to hominid bipedalism. Here are some of the best known ideas on the origins of human bipedalism, presented in chronological order:

List of ideas on human bipedalism

• 1871. Charles Darwin suggested that our ancestors were forced to shift to bipedalism after they became terrestrial, in order to have free hands to carry weapons and meat. The idea of bipedalism freeing hands was later used by many other scholars, but also with many varying functions for the free hands (to carry food, to carry weapons, to throw weapons, to carry children – see below).

• 1923. Arthur Keith, based on the fact that gibbons use bipedalism when on the ground, proposed that human bipedalism had a connection to the gibbons' locomotion pattern.

• 1925. Raymond Dart suggested that standing upright in open habitats would be adaptive to help our hominin ancestors to scan the surroundings in order to see their prey and avoid predators.

• 1936. John de la Marrett came up with a diet-oriented hypothesis, according to which bipedalism was caused by the lack of iodine in early hominid environment.

• 1942. Max Westenhofer suggested that human morphology and behaviour (including bipedal locomotion) evolved in a marine environment. Marine biologist Alister Hardy came to a similar conclusion in 1930, although he published his ideas a staggering 30 years later. The name coined for this hypothesis, "Aquatic Ape",

belongs to Desmond Morris. The idea was later popularized in several books written by Elaine Morgan.

• 1953. George Bartholomew and Joseph Birdsell argued that carrying tools and weapons was the key factor for the origin of bipedal locomotion.

• 1954. William Etkins (and later Tanner, 1981) suggested that infant carrying by mothers was the key factor for adopting bipedal posture and locomotion.

• 1954. Kenneth Oakley supported the idea that the need to look over tall grass was the initial motivating factor for hominid bipedalism.

• 1959. Raymond Dart suggested that intra and inter-species conflict and violence was one of the key factors for the adoption of bipedal posture.

• 1959. Raymond Dart and Craig Dennis also supported the idea that looking over the terrain was an important element in establishing bipedalism.

• 1959. Wolfgang Köhler, observing primate behaviour, proposed that moving on muddy and cold substrate (for example, snow) could lead to bipedal locomotion.

• 1960. Alister Hardy, and later also Helen Morgan in several books, suggested that human ancestors went through a long period of living in a coastal area, spending most of their time in the water.

• 1961. Gordon Hewes suggested that the principal reason for hominid bipedalism was freeing hands in order to transport food.

•1962. Frank Livingston (and later Roger Wescott in 1967, and Nina Jablonski and George Chaplin in 1993) suggested that as plenty of animal species use bipedal threat displays to look taller in order to intimidate antagonists, bipedal threat displays could have been the initial behaviour that led hominids to adopt permanent bipedal posture.

• 1962. Lloyd Du Brul, and later Wrangham (1980) and Rose (1977) suggested that bipedalism was a result of early hominid feeding and gathering activities on the ground.

• 1970. Clifford Jolly suggested that foraging and eating seeds from savannah grasses led to bipedalism.

• 1975. Russell Tuttle suggested an updated version of the gibbon hypothesis, suggesting that human bipedalism evolved from gibbon-like tree climbing abilities.

• 1978. Glynn Isaac suggested that, as a result of scavenging for carcasses on the savannah, hominids had to carry scavenged food back to the group base, and that hominids adopted bipedal locomotion in order to use their arms to hold the food.

• 1978. Valerius Geist proposed that human ancestors started bipedal locomotion while still in the trees, before their move to the ground. According to Geist, our distant ancestors were carnivorous and were obtaining food by stalking silently and killing tree-dwelling species with hand-held rocks.

• 1980. Jack Prost suggested that quadrupedal vertical climbing, used by apes, was the ancestor of human bipedalism.

• 1980. Peter Rodman and Henry McHenry proposed that bipedalism evolved as an energy-efficient way of walking long distances, albeit at slow speeds.

• 1980. Adriaan Kortlandt conducted field experiments with lions and proposed that hominid bipedalism was initially used as inter-species intimidating displays, standing upright and using thorny branches to defend themselves from large predators.

• 1981 C. Owen Lovejoy suggested that the origins of bipedalism were linked to monogamy and the male provisioning his family with food, thus improving the survivorship of the offspring and increasing the pair's reproductive rate. The same year Lovejoy suggested another similar hypothesis, but this time based more on a sexual selection model and without suggesting monogamy among early hominids.

• 1981. Nancy Tanner suggested a new version of the sexual selection model, suggesting that the male phallic display could have been the initial incentive for bipedal posture.

• 1983. Matt Cartmill (soon followed by Carrier in 1984 and by Bramble & Lieberman two decades later) suggested that our hominid ancestors were hunters and hunted prey using long-distance endurance hunting, which led to bipedal locomotion.

• 1984. Peter Wheeler proposed that, as bipedal posture raises the body away from the hot ground, it helps to keep the human body temperature lower.

• 1985. Vernon Reynolds suggested that bipedal locomotion started with moving from tree to tree.

• 1986. A.R.E. Sinclair and Pat Shipman virtually simultaneously proposed that hunting, scavenging, and then bringing the meat back to the base camp was the major factor in the gradual acquisition of bipedalism.

• 1987. Felix Fifer (and later Holly Dunsworth, John H, Challis, and Alan Walker in 2003) suggested that the defensive throwing of objects (especially missiles as weapons) was the key driver of hominin bipedalism.

• 1987. Barbara Isaac also wrote about the importance of throwing in human evolution; however she did not concentrate on the role throwing had in the evolution of human bipedalism.

• 1988. Renate Eickhoff proposed that human ancestors got used to bipedalism while still living on the tree branches, that they were carnivorous, and that their method of hunting was to sit and wait for the prey to approach and then grab them using their upper limbs.

• 1988. Liza J. Shapiro and William L. Jungers suggested that the acquisition of habitual bipedalism in humans probably involved not so much a major change in back muscle action or function, but rather an improvement in the mechanical advantages and architecture of these muscles.

• 1991. Derek Ellis proposed a version of the early "aquatic ape" hypothesis, suggesting that bipedal locomotion could have started after human ancestors spent arid periods of the year in the wetlands.

• 1991. Peter Wheeler suggested that the increased cooling, reduced heat gain, and reduced water requirements in a hot, tropical climate was the driving factor for bipedal posture.

• 1996. Kevin Hunt suggested that human ancestors were initially bipedal only when they ate. According to Hunt, bipedal feeding posture may have been a pre-adaptation for habitual bipedalism which appeared later, only in Homo erectus.

• 1996. Lynne Isbell and Truman Young proposed that the mixture of savannah and scattered forests led to increased terrestrial travel by proto-humans between clusters of trees, and that bipedalism offered greater efficiency for long-distance travel between these clusters than quadrupedalism.

• 1996, 1998. Richard Potts suggested in his publications that different environmental conditions were chiefly responsible for human ancestors starting bipedal locomotion.

• 2002. Algis Kuliukas proposed a hypothesis dubbed the "wading hypothesis", where humans were living in an environment of seasonally-flooding rivers, requiring them to resort to bipedal locomotion to avoid drowning, and that during the dry season they maintained this bipedal posture.

• 2002. Mark Verhaegen, Stephen Munro and Pierre-Francoise Puech suggested the idea of an "aqua-arboreal" phase in human evolution, which came from the Hardy and Morgan idea of "aquatic ape" although in this model our ancestors were also still living in the trees as well as spending plenty of time in the water.

• 2003. According to Jonathan Kingdon, bipedalism arose through adaptations in 'ground apes' whilst feeding on fallen foods on the floor of gallery forests.

• 2004. Richard Dawkins has argued that bipedalism could have begun as a kind of fashion that just caught on and then escalated through sexual selection.

• 2004. Holger Preuschoft suggested that transporting heavy loads was the primal reason for human bipedalism.

• 2004. Weijie Wang and Robin Crompton also suggested that load-carrying was the central reason for human bipedalism, albeit only for establishing the later Homo body proportions.

• 2005, 2009. Donna Hart and Robert Sussman suggested that defence from predators was the key issue in hominid evolution, although according to them none of the adaptive reasons was important for adoption of bipedal posture. Instead, as a part of ape locomotion, it was "given" to hominids and only proved to be advantageous for several purposes after bipedalism had already been adopted as a standard of locomotion.

• 2006. Adam Sylvester suggested that bipedalism was an adaptation in order

to maintain the mobility of hominid shoulders.

• 2007. Aaron Filler proposed that bipedalism was a result of a genetic mutation, and according to him human ancestors of some 20 million years ago already had the genes for bipedal locomotion.

• 2007. Susannah Thorpe, Roger Holder and Robin Crompton suggested that Orangutans using an upright posture in thin branches was the precursor to human bipedalism.

• 2009. Herman Pontzer, with David Raichlen and Michael Sockol, suggested that bipedalism was primarily a successful locomotion model because of the lower metabolic cost of walking.

• 2010. Stephanie Braccini, Susan Lambeth, Steve Schapiro, and Tecumseh Fitch researched the relationship between chimpanzee tool use and the ensuing effects on lateralization and posture, and suggested that tool use may have pushed our nearest ancestors upright.

• 2010. Carsten Niemitz supported the so called 'Amphibian Generalist Theory', a version of the wading theory, and suggested that though the earliest of ancestors would have needed hands and arms for many reasons (self-defence, food gathering, infant carrying), it was living in woodlands and thus close to the rivers that was crucial for bipedalism.

• 2011. Kirsty Robertson synthesized earlier suggestions by Wheeler (cooling heat) and Shipman (freeing hands) and came to a conclusion that bipedalism emerged as the need to be energetically efficient for subsistence strategies, such as scavenging.

• 2011. David Carrier proposed that sexual selection via male combat was the decisive factor for the origins of bipedal locomotion, and that bipedal posture was primarily a means to deliver a more powerful punch to rival males.

• 2012. Graeme Ruxton and David Wilkinson suggested that it was only after early humans began walking upright that they began to lose their fur coats, and that these two processes were closely connected in human evolution.

As we can see, the list of hypotheses and suggestions on the reason of bipedalism goes on and on. Hardly any other human morphological or behavioural trait has received as much attention from scholars as bipedalism has. Despite the large number of hypotheses as seen above, I must remind readers that this list still does not cover every single expressed idea about the origins of human bipedalism – it is merely a somewhat brief overview. Also, it is easy to notice that a number of existing hypotheses use similar reasons for the adoption of bipedalism as others, but sometimes with minor differences. Many scholars and authors tend to group different suggestions on the origins of bipedalism into several general frameworks, such as the "walking hypothesis", "postural feeding hypothesis", "ecology hypothesis", "thermoregulation hypothesis", "enhanced vision hypotheses", "wading hypothesis" and "provisional hypothesis."

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Most evolutionary hypotheses constructed to account for the appearance of bipedalism have serious shortfalls. For example, the hypotheses that connect the transition to bipedalism to a shift in environment to the savannah habitat cannot be correct as bipedalism started before this environmental shift. Bipedalism also started long before hominids started using tools. The male "provisional" hypothesis is based on a monogamous relationship between sexes which, in the light of available evidence, is unlikely to be true for our hominid ancestors. In the case of hominids needing to travel long distance, it is not clear why would they choose such an energy-consuming and slow mode of locomotion to use such as bidepalism. Supporters of the "wading" model fail to notice the fact that the areas in proximity to the river banks are the most predation-prone both from terrestrial predators (lions) and water predators (crocodiles). The more recent hypotheses for bipedalism which focus on male aggressiveness and the advantage in fist fighting also fail to explain why our ancestors were gradually becoming physically weaker if the selection was favouring stronger and more aggressive males.

My own suggestion for the origins of bipedalism is that bipedalism was merely one of the many parts of a grand survival strategy for early hominids known as **aposematism**. Although aposematism is mostly known among scholars as "warning colouration", it is much more than a simple colouration, and also contains audio, olfactory and behavioural signals. I prefer to use a more complex and more precise term: "Audio-Visual-Olfactory Intimidating Display". As the strategic aim of an aposematic display is generally to avoid unnecessary physical violence, the acronym which is produced by the above term, "AVOID", seems almost too much of a coincidence to take seriously.

The model of aposematism is so integral to this book that I was considering to title this book "Aposematic Model of Human Evolution." After some careful consideration I decided to acknowledge the importance that big cats played in our evolution, instead of merely acknowledging the strategy that helped our ancestors deal with the mighty ancestors of big cats and other predators.

Therefore, I believe that the origins of bipedalism must be explained through the principles of warning display (aposematism). Standing on hind legs, as we can remember from our previous evaluations of other aposematic species, is one of the most widely used means to rapidly increase body size in an aposematic display, and there is a vast amount of animals which utilise this form of warning display in tense confrontations.

The idea that human bipedalism could have originated from animal threat display is not new. We may remember from the list of ideas on human bipedalism that it has been postulated by a number of scholars during the last 50 years: Frank Livingston wrote about this in 1962, as did Roger Wescott in 1967 and Nina Jablonski and George Chaplin in 1993. Furthermore, according to Adriaan Kortlandt (1980) bipedalism was initially used for inter-species intimidating displays as well as standing upright and using thorny branches to defend themselves from large predators.

The largest issue that is pointed out by the critics of this scenario is that, in the animal world, the bipedal threat displays are only used for a few seconds – therefore how could this posture, maintained only for few second in emergency situations, eventually become the constant mode of locomotion? Bears can actually make a few bipedal steps, but they never became constantly bipedal, right? This is absolutely correct. In order to distinguish between bear bipedal steps and hominid bipedal locomotion, we need to remember that aposematic signals can be of two different categories: (1) temporary, used in critical situations only, and (2) constant, or displayed by the animal at all times. Temporary warning signals can be (and are) used by virtually all animal species (bears included), but constant warning signals are as a general rule used by aposematic animals only, i.e. those who try to constantly advertise their presence in various modalities. What our ancestors did was they turned a temporary warning/intimidating display into a constant aposematic feature. This was a revolutionary change, going from a temporary warning posture into a constant mode of locomotion, and one that indicates that our ancestors were finding the warning display a lifesaving strategy. Bears are not aposematic creatures - humans are.

For all animal species that are able to make several bipedal steps (from bears to African apes), maintaining this upright posture is quite difficult. Shifting to bipedal posture and maintaining this constantly was no doubt equally difficult for our primate ancestors as well. There must have been much stronger pressure for such a behavioural change to qualify through natural selection.

It might seem extraordinary to say this, but the original pressure that led our ancestors towards bipedal locomotion, that critical pressure from predators, is still present today. Do you want proof of this strange proposition?

If you search the internet for survival manuals on how to behave if you suddenly find yourself facing any big and dangerous animals (like a tiger, lion, bear, or a wolf), the most constant and important advice in the list of tips is to stay tall. Bending down, even for a few seconds, may cost your life. When I visited the Corbett National Park in January 2011, forest officials were hunting a man-eating tiger that had, by that point in time, killed two women. Both women, at the time of attack, were not standing erect. One of them was cutting grass and another one was answering the call of nature. Facts proving the importance of maintaining a tall bipedal posture for staying safe in the jungles come from many sources. From documental writings of Jim Corbett, Kenneth Anderson and their peers, who hunted man eating tigers and leopards, we know that Indian villagers were mostly attacked when they were cutting grass, collecting firewood, going to the toilet, or doing some kind of other activity which requires bending down and generally results in temporary loss of bipedal posture. Staying tall is still a potent aposematic signal, saving human lives in countless encounters with various dangerous animals.

On February 18th 1975 a terrible tragedy took place during a safari at the Namibia-Angola border. As a few cars full of tourists were viewing a pack of lions, against of all safety precautions a tourist came out of his car and walked up very close to the lions in order to film them from a closer range. It is difficult to

understand where exactly the tourist's common sense had escaped to when he left a car with his wife and two small children in it. There is graphic video footage on YouTube, filmed from another car, showing the tragic scene where the man is eaten alive in full view of his wife and two children. For several seconds the intrusion of the man in the midst of the lion pride is left unpunished, but the last straw that essentially provokes the attack is when the man crouches down. The man with the camera had crouched down to film the snarling male lion at a more effective angle - as soon as he went down to his knees, an unsighted lioness jumped on his crouched figure from behind.

I do not know whether staying tall would have saved the life of the tourist, but I am certain that when he bended down he severed all chances of survival. So remember, if you see a dangerous animal and cannot get to safety quickly, stay tall and you will have a much better chance of survival! If you do not look tall you are in danger – Because of this children are particularly vulnerable in the presence of big cats and it is advised to keep them in your arms. I am very grateful to Mr Soulemenn Kalee, a professional hunter from South Africa, who provided me (with the help of our common friend Kristof Kotecha) important information on why it is very dangerous for children to be next to big cats. Kalee has great experience in dealing with lion attacks on humans, and has also assisted Hajee Mackumboro, the chief ranger of the Selous park in Tanzania, in the hunt for arguably the worst man-eater of the 21st century, the lion pack headed by the notorious male man-eater "Osama". According to Kalee, a child's smaller stature (when the height is less than 140cm) ignites a lion's hunting instinct, and even hand-reared, disciplined lions can become dangerous when they encounter children.

From the evidence above it is obvious that predators would have provided strong evolutionary pressure for the establishment of bipedalism. Early hominids must have noticed that they were being attacked much less when they were staying tall, or more correctly those of our ancestors who were spending more time erect on two legs were attacked less and naturally outlived those who were moving around half crouched, similar to the evolution of other apes. In one way or another, staying tall and bipedal locomotion became a life-saving strategy for our distant ancestors. Staying tall still remains an effective strategy in encounters with dangerous predators to this day, and will remain so in the future.

According to ethnographers and contemporary ethologists (Schaller, 1972; Bertrand, 1972; Marshall, 2001), lions flee when they see even an unarmed human on foot. Brian Bertrand, who studied lions in the Serengeti the same time as George Schaller, wrote directly on this subject: "All my observations were made from a Land Rover, not for the reasons one might think but because lions in the wild are afraid of humans on foot" (Bertram, 1972:33), and also "If I had got out of my Land Rover and shouted out and waived my arms, the lions would have run off, for almost all wild lions are still afraid of humans on foot" (pg. 43). But it is a different story if a human crouches and loses the bipedal posture in the presence of lions and other dangerous predators. During a field experiment where two scholars, George Schaller and Gordon Lawther, covered on foot about 160 kilometres in the Serengeti, they encountered a number of lions, and "All the seven lion groups that we encountered

while we were on foot fled when we were at distances of 80 to 300 meters" (Schaller & Lowther, 1969:328).

The gradual shift to bipedalism must have taken hundreds of thousands, even millions of years, and also very importantly, the establishment of bipedalism must have eventuated while our distant ancestors were still living in the woodlands, well before they moved out into open grasslands. Bipedalism was **not** the *result* of our distant ancestors moving from the woodlands to the open savannah (as some theories of bipedalism suggest), but on the contrary **bipedalism was the necessary condition that allowed early hominids to move to open grasslands**. Our distant ancestors left the safety of the trees because bipedalism (and a number of other aposematic strategies which we will be discussing in the following pages) provided adequate security in a new environment where trees were not around to be climbed up in critical moments. Early models of human evolution were using the open African savannah as the only theoretical environment for early human evolution. We now know that all of the sites discovered in relation to early hominids (before 3 million years ago) seem to have been partially or fully wooded. No early hominids have been discovered to have been living in the open African savannah. The morphology of these early hominids shows adaptations for climbing as well.

Bipedalism was by no means the only new morphologic-behavioural means to look taller. I am sure that contemporary human morphology has several other important evolutionary developments that have made our ancestors taller and more visually impressive over time. Let us discus these evolutionary developments.

Long legs: Receipt of beauty and survival

Both male and female bodies are considered more attractive if they have long legs. This peculiarity of human taste does not seem to be connected to the influence of Hollywood film stars or the wide range of female and male models endowed with long legs. Our sense of beauty might seem independent from practical everyday needs, but often it is the practicality of certain forms and things that make them beautiful to our senses. Not everyone might agree with this Aristotelian understanding of beauty where the relationship between the beauty and virtue is crucial, but this idea certainly makes evolutionary sense. We can at least all agree that long legs are considered aesthetically attractive as well as having their practical advantages.

So let us ask a simple question: why do humans have such long legs? If you compare pictures of humans and our closest living relatives, apes, you will see that the change of proportions between the length of the body and the legs is striking. It is quite amazing how little attention was paid to this important morphological novelty,

particularly if we compare the number of works on this subject with the number of studies on bipedalism. Quite possibly for most scholars the link between bipedalism and longer legs was so obvious that they did not feel any need to explain it further.

The first and the most obvious answer for many readers would be that with the development of longer legs, humans became more efficient in walking and running. Sounds very logical, doesn't it? This would definitely be true if long-legged humans were better at walking, and particularly running, than our short-legged primate relatives - unfortunately this is not true. On the contrary, a chimpanzee, using its awkward knuckle-walking and running style, is much faster than even the best human professional runner. The development of long legs did not help our speed, but instead made us run slower.

Could the reason for long legs possibly be the cost-efficiency of long distance walking?

Herman Pontzer, an active researcher of human bipedalism, specially studied the importance of length of the legs for locomotive efficiency, and in a very recent publication of his he seriously questioned whether this factor affected the evolution of animal limb length at all: "Despite the importance of limb length in determining locomotor cost there is little empirical evidence suggesting that locomotor economy or limb length have been a primary target of selection in taxa that range widely. For example, despite their reduced digits and long metapodials, ungulates (artiodactyls and horses) are no more economical than generalized mammals... Similarly, despite the fact that carnivores travel an average of four times farther than herbivores each day, the cost of locomotion for carnivores is no different than that of other mammals, and limb lengths of carnivores are not exceptional; for example, a 25 kg goat and a 25 kg dog have similar limb lengths, about 40 cm. Within carnivores, average daily travel distance, is not correlated with limb bone length" (Pontzer, 2012:7).

Therefore, empirical evidence does not support the view that the length of the legs is a result of an evolutionary strategy for achieving further locomotor efficiency.

Could human bipedal posture have possibly been a more effective way of long-distance running? The story of an informal bet on who was better in long-distance running, a human or a horse, became a media sensation:

"Its originator was a Welsh pub owner named Gordon Green. One day in 1979 he got into an argument with an equestrian friend about the relative strengths of men and horses as distance runners. Green insisted a human could beat a horse in a long race, and to prove his point he helped instigate the marathon in 1980. For the next 24 years, he found himself losing the argument as riders on horseback left human runners behind. But then it finally happened — in 2004 a British man named Huw Lobb won. Three years later Germany's Florian Holzinger outran the horses, as did one other human contestant. The media loved it — a predictable farce had become a man-bites-dog story. Bookies were less enthused; they had to pay out on bets made at 16-to-1 odds favouring the horses" (Stipp, 2012)

American scholars Denis Bramble and Daniel Lieberman wrote in 2004 (pure coincidence with the 2004 man-vs-horse race upset) that humans can perform much

better as runners on long distances as opposed to short distances. Their argument on the efficiency of human long-distance running turned into a media frenzy and it was sometimes claimed that humans can outrun (over long distances) horses, dogs, antelopes and other animals known for running frequently (see for example, Remsen, 2011, "Elegance in running: How Humans can Beat Cheetahs, 2011). The new possibility that humans were long-distance runners who would follow their prey (for example, an antelope) until it could not run any more gained significant popularity. Some publications started creating an image of humans as champion long-distance runners.

Humans can boast of plenty of achievements, but running more efficiently than best animal runners is a bit of a stretch. Even if they win a race once in 25 years, this does not prove they are better endurance runners than horses or dogs. If we follow the thought process of the authors of some of the articles on this topic, humans can outrun all the animals on long distances, and the 2004 race is the proof. By the same logic we can come to the conclusion that Australians are better at soccer than Brazilians, because the Australian national soccer team won a friendly against Brazil in 2000. The authors are also neglecting the glaring fact that to have humans compete against horses on an even basis, you should possibly allow the horses to compete without having other humans strapped to their backs. Bramble and Lieberman's 2004 Nature Journal article was much more subdued and realistic about the use of this strategy for hunting than this "we are faster than any animal" media frenzy that arose later. In their 2004 Nature publication they concluded that "Although such demanding strategies have been occasionally documented among modern foragers…, they might have been too energetically expensive and low-yield for the benefits to have outweighed the costs."

I agree with the above summary of their 2004 article. Also, if we take into account that, after completing a marathon two to five hour run, successful hunters would then need to walk back all these kilometres that they covered in the long pursuit; if we also take into account that on their way back they had to carry the additional weight of the hunted antelope; and if we take into account that during their long walk back their cargo might have attracted predators, we can safely agree with the authors of the article in that there were just too many negative sides for this hunting strategy to prevail.

This strategy was possibly a desperate last measure in the open Kalahari Desert, where there are not many options for hunters and you do not see another animal for many kilometres. The strategy of scavenging must have been a much more viable option in the lusher Serengeti as opposed to the more desolate Kalahari. Bushmen themselves, if they see a scavenging opportunity, prefer to seize it rather following another running antelope to its exhaustion.

And still there is no doubt that humans are much more effective as stayers rather than as sprinters. I propose that, although early humans did not depend on their legs to get away from predators, their speed as long distance runners was still quite important to them. This speed was not however important for running down prey.

You probably know the old saying "time is money", but for our ancestors and other animal species that greatly depended on scavenging, this saying could be modified as "time is food." After the presence of a new kill was advertised in the sky by the vultures, our ancestors needed speed and endurance in order to reach the kill site as soon as possible.

Am I suggesting that our ancestors need longer legs in order to reach the kill site quicker? No. Locomotion is always more efficient when four legs are involved, and if only speed was paramount then our ancestors would not have been walking upright. To look at the true origins of our long human legs we need to recall the aposematic model that we were discussing earlier. This model proposes that one of the most popular ways to achieve more conspicuous visibility is to have a taller body size in order to be visually more impressive and intimidating to rivals and predators. One of the most obvious ways to achieve bigger body height is to have longer legs. I therefore suggest that the gradual appearance of much longer legs was connected to the same evolutionary strategy as bipedalism: it was aimed to look as high and visually as impressive as possible.

Not content with already unusually long logs, we (particularly women) try to prolong our legs and increase height by using awkward and sometimes ridiculous high-heel shoes. Our evolutionary fascination with long legged human figures continues – to the joy of fashion industry.

The mystery of the long head hair

We take for granted that humans have long head hair, often forgetting that it is one of our most defining unique morphological features. Very few scholars have paid attention to this mysterious addition to the human body. Unlike the length of human legs, which is universally considered better when proportionally long, head hair has very different shapes and functions. The cleanly-shaved trendy head of Yul Brynner, Jimi Hendrix's natural afro, the early Beatles mop-top and the highly stylized spike Mohawk hairstyle are only few of many hairstyle possibilities. Shaping one's hair in a different fashion has many functions, from altering physical appearance to the declaration of that person's group or cultural identity.

So let us ask a simple question: why did our ancestors develop to grow such large amounts of hair on their heads? This intriguing question has not been granted even a fraction of the scholarly attention in the studies of human evolution as bipedalism has; nevertheless a few very interesting and plausible ideas have been expressed on the topic.

Most importantly, Nina Jablonski suggested that it was evolutionarily advantageous for hominids to retain the hair on their heads in order to protect the skin there as they walked upright under the intense African sun (Jablonski, 2008). Sounds very plausible and convincing, but an unanswered question still remains: why would hominids (or early humans) need to have five-foot long hair to protect just their scalp? Many animals that live under the same burning African sun are

doing fine with a few centimetres of non-coiled hair covering their body and the skin on their head. Although Jablonski's idea does explain the presence of hair on the human head, it does not provide an explanation as to the extraordinary length of human head hair. It seems to me quite obvious that long human hair conveys some kind of visual information.

Desmond Morris suggested that overgrown head hair was used as a species-specific morphological sign for hominids, visible from afar (Morris, 2008). This suggestion also has its merits, as recognizing each other is an important element for any animal species. But herein lies another difficult question: why did our ancestors, who had such unique and visually distinctive morphological features such as bipedal locomotion, need yet another visual sign? Evolution is extremely economical, and if there are no important reasons for it then wasting energy on the growth of huge hair does not seem justified. What I like in Desmond Morris's idea is that it recognizes the importance of long human head hair as a visual signal.

To better understand the evolutionary function of human head hair, we need to remember two important facts about it:

(1) If left alone, untrimmed human head hair grows about 1.5 metres long. After this each individual hear falls out and gets replaced. I am specially mentioning this because in most scholarly reconstructions, our hominid ancestors look as if they just have walked out from a hairdresser, and the potentially very important visual signal is absent in these reconstructions.

Also, **(2)** most likely the initial style of hominid head hair was a tightly coiled bush of hair on top and around the hominid head, very much like the contemporary untrimmed "Afro" style that all peoples of African origin (including pygmies and bushmen) grow naturally. The long hair of our ancestors was not long and wavy like with many contemporary European rock musicians, but was forming a huge ball of hair like Jimi Hendrix.

My suggestion is that the unusually long hominid hair on top of the human head had the same purpose as long legs and the bipedal posture, and this purpose was to look taller. Of course, because of its coiled design, five feet long hair did not add a full five feet to one's body height, but it must have been worth about a foot of increase in body height. An untrimmed Afro hairstyle is several times as big as the diameter of a human head. Therefore, a huge ball of black hair must have been a significant addition to hominid body height. If you have a look at the tall military helmets of Napoleon hussars, or the colorful headdresses of the men of different tribes, you will see the perennial drive to look taller among human warriors (see the photos).

One more detail – when we measure human height, as a rule we do not include the hair on top of the head. I do not have any objections to this, but when it comes to measuring the height of our distant ancestors, the length of hair must be taken into account in the most serious way, as an extra foot would have added significantly to their relatively short body length, most probably saving the lives of many of our ancestors, and by extension – us, their descendants. For example, if the height of the

body of any of our distant ancestors was 130 or 140cm – but when taking into account the length of their most likely tightly coiled and untrimmed hair, they would have been about 160 or 170cm tall.

Of course, we have to agree with Nina Jablonski that the skin on top of the human head needed protection, and that head hair provided this protection. We may also agree with Desmond Morris that a huge ball of hair would be an effective species-specific visual sign. But I suggest that the primary evolutionary function of extraordinary long and bushy human head hair was connected to the strategically important drive to look taller and visually more impressive in order to intimidate rivals and predators.

Height-weight ratio (HWR)

The use of bipedal posture as a constant mood of locomotion, longer legs and a huge bush of hair on top of the head were a combination of highly effective visual elements, as all these three morphological features drastically increased the height of our distant ancestor.

The weight and height of animal species are naturally connected to each other, and we would expect heavier animals to be taller as well, but this is not always true, and humans are a great example of the deviation from the general correlation.

To be more objective, I would like to introduce a special ratio to quantify the correlation of animal height and weight, the Height-Weight Ratio (HWR). HWR is very easy to calculate – you just need to take the animal height (in centimetres), and divide it by the animal weight (in kilograms). The taller the animal (in relation to its weight) the bigger is the ratio. For example, a large male lion, weighting about 200 kilos, and as tall (with the raised head) as 140 cm, will have the HWR of 0.7 (140:200=0.7). Tigers are longer and heavier than lions, but male lions are taller than tigers (and remember, male lions are more aposematic!), so the height-weight ratio of the tiger is less than of a lion. For example, a large male Siberian tiger weighting 250kg can be as tall as 130cm, so it will have a HWR about 0.52. The African buffalo has the height of an adult human (about 180cm), but its weight is much bigger (up to a tonne), so a buffalo's HWR will be much lower. For example, a large 180cm tall male buffalo, which weights 800 kilos, will have a HWR of 0.225 (180:800=0.225). The African elephant is the biggest of the land animals, and although it is very tall (males reach up to 4 metres of height), they still retain a low HWR because of their huge weight (up to 10 tonnes). For example, a large male African elephant that is 350cm tall, and is weighing 5000 kilos, will have a HWR of only 0.07. Now for a stark comparison, an adult male human with the height of 180cm, and a weight of 80 kilos, will have a ratio of 180:80=**2.25**. A large male leopard, which weighs about the same as an adult human (80 kilos), and stands (albeit on four legs) at 90 cm, will have a HRW of about 1.125 (90:80=1.125).

Of course, animals of the same species come in different shapes and sizes just as humans do, so their HWR will have slight but largely negligible differences. A giraffe, for example, can be as tall as 6 metres, with its weight reaching more than 1500 kg. 600cm divided on 1500 kilos will give us 0.4 HWR (understandably higher than elephants). Some light antelopes can have their HWR even higher than humans. For example, the gazelle is about 60cm tall and weighs about 20 kilos, so the resulting HWR will be 3 (higher than humans). A large wolf as tall as 80cm and weighting about 35 kilos will have the HWR of 2.1 (very close to the human HWR of 2.25). In both the cases of the gazelle and the wolf, we have quadrupeds with a very slender body – the low relative weight is possibly connected to achieving a better running efficiency.

Humans, on the other hand, are very poor runners (although there have been some weakly substantiated suggestions they are very good as long distance runners). We have also discussed this topic later couple of pages ago and found that possibly the only time they needed to run was when they were rushing to a kill site to claim food.

Of course, such a crude calculation of the height and weight cannot be very reliable, but I believe HWR might still be a useful tool to keep a rough estimate of the correlation in height and weight in different animal species. In any case, we can definitely say that humans have an amazingly tall body for their weight. The average human weight is close to a leopard's weight, but their height is that of an African buffalo's. High HWR is in essence a very important characteristic if an animal needs to look as tall and as impressive as possible. The high HWR that humans possess was achieved during the human evolution chiefly by three above-mentioned factors (1) bipedal posture, (2) length of legs, and (3) five-foot long tightly coiled head hair. Here I must express my regret for following the tradition of not counting the length of human head hair when counting human height, although I did suggest earlier that untrimmed human head hair must be taken into consideration when overall human height it measured. Having a big ball of hair on the top of the head, a human's HWR understandably would be higher.

Our strive towards a taller body did not vanish in early human prehistory. As I have already mentioned, even today taller people have a wide range of advantages, from receiving less bullying during their school years, all the way to having better chances of winning a political election. With the appearance of clothes, high heel shoes and particularly head-dresses this perennial strive towards taller bodies has obtained an array of new outlets. Tall and more intimidating head-dresses and helmets been widely used in military campaigns, as intimidating enemies is an important psychological factor of any warfare. Tall military helmets, which, apart from the function of defence of the head from different weapons, also serve the purpose to make the wearer look taller and more intimidating to the opponent. Adding horns and other objects to helmets has the same intimidating function. Remember the ridiculously tall headdresses of Napoleon's Hussars and Grenadiers? Or think of the famous terracotta warriors, sculptures depicting the armies of Qin Shi Huang, the first Emperor of China. They all have a special hairstyle (usually by adding some objects to the top of the head) to make them look taller. The tall and

colourful head-dresses of the Native Americans, widely used during warfare, is another example of the use of different means to make a warrior seem taller and more intimidating. Sometimes even the hairstyle itself can be shaped to make a person look much taller: the well-known 'Mohawk' hair style, popular among some contemporary Punk demographics, originated from Native American tribal warriors, and has the advantage of greatly increasing the height of the wearer, making them visually much more impressive (see the photos 12-16).

Apart from the height, the very shape of the human body is ideally designed to make the most impressive visual impact. When we stand head-on-head in front of most of the animals, we see the animal's head, its chest, and the front paws. The shape of most quadrupeds is designed to make movement swifter and not for looks, so the quadruped locomotion helps the animal body to gradually acquire a streamlined shape. The human body is shaped strategically very differently from animals. Human bodies are shaped for taller and more impressive looks, not for the swiftness of movements. Take a matchbox and find the side where it looks the narrowest and shortest, the side that would be the best for the streamlined movement forward. This will be very close to the shape of most of quadrupedal animals. Now turn the matchbox upright and you get a frontal view that has the matchbox at its tallest and widest. This is very close to the shape of our human body in relation to the quadrupeds. Our body has long lower limbs, a solid torso which is stretched upright with wide shoulders facing with their wide flat side forward, and this already tall body is topped with a fully erect head placed on an upwardly-stretched neck, and there is finally the great bush of long head hair on the very top of the head.

If most of the quadruped animal body is shaped horizontally for more economical and swift movement forward, then the human body is shaped vertically in order to make its visual appearance as impressive as possible.

In conclusion, we have plenty of reasons to think that the evolution of human morphology was dominated by the perennial desire to make human body visually as impressive as possible. Bipedalism, long legs and long and tightly coiled hair were three central factors in looking tall. In a somewhat shameful history of human warfare these three factors were aided by ridiculously tall headdresses and special hairstyles making the appearance of warriors even taller.

But to look tall is not the only way to look impressive. There is one more very important factor that gives a more impressive look. We will be discussing this additional visual signal next:

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Colours! More colours!

Have you though why kings and queens as a general rule have such colourful clothes complemented with their shiny crowns? Or why Elvis had such colourful stage costumes? Or why many truck owners in India or the Middle East paint their trucks like a Christmas tree? Or why we are so impressed by a peacock's train? In all these cases the answer is simple: because bright and brilliant colours are much more attention-grabbing, impressive and beautiful than dull colours, and tend to stand out considerably more. Therefore if you want to look visually impressive, apart from increasing your size (for example by using a special hairstyle or an exotic headdress, or high heels) also try to use bright colours. This is the chief reason why aposematic animal body parts are often brightly coloured. Think of the brilliant colour schemes of the many venomous snakes, spiders and frogs of the world, such as the bright red colouring of the Central American Granular Poison Frog. You might say that comparing venomous snakes and spiders to members of the royal family and rock stars is not acceptable, but why not? Being visually impressive is as important for many animal species in their survival as it is for certain humans who want to make their social status and exclusiveness clearly evident. In evolutionary terms and reasoning, "impressive" means "useful". In human terms and reasoning, "impressive" means "beautiful".

"So what…" a reader might ask, "…human bodies are not colourful, so the display of colours has nothing to do with human evolutionary history!" This might seem correct at a first look, but do not jump to any conclusions. Unlike our closest living relatives, the apes, human ancestors were using various methods of aposematic display for millions of years, and despite naturally being deprived of the shiny colours that snakes, spiders and peacocks have in abundance, they still found ways with which to produce a stunning display of colours. In the next few sections I will argue that humans have two very different ways to achieve colours: (1) the natural way, which historically came much earlier (and was less effective), and (2) the cultural way, which came around later and is much more effective.

Colours of shame and rage

Have you even seen the face of any of your friends or relatives after they were ridiculed or offended, or were just possibly in an awkward situation? If you have a memory of such an unpleasant incident, you might also remember that in that moment the face you knew all too well suddenly changed colour and became red. We all know this phenomenon as 'blushing'. Some blush more and some less. Some people even complain that people do not blush today as much as they used to blush before, and attribute this to the gradual decline of morality in contemporary society.

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I do not know whether you yourself blush sometimes, or what your attitude is towards blushing, but if we are going to discuss human colour changes we definitely need to start with a few words about blushing, or the general reddening of the face in some awkward or conflicting situations.

There are two related, although caused by somehow different psychological mechanisms, conditions known as blushing and flushing. *Blushing* as a rule is related to embarrassment and *flushing* is generally caused by a rage. Reddening caused by flushing is more prominent than what is caused by blushing and also involves a larger surface area of the human body than blushing. To some readers it might seem that blushing is just a natural by-product of more active blood circulation, but in fact the reddening of skin is quite a complex phenomenon, involving morphological and physiological mechanisms from parts of our skin. We are not going to discuss face reddening caused by the use of alcohol and other substances.

The experience of blushing might cause distress - there are even people who seek professional help to fight their uncontrolled blushing. This help ranges from psychological advice to actual surgery (the surgical operation to stop blushing is apparently known as "endoscopic transthoracic sympathectomy").

Cross-cultural evidence shows that blushing (and flushing) is a universal trait of human physiology and its visibility directly depends on the bearer's skin colour. Interestingly enough, with people of a darker complexion the increased blood circulation causes their colour to get darker rather than becoming red.

In "The Expression of the Emotions in Man and Animals" Darwin mentioned blushing as 'the most peculiar and most human of all expressions' (1871:310). As uniquely observant person, Darwin paid attention to blushing much earlier, in 1938, when he was 29, by making entries on blushing in one of his notebooks. So what reason can be behind the phenomenon of blushing and flushing? Possibly blushing is an honest signal because it cannot be controlled? It is definitely in that sense, but due to the psychological scope of blushing, even a bluff question such as "why are you blushing" to a non-blushing person can also result in real blushing - a wrong accusation can cause an innocent person to blush and consequently lead to a wrong judgment.

Darwin's question as to whether blushing is a uniquely human behaviour still remains open. As recently as 2010, in a special article dedicated to blushing (Crozier, 2010), the author asked the same unanswered question: "Is it the case that it is a uniquely human expression?"

There are definitely plenty of animal species that do change colours for various reasons - but are these colour changes relevant to our discussion? In many cases there are no connections between these animals and our species, and also no connections between the behaviour patterns of these animals and humans. For example, we cannot consider human blushing and a chameleon's colour changing as related phenomena, simply because chameleons do not change colours because of excitement. A squid's ability to drop colours and create a "ghost copy" is also very close to the chameleon's "vanishing" technique. On the other hand, a sailfish changes

colours depending on the situation and mood. Interestingly enough with the sailfish, brighter colours appear in more aggressive situations. For example, when attacking prey, a sailfish's body becomes light blue with yellowish stripes. Another example of mood-related colour change is turkey. A turkey's head turns red when they are excited and ready to fight - there are some functional parallels here between turkeys and humans, particularly with flushing (reddening of face and skin in a conflict situation). Despite the similarity, the closest parallel to human blushing probably comes from a certain primate - the mandrill. Mandrills are the most colourful (and arguably the biggest) of the monkey family and their spectacularly bright face's colours intensify when excited or angry, very much like humans.

I therefore suggest that the change of colours, and particularly gaining a red colouration when excited or angry, is not a uniquely human behaviour. It is present in several unrelated animal species. Of course, it is unlikely that any of the animal species are blushing as a result of embarrassment, but human face reddening because of embarrassing situations is very likely a late development. A more pronounced reddening of the human face, known as flushing, is connected to strong negative emotions is most likely the ancestor of our embarrassment-related blushing. Flushing is often present when humans are in rage, and as a general rule flushing is present before humans resort to physical violence.

When discussing the reddening of face it is also important to note that the colour red, the most popular colour used by different animals to indicate emotions of rage and hostility, and as a result is the most widely used colour in warning and intimidation displays. I therefore suggest that blushing among our ancestors was in effect communicating the anger and readiness to behave aggressively if not left alone. It seems plausible to propose that blushing and flushing, as with most other aposematic signals, were designed by the forces of natural selection in order to warn antagonists and predators to stay away and as a result, avoid any unnecessary physical violence.

A change of colours can communicate very different messages and can serve different strategies and purposes. A sudden change of colour can be a cryptic move, aiming to make the animal unnoticeable, such as in the cases of the chameleon and the squid. On the other hand, colour changes can be used to make an animal more visually conspicuous and impressive - this is aposematic use of colours. In sailfish, turkeys, mandrills and humans, the quick change of colours is doing exactly this.

If we have a wider look in virtually all cases of colour changes, both cryptic or aposematic, they serve the same evolutionary function of survival of the species through avoidance of unwanted physical confrontations and injuries.

As we have discussed, blushing can redden our face and can certainly indicate changes in our mood, but apart from this naturally occurring reddening of the face our ancestors found much more effective means to alter their face and body colours in the most drastic possible ways.

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How old is the tradition of body painting?

If you Google "body painting", you will find an amazing variety of sites with plenty of artists, body painting patterns, and body painting festivals. Body painting is certainly a popular part of contemporary western culture, but its popularity is not exclusive only to the Western World. Body painting, like music and dance, is a universal trait of human culture. No human culture is known to be completely free of body painting. For many tribes body painting is an important part of their identity. Body painting in many traditional societies also signifies the status of a person or the moment of life they are experiencing – it also constitutes a very important part of initiation ceremonies in many parts of the world. Body painting was an important ritual for men going into a hunting session or to war. Women were also tattooed. Many readers of this book may also have some tattoos on their body. Apart from permanent body painting, like tattoos, there are many more temporary body paintings in use. Using a lipstick or an eyeliner pencil is so widespread that hardly anyone would consider them to be in the same category as body painting. So how far back exactly does the tradition of human body painting go?

Plenty of people know about the amazing paintings on the walls of the caves in Southern Europe, and possibly believe that these are the earliest paintings in the human history of arts. In an interesting twist, hundreds of thousand years before the estimated appearance of the first cave paintings, our ancestors were already using colouring materials – such materials have been found at several archaeological sites, although scholars have never found paintings of such an ancient age. The most likely explanation to this riddle (and one you can see coming by now) is that the first paintings were in fact done on their own human bodies. I am by no means the first or only person to suggest this. Some readers of this book, particularly the lovers of tattooing, may very well know already that body painting is most probably the earliest form of human art. Also, see for examples the following sentence: "Stone nodules containing mineral manganese dioxide, which has been scrapped with stone tools, have been found at several Neanderthal sites… As the Neanderthals have left no traces of pigment on cave walls or artefacts, the most likely explanation is body painting" (Mithen, 2005:230).

Well, even if we agree that the earliest use of painting materials was to paint bodies, why were the bodies painted in the first place?

Of course, just as everything else in human evolutionary history can be, body painting can also be also explained by the ubiquitous sexual selection model via the famed female choice. "Humans started using body painting as they were competing with each other for females so beautifying their bodies was a part of their strategy designed to get female attention." This not a citation, I just made this sentence up to generalise a certain viewpoint, but you can agree it sounds quite plausible to a degree. The only problem with this approach is that, according to this model, the only problem that our ancestors had when they descended from the trees to ground was how to attract choosy females, as if they had never before experienced problems such as defending from predators or finding food. If you seek an alternative

explanation for the tradition of body painting you do not need to go very far. We have already discussed how the strive to become more visually impressive became strategically paramount to our early ancestors. In other words, any physiological or behavioural changes that led hominids to acquire more impressive look (like bipedalism, long legs, long hair, blushing, or body painting) was giving certain hominid groups better chances of survival by intimidating predators and competitors more effectively. This approach places natural selection, not sexual selection via female choice, as the main driving force behind the tradition of body painting.

Scholars often complain that it is impossible to find artefacts of human artistic activity in archaeological records. Unlike vocal music, dance and language, which do not fossilize, there is a unique opportunity to have a glimpse into the artistic roots of body painting via archaeological records. I am talking about the remains of colouring substances most likely used for body painting.

According to the most recent article in the Proceeding of the National Academy of Sciences of the United States of America, the use of the most popular and most enduring colouring substance – red ochre goes, as authors suggest, has been in use "minimally" for 200-250 kya (kya = 1000 years) (Roebroeks et al., 2012). The users in this case were European Neanderthals, locked behind the ice sheets of ice age Europe. The use of painting substances among Neanderthals was doubted by scholars for decades, but growing evidence suggests that painting was widely used in isolated Europe much earlier than the appearance of anatomically modern Cro-Magnons. Here is an excerpt from the conclusions of the article: "Identification of the Maastricht-Belvédère finds as hematite pushes the use of red ochre by (early) Neanderthals back in time significantly, to minimally 200–250 kya (i.e., to the same time range as the early ochre use in the African record)" (Roebroeks et al., 2012). There are some indications that even *Homo heidelbergensis,* a much earlier, taller and muscular ancestor of the *Homo neanderthalensis* who lived in Europe 600-300 thousand years ago, also used the red ochre for about 400 kya. This evidence, although not universally accepted, comes from the Terra Amata site.

Let us now ask a very important question: is it possible that our ancestors used any other substances before their use of red ochre? I am talking about temporary substances that our ancestors could use to paint themselves before they found and started using durable substances like red ochre. The idea that colouring faces and bodies started long before the use of durable materials is not only plausible, but virtually unavoidable. What materials are we talking about? We are talking about readily available colouring substances, like some colourful berries, clay, even earth, and above of all, the liquid of life – blood.

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Colour of blood: The colour of life and death

It is difficult to find any other substance or object laden with so much symbolic meanings as blood. Blood is a universal symbol of life and death, a symbol of strength and relatedness, and a centrepiece of the mystery of sacrificial rituals and religion. Many of these symbolic (and real) meanings of blood came from the depth of human prehistory, and were possibly better known to our ancestors than to us. Unlike our ancestors, we mostly encounter fake blood only when watching action or horror movies. Our ancestors could, day-by-day, see how blood was coming out of a body, leading to the death of people or animals. Although I do not want to elaborate on this bottomless subject, I still want to mention to the reader a recurring scene I remember very vividly from my fieldworks throughout the 1980s in the Caucasian mountains. It is the scene of the village elder holding a blood stained dagger in his hand, drawing red crosses with blood on the foreheads of goats and cattle during religious rituals before sacrificing them to the deities and throwing their severed heads and headless bodies downhill. They consider themselves Christians, but the older-than-Christianity roots of these blood-rich rituals are very obvious. Cutting arms by adult unrelated males and mixing blood as a symbol of becoming 'blood brothers' is another widely known blood-related symbolic tradition in human cultures. It is also not accidental that the colour of blood, red, is by far the most popular colour used in national flags of the world.

I propose that blood, a highly effective colouring substance, widely available to our ancestors, was the very first colouring substance in the history of human art. The very first artistic creations (painted bodies and faces) were done most likely using blood. Red ochre, the earliest and the most popular durable painting substance in the history of human art, most likely substituted the use of real blood in history of body painting largely due to its resemblance to real blood. Among Indigenous Australians for example, in the most secret and sacred male ceremonies participants would extract blood from their veins, exchange it between participants and paint their bodies with it, however in less secret rituals blood was substituted by the red ochre (Lawlor, 1991:102-103). The term "blessing" actually comes from the old English term *blóedsian* which denoted the sprinkling of the blood of sacrificed animals. As the tradition of the Eucharist goes, the wine actually becomes the blood of Jesus for the worshippers to drink. Interestingly, at the Council of Jerusalem (about 50 CE) the apostles strictly prohibited Christians from consuming even a small quantity of blood. On the other hand worshippers were supposed to drink Jesus' blood in the mystery of Eucharist.

This deep symbolic importance of blood and the colour red in the animal world definitely comes from much earlier times than the origin of humans. Used in countless species of insects and reptiles, red is the leading colour for warning and

intimidating visual signals. The most venomous amphibians and insects are often coloured in bright red- there could be several reasons for such importance in the colour red for warning display.

(1) Red is the opposite colour of green, thereby making it the most contrasting colour against green tree foliage;

(2) By showing a red colour (colour of blood) an animal was possibly declaring it is ready to fight till the death;

(3) Possibly the red colour was working as a reminder to the opponent of its own blood and death;

(4) And finally, it is also possible that all of these factors were contributing to the strengthening of the message of the colour red as the ultimate warning colour of aposematic display.

The aposematic importance and qualities of body painting are quite obvious. Most tribal warriors, before they went into the battle, decorated their bodies with colourful paintings. Of course showing their allegiance to their tribes was an important part of these decorations, but another, possibly earlier function of the colourful display was to intimidate the enemy with colourful paintings and upsized additions to the warrior's body. One more important function of body painting, which we will discuss in detail in later chapters, was achieving a psychological unity between the warriors, reaching a specific "battle trance" where they were losing their individuality and were religiously dedicating themselves to the best interests of the group, up to the point that group interests were overriding the instincts of self-survival, making individual fighters ready to sacrifice their lives for a common goal.

In conclusion, I suggest that our early hominid ancestors, in a bid to look more aggressive and intimidating, apart from standing upright on long legs, sporting a huge ball of hair and making various sounds (which we will discuss soon in the audio section), were also colouring their bodies with different substances, primarily using red blood. When the red ochre was discovered, it became popular chiefly because of its close resemblance to blood, the symbol of life, strength and relatedness.

We naturally cannot answer the question of when our ancestors started using colouring substances, but we can safely say that the moment when one of our ancestors deliberately painted part of his/her body with fresh blood was the beginning of long and fruitful human artistic career. Also, it seems natural and even inevitable to propose that this must have happened much earlier than the first use of red ochre and manganese dioxide as painting substances. The human body painted with fresh blood was possibly the first artefact of human creativity.

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Clothes: For cold or for show?

Many readers would agree that the most effective means to change one's appearance is the use of clothes, or when put more broadly the use of external subjects covering one's body. We look out of the window to see the weather conditions and accordingly decide which clothes we should put on. Choosing clothes also depends on what occasion we are going out for, for example for shopping, swimming, work, going to the theatre, or going to a wedding. Choosing clothes also depends on some other factors, for example what transport we will be using - walking, public transport, or a private auto. Our ancestors did not have as many different occasions and activities as we do today, and they hardly had anything more than the odd piece of animal skin to cover their bodies with. The reasons and possible timelines of the first use of crude animal skin as cover by our ancestors is the central subject of our discussion in this section.

Clothes have gradually become a universal element of human culture, generating multi-billion dollar industries containing the production of fabrics in the factories all the way to fashion shows, models, and colourful magazines.

The question of when exactly clothes appeared in human history is far from being settled. Many scholars agree that animal skins and some other ready-made objects provided the first clothing for our ancestors. Scholars also largely agree that the study of the human body louse (more commonly known in its plural form: lice) is possibly the best way to study the appearance of clothing in human history. The reason for this is that human body hair cover is too scarce to sustain a steady louse population, so the use of clothes, or more precisely and importantly closely fitting clothes, is needed to sustain the lice. Scholars did genetic studies on human body lice, ultimately calculating the time that elapsed after human lice separated from its closest relatives, and then calculated the time separating the emergence of body lice from head lice.

According to the DNA study on human body lice, humans started using clothes about 100 000 years ago. For example, group of scholars from the Mark Plank institute (Ralf Kittler, Manfred Kayser, and Mark Stoneking) came to the conclusion that clothes appeared in our evolution together with the appearance of anatomically modern humans, giving a relatively precise date of 107,000 years ago (Kittler at al., 2003).

We should not forget that scholars in this publication are discussing the origins of closely-fitting clothes only. Regarding the timelines of the origins of loosely-covering clothes in human prehistory, we can only have a guess. The first clothes used were most likely animal skins, and their use was not connected to the appearance of lice, there is therefore no reliable method discovered thus far to find out more on the timeline of their appearance. At best we can only assert that the use of loosely-covering animal skins must be considerably older than that of closely-fitting clothes.

Let us now try to understand the most important functional question for our discussion: what was the primary reason for using the most ancient body cover (animal skins) by our ancestors.

The traditional approach to the origins of clothes is that they give protection from cold weather and other elements of nature. This explanation naturally feels correct, as we can hardly imagine our seasonal lives without different clothes covering our bodies, particularly when it is cold or raining (like at the moment of writing these words during an unusually cold Melbourne winter). And besides, what else could our ancestors have gained from wearing clothes?

Well, I propose that the initial use of clothes could have served three important functions. I will now discuss those three functions, all of them designed by the forces of natural selection to assist in the survival of our ancestors in confrontations against the predators (including the ancestors of lions), in aggressive scavenging situations, and also during possible conflict with other hominid groups:

(1) Visual intimidation based on the effect of unusual appearance.

Animals with a changing visual appearance as a rule trigger neophobia (fear/distrust of animals or food with an unusual appearance) in predators, and as a result are more likely to be left alone (unless, as we discussed earlier, the predator is too hungry);

(2) Deflection in case of a predator attack.

In the critical moments of a scavenging confrontation, if the hominids' audio-visual intimidation was not working and the lion went into a real attack, hominids and early humans could throw their loosely covering animal skins at the attacking lion. Such a simple and seemingly ineffective action can save lives, as it can break the big cat's attack and allow time for defensive action. For example, when the legendary Jim Corbett was filming wild tigers from a dangerously close range (up to five feet) he used to take a small pillow just in case any of the tigers attacked him. Throwing a pillow at the attacking tiger (or lion) might seem crazy and pointless, but it can break the attack and give some time for counter measures. Corbett biographer D.C Kala also provided some interesting information on this account. According to Kala, Corbett "on occasions did use his hat to break the charge of a wounded animal in high grass. He found the method useful" (Kala, 2009:71).

(3) Psychological transformation of those who were going to challenge the lion pride (or fight against other hominid groups) and chase big cats from their own kill.

We have only mentioned, but have not yet discussed, a specific altered state of consciousness which I call the *battle trance*, one where humans do not feel fear or pain. This state can be induced by rhythmic drumming, singing, stomping, dancing, as well as by changing the appearance of the participants, a method that helps in obtaining another, group identity. This change of appearance was done by the use of body and face painting, as well as with the use of specific clothes.

I suggest that these groups of hominids and early humans, who were loosely covering themselves with animal hides during scavenging confrontations, would have been more successful with their unusual appearance than other, naked groups. I suggest that these three factors (visual intimidation, deflection, and psychological transformation) were crucial for the early establishment of the use of clothing in human prehistory.

My suggestions on the visual and psychological importance of early clothing do not necessarily contradict the traditional idea of clothing being a defence from weather conditions. I hope we can all agree that clothes could have served both of these functions in human prehistory simultaneously, as they do today. I however still maintain that the intimidation and psychological transformation was the earlier and primary function for the early emergence of clothing, and that the weather factor came later. Let me explain:

There is a very important difference between these two possible functions of clothes (visual-psychological and cold weather). Clothes as a defence from the cold weather would have become important only after our ancestors moved to other geographical areas with colder climates. On the other hand, clothes as a part of an intimidating strategy would be beneficial from the moment our ancestors descended from the trees onto the ground, a time when our ancestors were still living under the hot African sun. They needed to employ all possible means to better intimidate predators and other human groups as soon as they were down on the more open, competitive ground. Let us all recall the traditional visual appearance of some African tribes living in the hot conditions of equatorial Africa. They spent most of their time without much clothing (as humans do not really need clothes in hot conditions), but when they were preparing to scavenge lion kills, or for warfare, they were putting on visually "screaming" clothing accessories, like tall headdresses and other light but colourful details of outfit. These tall headdresses and colourful pieces of clothing were not designed for defence from the elements or from predators - they were solely designed to make the hunters' and warriors' visual appearance more intimidating and thus more effective.

I therefore propose that our distant ancestors started using clothing items initially for increasing their apparent size and visual representation during confrontations with predators and other competitors. It was only later that they had moved out from sunny Africa to other areas with colder conditions, ensuring that clothes became important also as life-saving protection against the cold weather and other elements. Therefore, the closely fitting clothes were most likely a result of requiring weather protection. When I was discussing the possible function of deflection by throwing animal skin at attacking lions, one more point came to mind: The earliest loosely-covering clothing was arguably more convenient for this purpose than the later, closely-fitting clothes that gave our ancestors warmth and the breeding populations of body lice.

I propose that the earliest style clothing, loosely covering body animal skins, appeared while our distant ancestors were still living under the hot African sun. The initial function for human clothing was for an effective appearance rather than

defence from the elements (I think many fashion designers would be happy to hear this). Later, when archaic humans moved out of Africa to colder environments, the function of clothes changed and the defence from cold weather became an important and eventually leading function of clothing. Therefore the appearance of closely fitting clothes (and as a result, the uninvited companionship of body lice) must be connected with the later stage of human evolution after our African ancestors had moved from sunny Africa to much colder regions of the world.

Behind the mask

Last but not least, we need to discuss at least briefly the ultimate way to change and conceal the identity of a person: the use of masks. The use of the body painting and clothes can definitely change the appearance of a person, but possibly the ultimate way to conceal oneself is to wear a mask. In many societies, a mask (which was traditionally designed as a device that covers a human face only) was used together with other materials which would cover the whole body of the masked person.

Like the tradition of body painting or the use of clothes, a mask is a virtually universal part of human cultures across all continents. From the members of isolated tribes from the Amazon rainforest and the masquerades of West African tribes, to the masked carnivals of ancient Rome and Venice, contemporary carnivals of Brazil and the masked parties at Halloween in western countries, humans use masks for various reasons: for ritual practices, for theatrical performances, for medical protection against viruses and hazardous substances, for concealing identity of both criminals and law enforcement agents, and for various sporting games. Masks may depict animals, gods, spirits, ancestors, mythic dragons; they can be funny but they can be also extremely scary. Masks universally maintain their power and mystery for both their wearers and their viewers.

And of course, very importantly for the subject of our discussion, masks were and still are widely used in combat situations, by gladiators in ancient Rome, by Japanese Samurai, by professional wrestlers on American TV, and by special combat forces, to mention only a few. As some readers may have already guessed (and some possibly noticed before reading this), many of these masks, particularly those designed for combatants, apart from protecting the face and head of the combatant, were also serving the function of intimidating their opponent. Apart from this, masks possess possibly the greatest power to change the wearer's identity and alter the wearer's psychology. In many cultures the ritual wearing of masks is believed to transform a wearer into an animal (or a god, or a spirit, or a predatory beast). Masks can free humans from the boundaries of culturally expected norms and behaviours. Oscar Wilde once said, "Give a man a mask, and he'll tell you the truth." When Bob Dylan wanted to perform some of his most personal songs, he was putting masks on his face. When we are covering our faces with masks, we are possibly freeing

ourselves from the lifelong mask of culturally expected norms of behaviour that we live with perennially.

Regarding the origins of the tradition of the use of masks, we do not have such indicators from human prehistory as, for example, the presence of red ochre for the study of body painting, or the emergence of human body lice for the study of the origins of clothes. On the other hand, the universality of masks in human cultures and its continuing emotional strength on humans from very different cultural backgrounds suggests that masks must have been a very ancient development - they were possibly even part of the original set of cultural traditions that our human ancestors took from their African cradle.

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With the discussion on the evolutionary reasons for bipedalism, long legs, long and tightly coiled head hair, blushing, body painting, clothes and the use of masks we have finished our discussion on the visual elements of the intimidating displays of hominids and early humans. We can agree that our distant ancestors had an array of techniques with which to make their appearance more impressive – and more intimidating torivals and predators. We are now going to discuss the audio signals that were used by our ancestors in order to intimidate predators and competitors.

Audio Aposematic Signals

For some reason audio warning signals were not as readily noticed by scholars of the theory of evolution as visual signals were, but we must stress that audio signals are no less important for aposematic display than visual signals.

A reader might remember my claim from the earlier parts of this book that humans are possibly the noisiest species on our planet. We make plenty of sounds, and we love to hear lots of sounds around us. Although we often complain that we are tired of noise and crave silence, absolute silence is unbearable to us. This is the reason for the scenario you can find in many contemporary human households, in which a TV or radio is switched on although no one is actually watching or listening. This hatred of silence is also the reason why we start talking to ourselves when we are alone.

Throughout our lives we sing, talk, play musical instruments and listen to iPods, CDs, TV, and radio. We move body parts and dance under loud dance music; we take part in noisy religious rituals. In some cultures we even feel awkward to spend a few seconds together with other humans without talking to them. Of course, it would be naïve to think that we became such a noisy and chatty species only recently - we have been noisy since very far back in our evolutionary past. For example, we may remember that we are a unique species because we are the only

terrestrial species who sings (new research suggests the male mouse might be another unique species with complex vocal apparatus and the ability to sing and learn new melodies - see Goldman, 2012). We are also a unique species within the animal kingdom as we have a sense of rhythm and can be entrained in group rhythmic chorusing and dancing. For our four legged friends, pet dogs and cats, we must be quite exhausting due to our constant noise output, both mechanical and human. It is no accident that we have, over time, made our domesticated animal friends more vocal than their wild counterparts.

Humans love making and listening to sounds, and we will have plenty of things to discuss in this "audio" section as the primary expertise of the author of this book is that of human choral singing - so let us get ready for a long and noisy discussion.

The very first thing we will be discussing regarding the noisiest species of our planet is... silence!

Silent killer

Let me ask you a simple question: How long do you think you could you stay in a totally silent and dark room for the sake of a scientific experiment and possibly some reward? Could you stay for a couple of hours? More? Or possibly just until you get too hungry or thirsty? What if you are given food and water as well – could you last for a couple of days, even weeks?

The answer to this question is quite precise: even the toughest humans can withstand total silence for only up to 30 minutes. Most participants ask to stop the experiment after only 5-10 minutes. Such an experiment had been organised for a few years by the personnel of the famous recording studio, the Sound 80 Studio in the Orfield Labs in Minneapolis. Guinness book of records mentions this recording studio for two of its characteristics, (1) as the quietest place on earth, and (2) as the oldest digital recording studio in the World. Bob Dylan famously recorded half of the songs for one of his best albums, 1975's "Blood on the tracks", in this studio. The album's lyrics are mostly about loneliness and heartache, and there is possibly no better place on earth to give you a true feel what loneliness is than the studio in Minneapolis - the quietest place in the world.

"Experiment" is actually a very strong word for the informal and friendly wager that the Orfield Labs employees were organizing for a number of years for volunteers. The conditions of the game did not seem too difficult, as one only had to spend 45 minutes alone in the studio. There was also a trophy for the successful contestant – a crate of beer.

If the conditions seem to you not so difficult, you should know that despite the great number of volunteers, not a single contestant lasted more than 30 minutes. If you think you could have done any better, you are probably mistaken. Most tellingly, you should know that the "experiment" was banned in 2011, after one of

the attempts ended up like a scene from a horror movie. After staying in the closed studio for an impressive 26 minutes, a contestant emerged from the studio and, to the shock and horror of everyone, apparently had started eating his left hand.

What the hell could be happening in a closed and totally silent and dark studio without any real danger to drive a contestant to such an insane and horrible outcome? Nothing supernatural. However something strange happens as soon as a person is left in a total silence. All the sounds of our body that we do not usually hear, such as heartbeat, breathing and the movements of eyelids increase and keep increasing until they are akin to a train passing by your bedroom window. Apart from this, in total silence ears start to generate sounds, like ringing. We soon lose our feel of space and orientation, lose balance, start hallucinating, and most importantly, a terrifying panic attack gradually overwhelms us.

So the next time you hear complaints about the inhuman conditions of inmates sitting in an isolated prison cell, you should know that these are in no way exaggerated. Total silence is one of the worst things that can happen to a human being. Of course, no prison cell is built as a sound proof recording studio thankfully, but being in a relatively silent place for a long time is still devastating for the human psyche.

We can survive without food for about 2-4 weeks, we can survive without water for a few days, but we cannot survive without noise for even half an hour. Only our need for breathing fresh air is more urgent that our need to hear sounds around us.

This is the first most important thing I would like the readers of this book to remember: humans are not built to withstand silence. Silence is a killer - In total silence we literally go crazy, start hallucinating and can end up gravely damaging our body like the poor fellow who started eating his own hand out of desperation. In the next section we are going to discuss what evolutionary reasons could have designed such a strong human dependence on constant sounds.

Avoiding silence – the mystery of contact calls

Many social animals make constant sounds when they are in a group. These are not special calls, but rather haphazard sounds accompanying their everyday business, for example, foraging. Chickens make clucks, baboons make soft barks, wildebeest make grunting sounds, and wild horse and cattle herds also make clearly heard, random and seemingly pointless sounds. Charles Darwin was the first to notice that some herd animals were communicating danger to each other without actually making any alarm call. He wrote in his 1871 book: "Wild horse and cattle do not, I believe, make any danger-signal; but the attitude of any one of them who first discovers an enemy, warns the others" (Darwin, 2004:123). Darwin did not explain what kind of "attitude" he was referring to - so what could it be? It is of silence. In a herd of constantly grunting, clucking, and snorting animals, when one of the herd animals notices any sign of potential danger, instead of giving an alarm call the

animal stops moving or making sounds, keeps silent, and keeps looking in the direction of the potential danger. Neighbouring animals quickly realize that someone next to them has stopped making noise, and they follow the first animal by stopping and carefully watching in the same direction. This spreads like a chain reaction and within few seconds the whole herd is silent and peering in the direction of the potential danger.

Schaller noticed how wildebeest communicated to each-other about danger in the form of their mortal enemy, the lion, using silence: "Wildebeest may stop their incessant grunting when a lion approaches, thereby creating an area of silence which is as effective a stimulus contrast as an alarm call, particularly at night... There is no difference in behaviour toward a lean or gorged lion" (Schaller, 1972:234). In this case also, the signal of danger that is communicated upon the appearance of a lion is silence.

So, seemingly haphazard background sounds that are heard when social animals are going on with their everyday business is not really the "unnecessary audio luggage" of a social animal's groups. These sounds are apparently an extremely important and interesting phenomenon. These sounds are known to scholars under the term "contact calls." Contact calls have two very important functions:

> **(1)** When social animals hear this background sounds they know that they are among their kin and that there are no predators and other dangers around - they can relax;
>
> **(2)** Social animals can communicate the signal of danger by stopping making contact calls. "Hearing" silence around instinctively means danger for many social animals.

The same phenomenon is well known to some bird species. For example, according to Wickler, "in some species of babblers, one member of the group remains perched above the ground with the rest of the group feeding below. After some time, the individual is replaced by another group member who will take over the role as the sentinel. Coordination of vigilance is regulated acoustically: about every five seconds the sentinel produces a low-pitched, short range, and difficult to locate call, the watchman's song, which informs others that the individual is watchful and that nothing has happened" (Wickler, 1985; cited from Uster and Zuberbuhler, 2001:754). When the birds can hear the "watchmen's song", they know that there is no danger around - but as soon as the sentinel notices a danger, it stops producing the song. Foraging birds produce and receive the signal of danger without making or hearing an alarm call, instead using an "alarming silence."

Remember this profoundly important note: **for social animals, silence is a sign of danger**.

Humans, as we know too well, are highly social animals. The millions of years of interdependence between group members for survival created a firm connection between hearing noise emanating from group members and a feeling of relaxation.

Just like it is with other social animals, for humans silence is also an instinctive sign of danger - this is the reason we cannot stand silence, the reason many of us start talking to ourselves when we are alone, and the reason we commonly have TV and radio on although no one is watching or listening. Although we know that we are safe at home behind closed doors, or in the historical recording studio where Bob Dylan recorded some of his best songs, we are still overtaken by a panic attack.

Let us now ask a different question: do humans have any special sounds that could work as contact calls? I believe we do.

Humming as contact calls

As we all know, humans can hum. This vocal behaviour is so ubiquitous and so natural that, as often is the case, we largely fail to notice it. According to the results of my preliminary searches, there are no scholarly publications discussing this particular universal element of human musicality.

So, let me ask a few "humming" questions – Why do humans hum? When do humans hum? And most importantly for us: could humming have (or had) any adaptive value in human or hominid life?

Of course, there is always at least a theoretical possibility that there are some humans who have never hummed in their lives, but it would be quite safe to say that most humans hum at least occasionally, and that there are also a few who hum almost constantly. As far as I remember, my late father was from the latter category. He was humming while reading the newspaper, walking, thinking, playing chess and even while eating. As Bernadette, a 14 year old student from Mercy College in Melbourne told me, she hums during almost every activity. "But of course, I cannot hum at school during my classes," she told me with regret, "as it would be embarrassing… So when I am attending classes, I only hum in my head" (from a conversation on May 30th, 2008). I am sure Bernadette is not unique among humans in her love of humming and her frustration at not being able to hum in as many situations as she would like to. Jeff Titon, a prominent American ethnomusicologist, answering my question if he ever hums, told me that he does, although he only hums in his head (personal communication from October 25th, 2007). I guess the reason for this kind of "silent humming" or "singing in your head" is largely drawn from a concern for the etiquette of behaviour in human society. Another prominent American ethnomusicologist, Tim Rice, also belongs to the category of people who hum most of the time. "When he is at home, he is usually humming, whatever he is doing." His wife Ann tells me. "One day he came back from the University and I noticed right away he was not humming. I immediately guessed something was wrong. I asked him and he said they had had a very unpleasant meeting at the faculty. After about an hour I heard him humming again, and I guessed with relief that he was over it and was feeling fine again" (from a conversation on February 14th, 2008).

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There is no need to discuss the many cases of people humming when they're feeling good - the readers of this book would know this very well for themselves. Some might even be humming reading these words (if they enjoy reading, of course). It is not so easy though to notice when we are humming, as with most of us humming is more of an unconscious behaviour. An informal survey conducted by London Zoo (with only 450 participants) in March 2008 found out that 67.7% of people hum when they feel very good. People hum along when listening to music, walking, driving a car, even hum while eating (so my father is not alone), and one even when having sex (Humming makes you happy, 2008). The uniting feature for all these activities is that all these are generally pleasant activities.

Humming can also be used to induce negative feelings. As one of my students confessed "I sometimes hum to annoy my older brother…" The same London zoo survey found out that humming by others can also annoyed listeners (important detail: particularly if humming is out of tune).

"Humming" or "humming alone" in colloquial English means "everything is going very well", so the phrases like "keep your refrigerator humming" or "Keep your system humming" (from the ads of mechanical services on the Web), or "Apple keeps humming" (the title of an article about a particularly successful year for the Apple Company) are understood by readers without any trouble. Humming was routinely used instead of clapping as a sign of public approval of a performance or statement in Britain up until the 18th century. In contemporary British slang though, humming can have negative connotations (e.g., "That is humming" means "that smells bad"), but generally the positive meaning of "humming" cross-culturally is overwhelming. You might have noticed how often we use the hum "uh-huh" or "mmhmm" when talking to each other (particularly on the phone) to convey our agreement and approval to the person on the other end of the phone.

Whistling, finger drumming, teeth drumming and musical worms

Whistling is another very interesting and similarly neglected universal human behaviour that is often used with the same symbolic meaning as humming. "Whistle a happy tune" is not only a well-known phrase from the musical "King and I," it is an important psychological tool in order to feel more confident and improve your life. Saying "whistling in the dark" is a well-known phrase implying that whistling has the positive power of improving the mood of a person who is in an uncertain situation.

Whistling in many cultures is considered to bring a bad luck, evil spirits, snakes, and other undesired visitors, but the desire of many fellow humans to whistle seems to be another means to avoid loneliness and killer silence.

Still another interesting means to avoid silence and be engaged with music is finger tapping. My professor Grigol Chkhikvadze was known among colleagues for almost constantly drumming his fingers. Well, drumming with fingers is considered a bad habit and some workplace manuals prohibit this, citing it as a rude way to tell

someone you are bored and not interested. Possibly a more interesting and more widespread way of drumming is teeth-drumming, or playing various rhythms by your own teeth. The big difference from other forms of drumming is that teeth-drumming is mostly heard to the player only, therefore it is socially more acceptable. If a proper study is conducted we may very well find out that teeth-drumming is the most widespread form of drumming. Dave Grohl (former drummer of Nirvana and later front-man of Foo Fighters) does not seem to be the only teeth-drummer among famous rock drummers. Ringo Starr, who was known for his constant drumming on any available subjects from his early childhood, is most likely to be another rock-star teeth drummer. Interestingly, although on the internet there are plenty of places where this phenomenon is discussed, to my knowledge teeth drumming has not been granted any scholarly attention.

Humming, whistling and finger or teeth drumming are mostly unconscious behaviours, and when I inquired among Melbourne University students, I surprisingly found that large number of students (about 20%) had previously got into trouble during a test or exam because of their unconscious singing, humming, finger drumming of whistling.

There is one similar field though that has received plenty of attention. This is the well-known phenomenon of when a song tune gets stuck in our head for a long time, sometimes to our annoyance. This phenomenon, known under the term "musical worms," is known from the writings of Edgar Allan Poe, Mark Twain, Arthur Clark, and also to a number of scholars, including among others Theodour Reik, Oliver Sacks, Daniel Levitin and Peter Szendy. According to some estimates 98% of humans experience this phenomenon.

And of course, the relatively new and rapidly progressing sphere of musical therapy is entirely based on our desire to hear relaxing and soothing sounds around, particularly when we do not feel well for any particular identifiable reason.

It seems to me that the positive communicative functions of humming, whistling and drumming are quite obvious, and I doubt I have said anything too unexpected to the reader of this book - but I do suggest for them to pay attention to the manifestations of our need to constantly hear musical sounds and rhythms around us.

Mystery of swan song

People singing when they are in critical situations of life is another strong indication of the healing power of singing and humming. Legendary Georgian mountain climber Mikheil Khergiani was known among his friends to start singing a particular traditional song from Svaneti, his native region, when he was in a desperate situation with imminent death. This habit saved his life at least once (to find out what happened you can see my article "Music and Human Emotions: Humming in Human Prehistory," freely available on the internet). After his second cardiac arrest, my favourite Georgian writer, Nodar Dumbadze, asked his friends to

sing a song together with him before his death. William Blake, the author of the immortal "Tiger", also sung while feeling the approaching death. Charles Darwin's biggest life heartache, the death of his beloved daughter Annie, also provides a sad example of people singing (or trying to sing) when feeling desperately bad. Possibly feeling the approaching death, Annie made two attempts to sing just few hours before her untimely death at the age of 10 (Desmond and Moore, 1991:383).

The possible psychological benefits of hearing music for a dying person are difficult to refuse. Therese Schroeder-Sheker began using music in care for the dying in Colorado in 1973 (from 1992 the same project now operates in Montana). She proposed the special terms "music thanatology," "music vigil," and "prescriptive music." On the other hand, the singing behaviour of humans before their death and possibly in other critical situations, as far as I know, has never been studied. Possibly someone who reads these words, who will be sufficiently fascinated by this phenomenon, will have enough time and patience first to prepare a time-consuming grant application, and then to gather information on this somber but potentially very important topic.

You have possibly heard the term "swan song." This saying comes from the popular misbelief that swans sing before their death. According to ornithologists, swans do not sing before their death - they basically never sing. Pliny the Elder was possibly the first who refuted this misbelief in the 1st century AD. Well, we are certainly quite good masters of ascribing our feelings and behaviours to others. For another similar example I can mention that ostriches do not bury their heads when in danger. Therefore, although swans do not sing before their death, we humans, or at least some of us, have an instinctive desire to sing or hum when feeling death approaching, and this possibly make us feel better prepared for the mysterious transition.

Several practical suggestions: Why and how to avoid silence

Our constant need to hear sounds around us in order to feel relaxed gives me grounds to make couple of practical suggestions. The first suggestion is for the educators, and concerns how we conduct exams. Exams, as many would expect, are conducted strictly in silence, and no one is allowed to make any sounds. When I enquired among my students on this subject, quite a few of them confessed that this silence is "clinical" and the resulting atmosphere causes them feelings of anxiety, fear and sometimes causes a panic attack. Many of these students were very good students, and their fear was in no way connected to their fear of exam questions. Let us think about this - I suggest education psychologists to investigate this subject, and if the research shows that a big part of the unnecessary anxiety and fear during exams is connected to the silence in the exam room, I would suggest for them to create a more humane and thinking-friendly environment for students during the exams. For example, students could have the choice to do their written exams in two different rooms, one traditional silent room and another room with soft music (or

even a pre-recording of birds singing) playing in the background. Another, possibly better option would be to allow students to have personal music listening devices during exams.

Educationists will most likely dismiss my suggestion, but I hope there will be at least few readers that were terrified many years ago by a clinically silent exam situation, and will try to improve the psychological state of students of next generations during the most critical and feared moment of their educational life.

Another practical suggestion regarding silence came to me after reading a thought provoking article on the internet, which suggested that the usual words that police must use as a part of their arrest procedure, strongly suggesting those in custody to remain silent and that anything said can and will be used against them, are in fact quite inhumane. I hope we all agree that if you are arrested by the police, this is one of the most negative and shocking moments of your life - As a result of your anxiety, you naturally want to be vocally active, say something, express your feelings, or ask questions. You do not want to be in silence. Taking someone in custody and virtually forcefully silencing them increases the fear and anxiety of the arrested person. Justice should be just, but not necessarily cruel, particularly if we remember that a person that police suspects for criminal activity may later be found to be innocent of all charges.

Basically any place or situation that is potentially fear-inducing will induce more negative feelings if the place or situation is surrounded by an eerie silence. I remember very well how much I feared my visits to the dentist, and to my great relief I later started visiting a dentist I personally knew, and I could ask her to put on my favourite Beatles recordings during the treatment. I felt much better when hearing music than I did sitting in silence and hearing, with my exaggerated audio sensitivity, only the creepy and ominous sounds of the medical equipment. It is a pity that even in the progressive Australia, when I go for regular blood check-ups and ask nurses to put some music on while they are extracting blood from my vein, they repeatedly tell me they do not have any equipment to do this. At the same time they know that some patients feel bad and sometimes even faint during this simple procedure, and that's where I suggest that hearing background music might help. After all, if we already know that hearing music helps those who are afraid to go into lifts, why should it be any different for medical patients - after all humans usually fear visiting dentists more than entering lifts…

Vocal grooming, choral lullaby, and elevator music

Taking into account the intensely social nature of a whole human life on one hand, and the fact that humans are arguably the noisiest animals on earth on the other hand, it seems natural to suppose that the universal human habit of humming was routinely accompanying most of the everyday group activities of our distant ancestors. Humming was the ancient hominid "contact call" for our ancestors and retains the same function for contemporary humans. The fact that humming today is

a universal expression of our positive feelings suggest that the positive message implicit in humming is not a late cultural development, but instead has a very deep biological, innate basis. Hearing humming just tells us that everything is fine and we can relax - this simple message is especially important if you live under a constant threat to your life. Later we will discuss the opposite musical phenomenon, loud and emotionally rousing singing coupled with drumming, stomping and threatening movements. We will discuss the importance of this kind of rousing intimidating display and the role it played in interactions with big cats, but we should not forget about the soft and difficult-to-notice humming which still plays an important role in everyday human life both in pre-literate and technologically advanced societies.

In 1993 Aiello and Dunbar proposed a very unusual and attractive idea about the origins of language. They proposed that after the hominid contingent had grown, the initial function of the social cohesiveness via scratching each other's back, or physical grooming (very popular among primates, including apes) was replaced by a "vocal grooming." The phenomenon of humming and human contact calls fits in perfectly with the notion of "vocal grooming" suggested by Aiello and Dunbar. The idea of humming as a social bond between humans also fits the idea of the importance of the mother-infant interaction in human evolution proposed by Ellen Dissanayake (Dissanayake, 2000).

We have already mentioned how people sometimes try to sing when they feel death approaching. On the other end of life, and particularly after mentioning of the work done by Ellen Dissanayake, we must remember that we have the innate need for soft soothing humming from the moment of our birth. I am of course talking about one of the universal elements of human musical culture, the lullaby - sung by parents (mostly mothers) to their babies from a very young age. A lullaby is mostly hummed or sung softly, and fits perfectly with the model of soft and soothing sounds designed to relax a young baby. The innate basis for the preferences for lullabies in infants has already been proposed (McDermott& Hauser, 2005:33-34). Soft soothing music has also proved to be a helpful aid in the care and development of medically-fragile hospitalized newborn infants (Shoemark, 2012).

The idea that the lullaby is the natural descendant of the ancient human contact calls gives a very different perspective to the origin of the lullaby. As humming sounds were most likely present in hominid groups during various activities, hominid and early human babies were most likely falling asleep while hearing relaxing group humming sounds rather than the solitary sounds of their mothers. In popular culture lullabies are naturally connected to solo singing, as in contemporary cultures lullabies are sung by one person, usually the mother – but this could have been very different in our prehistory. For some readers the idea of "polyphonic lullabies," sung by a group, might sound crazy, but as a matter of fact they are not so rare. In many African and European cultures with vocal polyphonic traditions there are indeed polyphonic group lullabies (see, for example, Kalandadze, 2009). Polyphonic lullabies are performed even today during various ritual activities, like putting a baby to the cradle for the first time, after cutting the baby's hair for the first time, or while at the bed of a sick baby. Lullabies and healing songs have plenty of

elements in common (in my native Georgia, they are also often mentioned by the same term "Nana").

As living in separate dwellings is a relatively late development in human history, it is very likely that mother's solo lullaby replaces the ancient group humming. Both group humming and solo lullabies have the same aim: to relax and put to sleep. Therefore in this model, the solo lullaby is the descendant of the primordial group humming habit of hominids and early humans.

The universality of humming as an expression of positive feelings on one hand, and total silence as an expression of a potential danger on the other hand, suggests that the human brain must be pre-programmed to perceive these emotions from hearing (or on the other hand, not hearing) audio background. We have already discussed the fact that prolonged silence affects our emotions in a profoundly negative way. Silence can be perceived as an ancient sign of approaching danger, or as Tim Rice suggested (through a personal communication on October 25, 2007), "one suddenly feels as if he is alone." I love this comment as it is based on the reminiscence of the ancient fear that hominids had of being apart from the group, and therefore vulnerable to predation. When we are surrounded by total silence, even if we know there is no danger around (like in a locked recording studio where Bob Dylan made historic recordings), we suddenly have a rapidly-increasing, instinctive fear, induced by our several million years of audio experience – a fear that we are in a mortal danger, and this fear comes from the fact that we are alone and there are no sounds around. In this situation our ears instinctively try to listen for signs of danger, and with the increased audio sensitivity we even perceive the sounds of our own body as ominous and fear-inducing.

This ancient desire to avoid silence must be the reason why there is so much music everywhere we go – in shopping malls, elevators, cars, trains, sporting events, political rallies, parties, and even funerals. Some complain that hearing music in such places, where people do not really listen to the music, is a sign of decline in musical taste. I believe that this kind of highbrow attitude towards music is not justified and is in fact inhumane. Listening to music for pleasure at organised concerts is a much later phenomenon. We did not "invent" music in order to fill up our free time and have fun with. For millions of years the function of music has been to help humans live more secure and more harmonious lives. In this context the infamous 'background music' is the evolutionary continuation of the ancient human habit of humming, and it has the worthwhile purpose of helping humans feel better, have a more positive attitude, combat their fear of small spaces in the elevators and alleviate their anxiety at exams or in hospitals. Unlike a few of life's other pleasures, like eating, drinking or sex, we cannot harm ourselves with too much music (providing that it is not so loud as to damage our ears). I suggest that this extremely high tolerance towards a musical environment and our generally positive reaction towards musical sounds is the consequence of our evolutionary past, where soft humming sounds were accompanying virtually every moment of our ancestors' lives, giving them enduring feelings of security and well-being.

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Origins of music and the battle trance

The August of 1839 saw possibly the fiercest fight that the war-torn Caucasus has seen to this day. The military forces of the mighty Russian Empire were finishing off the prolonged resistance of the legendary Dagestanian military and religious leader, Imam Shamil. Shamil had been leading an armed resistance against Russian forces for many years. After an epic 80-day-long siege at their mountain stronghold Akhoulgo where each side had lost about 7,000, a small remaining group of Shamil supporters (Shamil himself included) were surrounded by an overwhelming number or Russian troops. Neither side took prisoners in this battle, nor did anyone expect to be spared. The deaths of Shamil and his remaining followers were imminent. In this most critical situation, during a short break between the battles, Shamil suddenly started singing and dancing a traditional dance. His fighters looked at him first with amazement, but he gradually involved all his exhausted fighters in the singing and dancing. The speed of the dance was becoming faster and faster...

Russian soldiers, also exhausted after the fierce 80-day battle, were in total amazement at hearing the sounds of singing and dancing from their encircled enemies. When the tempo and the vigour of the dance reached a boiling point, Shamil suddenly stormed out with his sword in his hand and with a fierce war cry attacked the shocked Russian soldiers. All his surviving fighters followed, and despite an overwhelming number of Russian troops, a few fighters including Shamil himself and his family escaped down the slopes of the treacherous mountains and continued to fight the Russian Empire for many more years.

If you think that this kind of history can only happen with the members of conservative traditional societies, you are not correct. Even now, as you are reading these words, it is possible that a group of American soldiers, positioned somewhere in Afghanistan, are together singing and dancing to the loud sounds of heavy metal. Why are they doing this? Because, very much like Shamil and his fighters, they will be soon going into a combat zone where they can be ambushed and killed, and this singing and dancing is so they are prepared for their dangerous mission. It is not easy to prepare yourself for such a hard task - any soldier is a human in the first place, and killing another human for them is as difficult as for us. However, during the battle soldiers, and particularly soldiers with extensive experience, can be transformed psychologically and can reach a very special state of mind in which they do not feel fear or pain, and where they can disregard their personal safety in the interests of their friends and the common goal. In my 2011 book I called this state the "battle trance." Achieving this state is the prime goal of the psychological preparation of combat groups, and music (particularly loud and vigorous music) coupled with dance is the best way to reach this state. In a way both Shamil's fighters and the American soldiers in Afghanistan use the same way of achieving the psychological state necessary for dangerous combat missions.

According to some fascinating research by Jonathan Pieslak, an American composer, ethnomusicologist, an associate professor of music at City College in NY who specially studied the role that music plays in war, many American soldiers

confess that it would have been impossible for them to get into the required combat spirit if they did not listen to heavy and rhythmic rock music. "I'd listen to Slayer to get all into it." Colby Buzzell, an M240 Bravo machine gunner in Iraq, told Pieslak. "Sometimes your motivation is down and you're like, "I don't want to play soldier today"… But then you hear 'The Good, the Bad, and the Ugly' theme song and you're like, 'Fuck yeah, hell yeah, I'll go out on a mission today." "You've got to become inhuman to do inhuman things," Sergeant First Class CJ Grisham, who was a part of the initial US invasion force in Iraq in 2003, told Pieslak. The Eminem song "Go to sleep" became a powerful drug for SFC Grisham to get into the fighting spirit during his deployment, but after returning back from his service the song became unbearable: "Now that I've returned to normal, I can't listen to this song."

In 2010, after reading Pieslak's fascinating book, American actor Tom Wiggin started a campaign to distribute personal MP3 players to all soldiers stationed in Iraq and Afghanistan (Villarreal,2010).

I hope we all can agree that, when a combat unit goes out for a combat mission, it is of paramount importance that they all feel the strength of their unity and an utmost trust towards each other. Something of the same manner is happening when social animals prepare to go out for a hunt. Hunting is a dangerous activity not only for the prey - predators can also be injured or killed during a hunt. This is the reason lion pride members have their means to raise the morale and social bonding between the group members: "At dusk, before setting out on a hunt, group members rub frequently and intensively" (Schaller, 1972:87). What lions do with rubbing, humans do with rhythmic singing and dancing.

This power of music to prepare warriors for battle, to put them into a state where they do not feel fear or pain and where they can sacrifice their lives for their friends is in the very essence of the origins of human music. Before I continue on with this proposal, let me give you a brief chronological account on existing theories on the origins of music.

Theories of music origins

Here is a list organised in chronological order to make it easier for readers to follow the development of the scholarly approach to this currently very "hot" topic. We start with several important ideas expressed in Ancient Greece, as ancient Greek thinkers were extremely interested in the nature and origins of music, and some of their ideas still circulate in the writings of contemporary scholars (sometimes without them realising).

- 6^{th}-5^{th} centuries BC. Pythagoras proposed that the essence of music was in numbers. His ideas of the consonance as the sound with the simpler mathematical relations and the dissonance as the sound with more complex mathematical relations, was in a way a predecessor to Helmholtz's ideas of musical acoustics based on natural overtones.

- 5th-4th centuries BC. Plato acknowledged the unique emotional power of music, and considered music as the most potent means for instilling morality in the citizens of Ancient Greece. In his writings Plato suggested to promote some scales and to ban other scales for the good of society. Attempts to ban certain musical styles, composers, or compositions had been a policy for many religions and states, including more recent Western societies.
- 4th century BC. Aristotle, one of the greatest Greek philosophers and founder of western philosophy, considered arts and music as a means of imitation of the natural world.
- 4th century BC. Aristoxen, Aristotle's pupil, opposed Pythagoras' mathematical model of music, arguing that emotions, not numbers, are behind the phenomenon of music. For Aristoxen, consonance was primarily a sound that pleases our senses rather than a sound with simpler mathematical relations.
- 1st century BC. According to Philodemus, follower of Epicure, 'music cannot express anything, it can only tickle and please our hearing, very much like the art of culinary'. 21 centuries later, in his 1997 book, Steven Pinker expressed a similar idea with almost the same words, labelling music, to the outrage of many music lovers, as "auditory cheesecake" (see later on this list).
- 1722. Jean-Philippe Rameau published his influential work on harmony, declaring that harmony was the natural basis for music and that melody was derived from harmony.
- 1761. Jean-Jacques Rousseau disagreed with Rameau, suggesting that melody was the original element of music and that harmony was added later. According to his views, both music and speech had a common ancestor - this initial human communication was based mostly on singing, and it was more passionate and emotion-driven than contemporary human language.
- 1832. William Gardiner, the musician who introduced the music of Beethoven to British audiences, wrote one of the first articles on the origins of music, arguing that music was derived from the sounds of the natural world around us.
- 1857. Herbert Spencer suggested that music evolved from the exaggerated emotional speech of our ancestors, or in other words, from the prosodic elements (or tones) of human speech.
- 1871. Charles Darwin criticized Spencer's idea of music being an outgrowth of human speech, and suggested that, on the contrary, music predated the origin of language, serving the needs of sexual selection through charming the opposite sex. Maybe even more importantly, Darwin famously declared 'as neither the enjoyment nor the capacity of producing musical notes are faculties of the least use to men in reference to his daily habits of life, they must be ranked amongst the most mysterious [phenomenon] he is endowed.' Darwin's ideas about music and sexual selection are still quite widely known and often shared in contemporary scholarship.

- 1891. Richard Wallaschek suggested that both music and speech originated from a shared primitive stage of communication, and that music came from primordial 'dance-play'.
- 1895. Otto Jespersen hypothesized that language must have begun as 'half-musical unanalysed expressions for individual beings and events'.
- 1895. Ernst Newman proposed that the origin of music was independent of speech, and that humans had the ability to express their emotions through music much earlier than when they developed speech.
- 1911. Carl Stumpf suggested that music came into existence as a means of long-distance communication between early humans.
- 1919. Karl Bucher stressed the important links between music and rhythmic movements, and suggested that music developed out of labour-related rhythmic movements and sounds.
- 1923. Boris Yavorsky introduced the idea of 'intonatsia' [intonation] as the smallest and oldest element of musical language, with it subsequently dominating Russian musicology throughout the 20th century and fundamentally influencing Boris Asafiev's view on the essence and development of musical culture. Yavorsky suggested that intonation was the earliest form of human language.
- 1930. Boris Asafiev suggested that music and language had a common ancestor that was later separated during the course of human evolution into two related but sometimes conflicting phenomena.
- 1930. Siegfried Nadel proposed that music originated as a supernatural language, used in religion and rituals, and that musical language was added to everyday speech through artistic expression.
- 1943. Curt Sachs suggested that music could have originated from two sources: (1) speech and (2) emotions. Later (in 1962) Sachs rejected all theories on the origins of music as un-provable or wrong.
- 1956 onwards - Bruno Nettl wrote in one of his early works that both music and language were born out of a common ancestor, a specific system of communication that shared elements of both music and language. In his 2000 article and 2005 book, Nettl discussed musical universals and the origin of music as a cultural invention.
- 1973. John Blacking considered music as a purely human creation, inseparable from social context and primarily serving the needs of social cohesion in human groups. His definition of music as 'humanly organised sound' is contradictory, as it excludes the possibility of the presence of elements of music in the animal kingdom (for example, the singing of birds or humpback whales), and implies that human speech is part of music as well.
- 1971. Roger Wescott suggested that the earliest predecessor of human language among Australopithecines was whistling, combined with some other non-vocal

sounds like 'hand clapping, foot stamping, and drumming on their chests or on external objects'.

- 1973. Miron Kharlap suggested that the historical development of human musical culture went not from monophony to polyphony, as it was universally believed by music historians, but from polyphony to monophony - from group to individual musical activity.
- 1981. Ivan Fonagy suggested that our ancestors' language was musical and that pitch modulations directly carried the meaning of the communication, and that speech evolved later as a more complex system to express more complex ideas efficiently.
- 1983. Frank Livingston suggested that human ancestors as far back as the Australopithecines were communicating by singing, although later he changed his view and linked the origins of singing to the period of tool-making technologies.
- 1984. Juan Roederer specially looked for the survival value of music and suggested that music was developed to play the role of assisting the human brain in acquiring language.
- 1986. Izaly Zemtsovsky stressed the importance of dialogical forms of communication for the origins and the initial forms of group singing. Zemtsovsky and the four following authors were participants in a special conference dedicated to the genesis and specificity of early forms of musical culture, held in Armenia in 1986.
- 1986. Viacheslav Ivanov suggested that the presence of 'personal songs' for each member of society in different cultures might imply that these songs were the oldest form of personal 'naming'. He also stressed the importance of the neurological aspect of musical activity, suggesting that music could play a crucial role in memorizing important texts in early human history, before the invention of a writing system.
- 1986. Boris Frolov and A. Demirkhanian stressed the crucial importance of rhythm in the initial stages of the development of human musical and social activities.
- 1986. Joseph Jordania (the author of this book), in his first publications on this topic, suggested to distinguish musical language (as a means of communication) from musical culture (as a later cultural expression, art), and argued for the specific role of polyphonic group singing in the early stages of human evolution. In 2006 and 2011 he published books on the origins of choral music in the wide context of human evolution.
- 1988. Bo Lawergren proposed that the first fixed vocal and instrumental sounds were formed by humans as part of their hunting activities.
- 1991. James Brown and William Greenhood noted the evolutionary primacy of musical communication and suggested that the melodic utterances of *Homo*

erectus changed into staccato-like speech with long utterances when they reached the*Homo sapien* stage.

- 1991. Nils Wallin researched the biological foundations of human musical ability based on a multidisciplinary approach to the human brain, physiology, auditory and vocal systems. Together with Bjorn Merker and Steven Brown, Wallin organised a cross-disciplinary conference on the origins of music in 1997 that resulted in the release of the ground-breaking volume 'The Origins of Music' in 2000.
- 1992. Bryan Levman provided a good review of existing theories on the origins of music. He suggested that both speech and music must have had a common ancestor, and argued that pitch modulations played a crucial role in the human protolanguage.
- 1993. Bruce Richman suggested that initial choral singing could have been a crucial element in the development of a more complex communication system – human language.
- 1993.Leslie Aiello and Robin Dunbar suggested that about two million years ago, as the size of the groups of homo habilis and Homo rudolfensis were too big to allow grooming, physical grooming was substituted by vocal grooming (i.e. group singing), the precursor of both music and language.
- 1995. John Barrow declared that music had no survival value for humans, and that it derived from an instinctive sensitivity for certain sound patterns that itself was the result of adaptation.
- 1996. Dan Sperber declared that music arose out of the ability to exploit parasitically our cognitive capacity to process complex sound patterns used for early stages of human communication.
- 1997. Steven Pinker famously dismissed the role of music in the evolution of human communication as a late phenomenon, mostly a by-product of language development, and continuing the line of Greek Philosopher Philodemus, infamously labelled music as an 'auditory cheesecake'.
- 1997. Nathan Kogan discussed the possible adaptive functions of music and suggested that music could have enhanced the group movement synchronization and cooperation necessary for hunting.
- 2000. The volume 'The Origins of Music' was published by the MIT Press, providing an important precursor to the explosion of interest towards the origins of music. Several of the following authors published their ideas in this collection. The publication of this volume virtually opened the gate to myriads of new publications on the same topic.
- 2000. Geoffrey Miller revived and refined the initial idea of Charles Darwin about the role of music in attracting the opposite sex, suggesting that the function of music and dance was to demonstrate to the opposite sex the dancer's fitness to mate.

- 2000. Francois-Bernard Mache demonstrated existing parallels between human music and animal vocalizations and suggested that human musical faculty has strong links with animal singing behaviour.
- 2000. Ellen Dissanayake suggested that the origins of music are intimately connected to mother-infant interactions, particularly during the early stages of infant development.
- 2000. Bjorn Merker proposed that music could have originated among hominids as a group activity, by which competing groups of males were inviting wandering females for mating.
- 2000. Steven Brown suggested the highly influential idea of "musilanguage", a common predecessor of music and language. In 2003 he suggested the model of 'contagious heterophony' for the origins of music. According to this model, group-singing behaviour was at the very beginnings of music, and that mirror neurons played a key role in this process.
- 2000. Thomas Geissmann presented a comparative study of gibbon singing and human singing behaviour, and suggested that one of the early functions of music could be to scare away aggressors and competitors.
- 2000. Peter Marler suggested using animal singing behaviour as a possible model for the study of the origins of human music.
- 2000. Jean Molino proposed that music, language, dance, chanting, poetry, and pretend play have common origins based on rhythmic formulas and imitation.
- 2001. 2006. Ian Cross discussed the possible biological and cultural foundations of human musical faculty, and criticized dismissive attitudes towards music that were often present in the mid-1990s.
- 2001. William Benzon wrote about the particular importance of shared musical creativity from the perspective of a jazz musician, and argued that 'music is a medium through which individual brains are coupled together in shared activity'.
- 2003. Edward Hagen and Gregory Bryant suggested that music and dance were primarily used as an 'honest' signal about the quality of a group's cohesion to be displayed to other human groups.
- 2003. Isabelle Peretz summed up recent studies on the cerebral localization of musical functions: 'In my view, the only consensus that has been reached today about the cerebral organization underlying music concerns pitch contour processing … However, it remains to be determined if this mechanism is music-specific, since the intonation patterns for speech seem to recruit similarly located, if not identical, brain circuitries.'
- 2004. Robin Dunbar also suggested that the evolution of human language went through a musical phase.
- 2005.Steven Mithen suggested a model for the origin of music from the 'Hmmmm communication' (combination of 'Holistic, multi-modal,

manipulative, and musical' features), and noted that pre-linguistic hominids may have had better musical abilities than modern humans.

- 2005. Timothy Justus and Jeffrey Hutsler investigated the possibility of innate constraints on the human musical faculty, and suggested that despite the strong possibility of such constraints being innate, they could have emerged from selection pressures in various domains.
- 2003, 2005. Josh McDermott and Marc Hauser offered a comprehensive review of the existing publications on the innateness of several musical faculties. This review was 'motivated by the desire to understand music's evolutionary origins and adaptive significance'.
- 2006. Tecumseh Fitch examined the drumming behaviour of African apes (chimpanzees, bonobos, gorillas) and suggested that drumming among apes could be viewed as a potential precursor to human instrumental music. Fitch also suggested the term 'prosodic protolanguage' as a reference to the pre-linguistic system of communication.
- 2006. David Huron studied the mechanisms of emotional gratification through the process of anticipation, and then presented an interdisciplinary theory on the human emotional response to different elements and styles of music.
- 2006. Erich Jarvis discussed the importance of vocal learning in birds and mammals for the research of the origins of music.
- 2006. Victor Grauer proposed that the primordial music that anatomically modern humans took from Africa about 100 000 years ago was polyphonic and was close to the contrapuntal polyphony of Central African pygmies. According to Grauer, imitating animal sounds was the key factor in the emergence of human musical abilities.
- 2008. Daniel Levitin suggested that six main types of songs constituted the basis of human musical culture, and proposed that the most ancient type of songs, so called 'songs of knowledge' provided a 'powerful mnemonic force for the encoded knowledge'. This idea is close to the idea expressed by Viacheslav Ivanov in 1986, and discussed above. Levitin also mentioned the 'gruesome human invention' of the use of group singing by humans to intimidate opponents before battle.
- 2009. Steven Livingstone and William Thomson continued the non-adaptationist line of Barrow, Sperber, and Pinker, suggesting that music can be a secondary phenomenon originated from Theory of Mind (ToM), the ability of humans to recognize the emotional state of other humans.
- 2009. Andrea Rinaldi provided a review on the biological foundations of music and their relationship with language and speech.
- 2009 Richard Parncutt from Austria, an Australian-born professor of systematic musicology, endorsed the idea that music originally spawned from 'motherese' – the playful voices mothers adopt when speaking to infants and toddlers.

- 2010. Leonid Perlovsky published a wide overview of existing theories on the origins of music, focusing on the emotional power music has on the human brain.
- 2011. Joseph Jordania (the author) suggested that the phenomenon of "Battle trance" and acquiring "Collective Identity" through rhythmic singing and dancing was crucial for human survival.
- 2012. Gary Marcus, true to the ideas of his advisor Steven Pinker, argued that music is not an adaptation, but a cultural invention.

Despite a long list of authors and ideas, the reader must understand that this overview is far from being comprehensive, although it does present major theories and many of the authors who wrote on the origins of music. Now, after this review, we are ready to move towards the search of the origins of human singing in the context of human evolution.

Origins of human choral singing behaviour

If you have a look through the huge amount literature on the history of music, you will see that human musical abilities have undergone a long process of development, kind of a "from caveman to Beethoven" movement. According to the long tradition of musical history, our distant ancestors had only very primitive musical faculties, and then with the development of culture and raise of religion and civilization their musical tastes improved, and initially haphazard sounds were gradually organised into tonalities (also known as 'key').

In this strictly ascending picture of development in human musicality, choral singing comes closer to the very end of our musical development. For those who are unsure, by "choral music" we to refer to people singing in different parts, creating harmonies. The natural progress from one-part singing to singing in different parts sounded so natural that no-one took any pains to put this idea in the form of falsifiable hypothesis. After all, there are things that we call "axiomatic", which means they are true because merely because everyone can see they are true - there is no need to prove it, and there is no alternative (Nettl, 1960:360-361).

Well, the danger of axioms is in the fact that they are blinding to the point that no one can see the possibility of even considering alternatives. Sometimes it is not so easy to oppose and check axiomatic ideas.

One such axiomatically accepted idea was discussed earlier – a peacock's amazingly beautiful train. It was so obvious to all that it was designed by the forces of sexual selection to attract females that, for a long time, no one even thought to do any research. Well, today, as I have already mentioned, at least some scholars have big doubts that the peacock's glimmering train was designed to charm females, as

the first long-term study of a free-ranging population of peafowl found the old and seemingly axiomatic idea was not supported by the evident facts.

The origin of human choral singing is an example of another such seemingly axiomatic truth. On one hand it is understandable why this was considered so axiomatic. Think for yourself: a group of people can sing in one part, very much like everyone singing a tune of "happy birthday" at a party, but a group of singers can also sing in several different parts, like they do in professional or well- trained community choirs. Now, if you are asked which out of these two forms of singing is historically earlier and which is later, most likely you would respond that the one-part singing must be the earlier one, and that singing in different parts must have appeared much later, when human music had reached a certain level of complexity. This seems quite obvious, doesn't it? Because it was so obvious, for centuries musicians and music historians believed that singing in different parts was a cultural invention from somewhere at the end of the first millennium, when professional church composers organised choirs with professional singers who could learn and sing a multi-part composition.

The problem with this very logical scenario is that it does not agree with the existing facts. If you want to know to which facts exactly I'm referring to, I will detail merely a few of them below:

Most polyphonic singing is found in the most geographically and culturally isolated and hard to reach places of the world, not in cultural centres. For example, in China there is plenty of polyphony in the south-western part of the country in the most impenetrable mountain ranges of the world, which include Tibet, Sichuan and Yunnan provinces, where roads still do not reach some villages today. The Han people, the heart of ancient Chinese civilization and its booming prosperity, sing in one part. Furthermore, people sing in polyphony in remote areas of Papua New Guinea and the mountains of Afghanistan, but not in central France. In the Balkans, the kingdom of polyphony, the richest traditions of polyphony are present in Albania, arguably the most conservative country of the Balkan states. When Europeans reached Polynesia, they virtually refused to believe that natives were singing in different parts. Possibly the most telling of examples is arguably the most intricate vocal polyphony in the world, which is performed by Central African Pygmies - who by no stretch of imagination could be considered to be among the long list of technologically advanced societies.

Basically, music played a much more prominent role in human and hominid prehistory than it did after the development of civilizations and emergence of professional musicians. There are already scholars suggesting that we have actually lost part of our musical abilities compared to our distant ancestors, however I will not discuss this in detail. Victor Grauer (2006) and Steven Mithen (2006) wrote about this, and research showing that newborn babies all have absolute pitch also points in the same direction (Safran, 2003; Safran & Griepentrog, 2001)

Joseph Jordania (2014). Chapters 1 to 3 In: *Tigers, Lions and Humans: History of Rivalry, Conflict, Reverence and Love*. Logos Publishing. ISBN 978-9941-437-60-1

The author of this text has written three books on the origins and history of human choral singing over the last two decades[4]. After studying the distribution of the tradition of choral singing in the world, and studying all available historical sources from audio recordings, literary sources, and examples of musical notation (which has at least 4000 years of history), a conclusion was made that group singing in parts has been an important part of an early hominid survival strategy, and that polyphonic singing has been in a state of constant decline ever since the advance of the last major acquisition of human evolution – articulated speech.

If a reader is interested to know why there are regions of the world that do not have almost any traces of polyphonic singing, whereas in other regions polyphony is so prevalent, I can suggest reading my 2006 or 2011 books on this subject (the 2006 book is freely available on the internet). I would like to mention that the distribution of polyphony all over the world has incredibly interesting parallels with such ostensibly unrelated phenomena as the prevalence of stuttering and dyslexia, the acquisition of a phonological system in different parts of the world, and even the contrast in achievements in literacy between contemporary school children from East Asian and Western countries.

First let us return to our subject of group singing by our distant ancestors, and find out whether there was any need for developing such a behavioural trait.

Mobbing in animals and humans, or the history of human war cry

The mobbing or intimidation of an enemy, competitor, and particularly a predator is widely known in animal kingdom. Smaller and less powerful creatures unite their efforts in order to mob and scare away a dangerous enemy. Many species of birds use mobbing to secure their offspring from the predators. Some species are sometimes even mobbed and then subsequently go get some buddies together to go mob someone else. The crow is a great example of such a species that can be on both sides of a mobbing encounter. Mobbing birds use a special call which is different from their regular alarm call. If birds hear the alarm call they try to take cover, but when they hear a mobbing call many of the birds join forces to create a bigger mobbing group. In its essence mobbing is an altruistic behaviour, as there always is a chance that a predator can lash out and injure or even kill some members of the mobbing group. Another important detail to note: mobbing is a behaviour only exhibited by social animals – non-social animals deal with predators on their own.

Not all attacks of a group of animals on a bigger opponent qualify as a mobbing. A lion pride can, for example, attack a huge buffalo or even an elephant, and while this might look like a mobbing, there is a big difference between mobbing and group hunting, which is what the lions are engaging in. The goal of mobbing is

[4]1989, "Georgian Traditional Polyphony in International Context of Polyphonic Cultures: the problem of the origins of polyphony" (in Russian); 2006 – "Who Asked the first Question? The origins of Human Choral Singing, Intelligence, Language and Speech", 2011 – "Why do People Sing? Music in Human evolution" (all of them published by Tbilisi University Press).

to scare away an opponent (although a mobbing attack can sometimes result in the predator's death), whereas the goal of group hunting is to kill the opponent for food.

Mobbing has all the attributes to be considered a classic case of the aposematic behaviour of social animals. Cows and buffaloes, for example, often unite in numbers to fight against attacking tigers of lions, and their attempts have saved not only the lives of their fellow herd members, but many of their human herdsmen as well.

We will discuss later the possible mental state of altruistically-behaving animals (or humans) in the exact moment when they risk their own lives in order to save another, but for now I want to draw the reader's attention to the audio background of mobbing.

Mobbing as a rule is connected to making loud calls and different intimidating sounds. Our ancestors, as I have already mentioned a few times, were arguably among the noisiest animals and it would be natural to propose that they were using, as they do this today, mobbing behaviour accompanied by mobbing shouts. The most important requirement of a mobbing sound is that it must be as loud as possible. In the next sections we will concentrate on the different ways to make sounds as loud and as intimidating as possible. We will have a look at several elements: (1) making sounds together; (2) making sounds in perfect synchrony; (3) using strong dynamic accents; (4) singing with lower range voice; (5) singing in octaves; (6) using singing in harmony; even more specifically, (7) using sharply dissonant harmony; and (8) using drumming and stomping on various subjects.

Group vocalization

Although Charles Darwin did not think of the loud sounds made by our ancestors as a tool against predators, in later scholarly works the mention of group shouting and screaming as a part of the hominid and early human defence system became quite usual. There is no reason to think that our ancestors would not use the power of sound when they were standing their ground against such formidable predators as the ancestors of the big cats. It is also obvious that a sound made by several humans is louder than a sound made by a single human - basically the larger the group, the bigger the sound. Our ancestors were by no means unique in using group sounds to fend off predators. Plenty of animals do this (including lions). However the next element our distant ancestors were using in order to make their sound more effective was truly unique. It was the power of perfect synchrony that was making the group sound of our ancestors much more impressive and truly unique in the world. I am talking about the phenomenon of rhythm.

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Rhythm

The phenomenon of rhythm and rhythmically organised group vocalization is crucial for understanding the origins of human music and the wider human defence system, human dance and religion. In the animal world we do have several instances of the use of rhythm. For example, fireflies can synchronize their flashing – but synchronizing their sounds in rhythmic unison is alien to animal kingdom.

You may have possibly watched the wonderfully entertaining TV program "How Music Works" on TV or on the internet. When the researcher and presenter of the program, Howard Goodall, discusses the origins of human rhythm, he presents theories that human rhythm recalls the regularity with which we walk and of the heartbeat we hear in the womb. This is all correct, but the rhythm of walking and the rhythm of heartbeat cannot explain the presence of rhythm in humans. Plenty of animals walk very rhythmically and can hear a heartbeat while they are in the womb, but they still cannot synchronize their vocalizations and other activities with each-other like humans do. There obviously is something very special in human sense of rhythm.

The idea that synchronous movement improves group cohesion is quite old. Generals have known for centuries that having recruits march together for many hours and for many weeks improves not only their marching synchrony for parades, but also their morale and the dedication of each soldier to each other and to their duties. In his insightful book "Keeping together in time: Dance and drill in Human History" William H. McNeill suggested that not only armies, but churches and communities all benefited from this rhythm-related bonding, which McNeill calls "muscular bonding" (McNeill, 1995). This physical synchrony, which occurs when people move in perfect synchrony with one another, produces positive emotions that weaken the boundaries between the self and the group (Ehrenreich, 2006; Hannah, 1977; Haidt et al., 2008). Durkheim called this phenomenon "collective effervescence"(Durkheim, 1965;Turner, 1995).This phenomenon has been happening throughout human cultures for millennia, if not for millions of years. Radcliffe-Brown wrote that, through synchronized dance, Andaman Islanders become "absorbed in the unified community" (Radcliffe-Brown, 1922:252). The same is happening during carnival dancing, and during long Kandomble dancing sessions. Olaveson analyzed rave dancing in contemporary youth culture to strong-beat music and suggested that humans need that particular feeling of losing themselves in a big shared identity (Olaveson, 2004). Haidt proposed the idea of "hive psychology" and argued that people must occasionally lose themselves in a larger socialorganism to achieve the highest levels of individual well-being (Haidt et al., 2008).

Losing personal identity and acquiring group identity can happen in very different environments, both in joyful and in stressful situations. A soldier's unit marching, a religious sect singing and a crowd chanting in support of their sporting team are all examples of people absorbing themselves in a shared identity. Trying to understand the evolutionary roots of this phenomenon without applying the mechanisms of multi-level selection is impossible.

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First of all let us discuss whether the sense of rhythm is absolutely devoid within animal species. As we know today, there are at least a couple of cases of individual animals that have a sense of rhythm and can follow an external beat. An elephant star from the Thai Elephant Orchestra and also the YouTube sensation cockatoo Snowball do exhibit the ability to follow external rhythmic stimulus, although this sense of rhythm is not a characteristic of their respective species as a whole. World-famous African grey parrot Alex was possibly another bird that had the beat running through his veins, but unfortunately he passed away before the full study of his phenomenon could be conducted. The presence of these few cases are very important for our understanding of the origins of human rhythmic sense, as they suggest that the ability of rhythmic behaviour can arise in different species independently from each other, most likely as a result of genetic drift.

The fact that rhythm is universally present in humans, and that it remains so even after a stroke is suffered and all other mental abilities are diminished, is another piece of evidence that shows rhythm is a very deep seated, important and ancient mental ability. The crucial question for the origins of human rhythmic sense is of why it became such an important element of human behaviour after it appeared as a result of genetic drift - could sense of rhythm be an adaptation designed by the forces of natural selection?

Yes, it was, and it still is. When American soldiers listen to heavily rhythmic music and stomp and dance together before combat missions, or when Australian aborigines dance and stomp together before going to war or to hunt, they do this not for entertainment. Rhythm is the most potent transformer of human psychology from naturally selfish individuals into religiously dedicated members of a group. Soldiers who do not undergo exhausting drills for many weeks before combat are much more likely to run away as soon as they hear the first shots. Rhythm has saved many lives in our prehistory, and continues to do so. On a more negative edge, we can possibly say that it is the feel of rhythm and resulting intoxicating feeling of the "battle trance" that makes such a horrible thing as war so common.

John Locke famously wrote in 1690 that despite human participation in wars he is by nature cooperative[5]. I would agree with the great English philosopher, the father of classical liberalism, about the cooperative nature of humans but I would like to argue with him about the nature of war. It seems to me that war IS the biggest proof of human cooperative nature. It is cooperation, altruism and love towards fellow humans that forms the foundation for ethnic and religious wars with all the sacrifices towards a common goal. In April 2013 I asked my University students a question - what is war? Is it the example of extreme *cooperation* or the example of the extreme *non-cooperation* between people? To the credit of my students, they maintained a wise silence for some time, and then started discussing that war can be viewed as the example of both non-cooperation and cooperation - this is true. It is only in a very broad view that war seems only as an extreme case of violence and non-cooperation between people. On the other hand, the same war is a case of

[5] On the cooperation in natural world you can see the Alan Dugatkin's1997 book "Cooperation among Animals: An Evolutionary Perspective." The book also has a good survey of various ideas and authors on cooperation (on pages 151-155).

extreme altruistic cooperation to the point of self-sacrifice for the good of a bigger group. Extreme altruism within groups and extreme violence between groups are the two faces of war, and they are inseparable.

Let us return to rhythm as a tool for defence against predators and the basis for group cooperation. Rhythm has several features that make it one of our most important evolutionary acquisitions as a tool for the intimidation of predators and enemies:

(1) Rhythm makes a group sound louder, as putting audio accents together is as important as simultaneously combining the physical force of a group to perform manual labour (for example, lifting a very heavy load or pulling a tree down);

(2) Rhythmic synchronous sound creates an impression of a better-organised and more coherent group. When a predator (or competitor) hears a rhythmically perfectly blended wall of sounds, this gives off a message of the unity and dedication of the group members;

(3) Even more, hearing a well-organised and well blended sounds creates the impression that the sound comes from a large super-body rather than a number of smaller individuals;

(4) Perfectly synchronized group movement also creates the very interesting visual illusion of a monstrously big living organism. If you have ever watched the perfect marching of German soldiers from World War 2 archival footage you will understand what I mean;

(5) Rhythm is a crucial part of another important human phenomenon, known as entrainment, or synchronization to an external rhythm. Entrainment is a crucial part of dance, another human universality and potent means in achieving a collective identity and acquiring battle trance.

(6) Rhythm has also given way to poetry - a stream of meaningful (well, not always) words that have a rhythmic pulsation, and it is by the virtue of this rhythmic pulsation that poetry creates the particularly strong emotional effect it is famous for;

(7) On the internal side, rhythm is the most potent means in humans to achieve the state of "battle trance." The state of battle trance is absolutely crucial for a successful confrontation against enemies and predators;

As we can see, the appearance of rhythm and the ability of entrainment was an event of profound importance in our evolutionary history, particularly for the ability of selfish individuals to get lost in the intoxicating feel of a collective identity. As the

feel of rhythm can appear randomly in individual animals of various species, we can hypothesize that the feel of rhythm among human ancestors also appeared first as a result of random genetic mutation. In the next generation it was most likely transmitted to few of the offspring of the first ancestral Ringo Starr, and these first grooving hominids gained a strong survival advantage in their rhythmically united audio display and the enhanced feel of group identity. As a result, with every new generation the number of hominids with the sense of rhythm would increase, until the entire stock of future humans had an amazingly sharp sense of rhythm and the ability to lose themselves to a collective identity.

The spread of new useful genes and behaviours can happen very fast. When the importance of military drills was discovered, or more correctly, re-discovered by the Dutch army of prince Maurice of Orange in the 16th century, it spread throughout the armies of Europe like a bushfire. The reason for this rapid popularity of military drills was the fact that drilled armies were routinely defeating bigger but non-drilled opposition (McNeill, 1995). I suppose that the reason for the universal spread or the sense of rhythm among our ancestors was the same – the deadly and intoxicating power of rhythm to put participants into the coveted battle trance and to fight with a true disregard for their personal safety.

As a phenomenon, rhythm gave our ancestors on one hand a wonderful tool for better audio intimidation of an opponent, and on the other it revolutionized hominid group cohesiveness by introducing the shortest way to reach a specific altered state of consciousness where the interest of the group was overriding all the instinctive fears of self-preservation.

Rhythm and the resulting mental state of the battle trance made possible such profoundly important elements of future human culture as religion and war. Both religion and war are based on a new hierarchy of instincts, where in critical situations group interests are overriding selfish instincts. Rhythm became one of the strongest factors of the group selection mechanisms in the complex interaction of different selective methods of multi-level selection in human evolution. The phenomenon of dance, another universal element of human culture and evolution, became profoundly intertwined with the sense of rhythm and the feel of collective identity.

Maurice de Saxe knew this in the 18th century (and possibly Maurice of Orange in the 16th century). Talking about the secrets of preparing soldiers for action in his classic military tractate *Mes Reveries*, published posthumously in 1757, he proposes that the secret of war "is nevertheless very simple, because it is dictated by nature – it is nothing more than to march in [synchrony] in which alone consists the whole mystery…Nothing is more common, than to see a number of persons dance together during a whole night, even with pleasure; but deprive them of music, and the most indefatigable amongst them will not be able to bear it for two hours only, which sufficiently proves that [musical] sounds have a secret power over us, disposing our organs to bodily exercises, and, at the same time, deluding… the toil of them."

We could go on and on about the importance of rhythm in human evolution and cultural behaviour, but let us now turn our attention to another factor that

stemmed from the human ability to follow rhythm, and is known to every reader of this book who has heard rock musicians famously counting in: "One, two three, four…"

The Sign of Four, or Why Paul McCartney's "Yesterday" is truly unique

Yesterday evening I watched a wonderful Russian adaptation of Conan Doyle's "The Sign of Four" with Vasily Livanov as Sherlock Holmes. Livanov is outstanding as Holmes – simply the best. It is no accident that, out of all actors to play detective Holmes, a character portrayed over time by more than 70 actors, his Holmes was singled out by Arthur Conan Doyle's youngest daughter Jean as the best one, and it is also no accident that Livanov was the only actor playing Holmes who received the MBE from Queen Elizabeth for his portrayal of the legendary detective. Sherlock Holmes is the Guinness Book of Records holder as the most portrayed character in movie history.

Anyway, why did I mention this in the first place? Oh yes, I wanted to discuss the mysterious power of the number four in music.

Number four is a truly universal element of human music and has a dominating position in human music both on a micro and macro level (Brown & Jordania, 2011). Four beats is arguably the most popular length of a unit known as a bar. Four beats in a bar is a time signature so popular that it is known among musicians as "common time" (C, or 4/4). Furthermore, on every level we have the prominence of four-fold increases in the numbers: 4: 8, 12, 16, 24, 32, etc. and even the number of parts of a classical symphony, arguably the pinnacle of classical music, is four. In all genres of music, from traditional and jazz to classical, pop and rock music, four bars, four sentences, four repetitions of structures is a common practice. You will struggle to find a pop-music song which has a verse, or a chorus, consisting of, for example, seven bars.

There is a famous example of a seven-bar song structure. Paul McCartney's "Yesterday," possibly the most popular pop-song of all time, has one of the most famous verses lasting seven bars. I do not think Paul himself knows this unique fact about possibly his most famous song. In the book specially dedicated to this song (yes, there is such a book, see Coleman, 1995) this unique feature is not even mentioned. It is not easy to notice this asymmetry at all, as the melody flows so effortlessly that unless you count for some reason the number of bars, you will not notice the unusual number of bars. Although I am an avid fan of the music of The Beatles and have arranged many dozens of their songs for classical guitar and piano, however it was not until I started arranging this song for a choir and wrote the arrangement as a score, that I realized the verse was only seven bars - this is a truly unique occurrence, particularly for popular music. Hundreds of thousands of musical compositions, from classical music to pop-songs, are based on four and eight bar structures.

Every human universal, I believe, has a strong evolutionary reason. So what evolutionary forces could be behind this magic power of "the sign of four"?

First of all, if you want to create the maximally impressive sound with the use of group of a people, your best shot will be to have them making sound in a well-coordinated rhythmic unity. This was the appearance of the sense of isochronous rhythm, and we have discussed this on previous pages. The next step to make the sound even more impressive would be to have certain moments where there is a burst of particularly loud sound. This can be achieved if everyone makes their loudest call exactly at the same moment. If you hear a threatening sound, the effect will be tremendous if the sound gets louder for a fraction of a second. To achieve this in a group of singers every member of the group needs to know exactly at which moment they need to give their loudest call. This can be achieved if everyone agrees prior to make their loudest call after a certain number of beats, for example, after each three or four beats. But of course, at this distant historical epoch no mathematical abilities were yet present in hominids, so any such mathematical "pre-agreements" had to be formed and maintained purely instinctively. I propose that organizing rhythmic flow in regularly accented patterns was developed by natural selection as an important device to make the group human sound more impressive. This was the birth of a well-known phenomenon that musicians refer to as "musical metre," the division of musical flow into musical "bars" ("measures"). Apart from making the sound more impressive, synchronous accents show the level of coherence of the group to the opposing side.

OK, but why four? It will be very difficult to correctly guess why such a universal number was chosen to be four, not three, or five, or seven. The number four has several unique features - some objective and some culturally designed. It is the smallest composite number. Even all DNA in every live organism consists of four elements. Most mammals have four limbs. There are four directions of orientation as can be seen on a compass, the Christian cross has four ends, the crossing motion across the chest contains four movements in four directions on four sides, etc. There can be many other factors that empower the number four to become a basis of human sense of rhythm and musical structures. Most likely, there were several factors that contributed to the number four become the most dominant number in music and human rhythmic feel. We can also propose that the fact that we have two feet (and before we used to walk on four), made us predisposed towards even numbers.

Even if we do not understand what the crucial factors are behind this choice, we have to admit that dynamic accents based on four counts were not a human cultural choice of certain talented musicians, but rather was a choice made by the forces of natural selection in order to assist the survival of our distant ancestors on the woodlands and savannah of Africa. Interestingly, in Japan number four is a number for death (possibly a completed cycle?). For our species, the number four was a number for life, symbol for unity, and a number that assisted our survival for the millions of the years.

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The importance of low range voice

If you want to impress or intimidate someone with your voice, apart from having a loud voice having a low range voice is another great advantage. A lion or a tiger growl is possibly ten times more impressive than the sound of a leopard, although the leopard is not that much smaller and can also easily kill humans. Military officers with lower and more impressive voices, as a general rule, have a better military career.

It is obvious that the range of the sound made is directly connected to the size of the animal making it. Bigger animals can produce lower and louder voices – that is why when you hear a lower sound, you instinctively think of a bigger and stronger animal producing such a sound. Elephants and whales can produce sounds so extremely low (so called 'infra-sounds') that we humans cannot hear them.

The peculiarity of the human voice is that our voice range is much lower and louder than it should be according to our body mass. For the sake of objectivity we possibly should introduce a sound-weight ratio (SWR) to find how strong and how low the sounds are that animals of different species can produce. Unfortunately, unlike the earlier discussed height-weight ratio, sound-weight ratio cannot be easily put in action as there are virtually no works where a wide range of sounds produced by different animals has been be measured or discussed. The ratio itself is easy to measure: you just need to know the weight of an animal (this parameter is easily available for any species of animals), and the lowest range of the sounds that an animal can produce (this is the difficult part, as such information is often absent).

The situation with SWR (sound-weight ratio) is even more complicated as this ration should actually have two versions SWR1, and SWR2: the first that measures the **strength** of the sound in decibels (this will be SWR1), and the second one that measures the **lowest range** of sounds that the animal can produce (SWR2).

Even without precise measuring tools we can say that the SWR1 will be very high in some birds and smaller monkeys, who have incredibly loud voices in comparison of their tiny body mass and weight. Some singing birds, particularly some parrots, are possibly the champions of this category.

Interestingly, although flying, singing and mimicking birds can have incredibly strong voice and respectively very high SWR1, their voice range is not among the lowest of the voices. It seems that it is easier to produce a stronger sound with a smaller body, than it is for that body to make a lower range sound.

Humans, the only singing terrestrial species, can compete with the loudest animal species in the loudness and the range of the produced sounds, including low-range sounds. Lions and tigers are among the animal species that have an incredibly strong and low voice - humans, very tellingly, can imitate the sounds produced by these big cats. Jim Corbett and Kenneth Anderson, as we know, could imitate tiger sounds in order to call them, and used this skill to get rid of several man-eaters.

It is true that not many of us have voices as strong as Luciano Pavarotti or Paul Robson, but we should remember that we live today in a completely different world with different life concerns and different survival needs than our ancestors had few million years ago. Today good linguistic and math skills are much more important for attaining general success in life than a loud or low voice, but this was not the case with our distant ancestors. Language and math were not yet around, but groups with more members with stronger and lower voices would have better chances of survival as they were better at intimidating predators and competitors. Therefore, our ancestors most likely were selected for the strength (and range) of their voices.

The telling detail of our voices is that the male voice is unusually lower than a female voice. Sure, males typically have a larger body than females, but this difference is not as much as to create such a large difference in range. We take this difference in voice ranges for granted, but if you pay attention to the facts you will quickly realize how unusual it is for the animal kingdom. Male and female lions and tigers definitely do not have such a big difference in voice ranges. Yes, male lion sound is somewhat louder and lower, but the difference is in no way as drastic as it is in human voices. So how big is the difference between male and female voice ranges? Can we measure it objectively? Yes we can.

Directors of choirs know very well that the difference in range between male and female voices is precisely an octave (this means male voices are twice as low as female voices). No other primate has such a huge difference in range, including gorillas where the difference in male and female body masses is huge.

It is clear that our evolutionary predecessors developed such a low voice for good reasons. In explaining this feature of human morphology, both sexual selection and the aposematic model may suggest their explanations with different reasons. I am sure that if the proponents of sexual selection paid attention to the huge difference between male and female voice ranges, they would have suggested that males with lower voices were selected by the choosy females as those with lower voices are perceived as stronger, healthier, and generally better for the role of the prospective father of the offspring. On the other hand, the principles of warning display (aposematism) suggest that those with lower voices had a better survival chance as they were better at intimidating predators and competitors. Well, as I have already mentioned, we do not need to perceive these two factors as mutually exclusive. On the contrary, the low male voice could have had both functions, and I propose that the factor of warning and intimidating predators and opponents was the primary cause of dropping the male voice range. As a useful morphological feature for survival, it was selected by the forces of natural selection and later also became more attractive to the better half of humanity.

Furthermore, the proponents of sexual selection should also take into account that a lower male voice is not considered better for the attraction of females. Male singers with high voices are doing much better in attracting female admirers – the majority of world famous singers are tenors, not basses. Similarly, the absolute majority of rock star singers also sing very high. Also, in most of the operas charming romantic characters are as a rule tenors, and low voice bearers are often the

antagonists. This is another strong argument that the lowering of male voice evolved for intimidation, not for attraction.

On the other hand, as Harrington writes, "Lowering the pitch of a vocalization is a nearly universal sign of increasing aggressiveness in mammals ... In the above example, an alpha male howls after approaching a stranger who had howled close to the rendezvous site. The long, low-pitched and coarse howls seem designed to scare off the intruder without the need for a face-to-face confrontation" (Harrington, 1997). These few sentences sums up the very essence of aposematic audio display: scaring away a competitor with a low voice display without the need to engage in a costly physical confrontation.

So, in explaining the evolutionary reasons for the emergence of the unusually deep male voice, I totally agree with the suggestion of Desmond Morris that a low male voice could have been very useful to "intimidate human rivals, to drive prey or to scare off predators" (Morris, 2008: 92). The low voice of human males was almost certainly a part of the intimidating package that our ancestors used against predators, including the ancestors of contemporary big cats.

Thrilling octaves

Let us discuss the big difference between the male and female voice ranges. The difference, as we remember, is an octave. Let us now ask ourselves, why is it an octave and not any other interval?

Playing (or singing) in octaves is widely used in some cultures where men and women sing together, seemingly in unison. This enables both men and women to sing together and feel as if they are singing the "same thing". Even more so, playing in octaves is also widely used in heavy rock music, and also interestingly enough in Hollywood thrillers. This preference of octave-playing in rock music and Hollywood thrillers is connected to the sound and feelings arising from the sound of the octave interval. An octave often has the emotional feel of suspense, aggression and danger. For rock music's expression of protest, frustration and aggression this is an integral part of the design. This is why, since the appearance of Led Zeppelin's trademark sound where the lead guitar and bass guitar were playing in unison the same riffs an octave or double-octave apart, this sound became arguably the most enduring musical symbol of rock music (particularly heavy metal rock music, known for its aggressive qualities). For the very same reason, movie composers often use the hollow and unsettling sound of octaves (and double or even triple-octaves), as these sounds instill a feeling of concealed danger and are thus very suitable for thrillers and horror movies.

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The magic of harmony

We all agree that a group of people singing (or even shouting) together will increase the volume of the sound. However there are various other ways to achieve a more impressive overall sound - one of them is to sing in a harmony, or sing in different parts.

Many choir directors would agree with me that the quality in the sound of a choir increases when its members sing in harmony. When the overtones of different pitches clash with each other in one simultaneous harmonic sound, the result is a more robust overall sound. Another very important effect of singing in harmony is the impression of a bigger number of participants than there is in reality. You may agree that this feature of singing in harmony is of particular importance if you have to scare away predators of competitors with your sound. This phenomenon, when sounds created give the impression of a larger group, is known as the "Beau Geste" effect. If you are interested to know how efficient this effect is, here is a short example of American Civil War history: "General Ulysses S. Grant reported hearing what he took to be a pack of "not more than 20 wolves" while traveling. A short time later he reached the pair of wolves that had been making all the noise!" (Harrington, 1989:217). Fred Harrington, who studies this phenomenon, came to the following conclusion: "The observation that chorus howling by adult pairs is often perceived as that of larger groups with pups suggests that chorus structure has evolved to exaggerate the apparent size of the pack, especially those newly-established or otherwise reduced in number. If so, wolf howling choruses may represent a mammalian example of the Beau Geste effect, made particularly viable because of the relative immunity of the signal to probing" (Harrington, 1997).

The singing in harmony that so many of us enjoy possibly evolved initially in order to make the sound of our distant ancestors deceitfully impressive.

Dissonance: The ultimate sound

We have just discussed that singing in harmony makes the overall sound more robust, creating the impression of a larger and more imposing group. Another question is: what kind of harmony could have been employed by our hominid ancestors? Professional musicians know that there are several different ways of singing in harmony. You can sing in parallel thirds and parallel sixths, and this will lead to a nice relaxing harmony, prevalently used in classical and contemporary pop music. Parallel fourths and fifths make a very different sound – rough and somehow hollow. The opening riff of the classic rock song "Smoke on the Water" uses parallel fourths. Parallel fifths are so prevalent in rock music that a special type of chord, consisting of only a fifth, was created. This chord is known to most as a "power chord", and if you have ever played in a rock band you will most likely have played

thousands of power chords. Apart from singing in intervals, you can also use a drone (sustained note) together with a melody, you can sing in very wide or very close intervals; you can also sing in two, three, four, or more parts, and also you can sing in consonant or dissonant intervals and chords.

All these different types of singing in harmony create very different end-results. According to my over 30 years of experience as a choir leader and a university lecturer in various styles of harmony, singing in dissonant intervals and chords creates the most startling, the most robust, and the most impressive overall sound. The interval that is particularly impressive in this regard is the second. The second interval is the closest possible interval. There are two types of seconds: major second and a minor second. Interestingly, the most impressive dissonance is not a minor second, or even a major second, but a neutral second, which is in between the minor and major seconds (you cannot play this interval on tempered instruments). These characteristics make singing in dissonant harmonies, and particularly in seconds, the best possible option for the intimidation of opponents.

In my 2011 book I suggested that singing in harmony and singing in seconds was created by the forces of natural selection, and that this tradition was taken by our distant ancestors from the African 'cradle' to the different regions of the world. I also suggested that some remnants of this primordial polyphonic singing style are still surviving in the most isolated regions of the world. Is this possible? To search for the answer to this question, the best way would be to search for a polyphonic style with a loud and piercing sound and with very sharp dissonances. And ideally, examples of this style must be found in geographically isolated places, ideally on different continents.

If we look at the stratification of singing styles (discussed in the first chapter of my 2006 and 2011 books), we can see that a very specific polyphonic style stands out in different parts of the world. This is a piercingly loud singing style, based on an acoustically maximally dissonant interval of the second. Even more precisely, this interval is between the major and minor seconds, measuring 14-16 hertz. This is "the most dissonant dissonance" - the neutral second mentioned above. This interval and this type of harmonic singing is known in ethnomusicology under the German term 'Schwebungsdiaphonie' (lit.: "rough sound," "rough harmony").

Another amazing fact is that singing in this style is distributed to the most isolated and distant regions of the world - the Himalayas, the mountain ranges of Hindu-Kush, the Caucasian and Balkan mountain ranges, North Vietnamese and Taiwanese mountains, South-West China's forest-covered mountains, hard to reach regions of Papua New Guinea, some islands of Indonesia and Melanesia, the swampy forests of East European Polesie between the Ukraine and Belarus, and the fringes of Europe in the Baltic region. I call this polyphonic style Drone-Dissonant style (D/D Style), referring to the two most important elements of this style (drone and dissonances). Some remnants of D/D style are also found in isolated regions of Africa, in North Japan among the Ainu peoples, and in the Andes among the Q'eros of South America. The amazing similarity between the polyphonic styles of such isolated regions and cultures strongly suggests that these can all be remnants of a

common singing tradition. The development of such a specific polyphonic style by so many differing cultures as a coincidence is virtually impossible to imagine.

The striking resemblance between Balkan and Indonesian traditional polyphonies left the brilliant Dutch ethnomusicologist Jaap Kunst totally astonished. He published a book in 1954 on this subject, in which he tried to substantiate a fantastic hypothesis that the there was a major prehistoric migration from the Balkans to Indonesia. The problem with this hypothesis was that the parallels between the Balkans and Indonesia that he discovered are only one of many such parallels: the same style of singing is present in many other parts of the world, and is abundant in the most isolated localities.

The similarity of stylistic elements and the sound between these traditions is amazing. When, in the 1980s, Austrian-Australian comparative musicologist Florian Messner played a recording from Bulgaria to Indonesian villagers, the Indonesians were sure that this was a recording made in a neighboring village, and the reaction of Bulgarian villagers was exactly the same upon hearing a recording of the Indonesians' polyphony. I can also say that, although I have been studying these polyphonic styles for years, I still cannot distinguish them from each other.

The only serious argument against the suggestion that these polyphonic styles are survivals of pre-historic and even pre-modern human times is the immense stretch of time (literally millions of years) that supposedly passed without much change in these singing traditions. Otherwise the amazing closeness of singing traditions on one hand, and the distribution of this style in many extremely isolated regions on the other hand represents a classic case of 'remnants of an ancient common practice'. Victor Grauer famously declared that Bushmen/Pygmy polyphony (based on yodeling) can be a survival of the earliest singing style of humanity, stretching back for the last 100 000 years. Grauer relies on the 'Recent African' or 'Total Replacement' model. My research and polyphonic data supports more the 'Multiregional model', also known as the 'network model', where the count for the age of humanity goes on for millions of years rather than thousands.

If we believe that such a long survival of a singing style is impossible, then we are facing the even more difficult task of explaining the presence of amazingly similar and very specific dissonant singing traditions in very specific intervals in such wildly different places of the world. Therefore, I suggest that we should not discount the simple possibility that these are all remnants of the oldest human singing style, the style that helped our ancestors get into the battle trance and obtain collective identity in order to fight together, as a unit, for their common survival.

Some readers may consider this suggestion of the direct links between choral singing, one of the highest expressions of human musical and spiritual culture, and the singing of prehistoric hominids as a bit of an insult, but for me there is something very deep and very poetic in making evolutionary connections between Bach's chorales and the final chorus of Beethoven's 9th symphony on one hand, and the trance-inducing loud singing in harmony of our distant ancestors in order to stand their ground against mighty predators a few million years ago on the other hand.

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It is widely known that many cultural inventions that make human life safer, more convenient and more meaningful were initially invented for the reasons of safety and military capability. I suggest that human choral polyphony is one of these elements, a phenomenon that belongs to human culture, but has its roots deep in safety concerns, seemingly out of the realms of human "culture."

Thus, I believe we should not speak about the "invention" of polyphony among early hominids of humans in the same way as we should not speak of the "invention" of rhythm. It was a case of the selection of an advantageous trait by the forces of evolution, very much like the adoption of bipedalism, or the growth of head hair.

Drumming as a defense tool

Apart from making sounds with voices, humans can make plenty of noise by employing other means as well. Drums, for example, make an effective tool for intimidating the most dangerous predators. Jim Corbett gives a brilliant example of the use of drums for intimidating and driving out a man-eating leopard. Here is an excerpt of Corbett's account from his hunt of the Rudraprayag man-eating leopard, arguably the most famous man-eater in human history, one who's notoriety not only earned it a book, but a film as well.

The last victim of the Rudraprayag leopard was a young boy who was snatched from his own house as he was following his mother and other family members up a staircase, carrying (as others also were) some kitchen utensils they just washed. The boy was last in the queue of family, and when the family members entered the house they heard the noise of fallen kitchen utensils. They naturally assumed that the boy had dropped the kitchenware and went out to punish the boy for being so clumsy. The fallen kitchenware was lying on the ground, but there was no trace of the boy. They decided that the boy had been embarrassed of his clumsiness and was hiding, and started calling him. It was only then that they noticed, in the fading light, traces of blood and understood that the dreaded man-eating leopard had attacked and took away their boy. Realizing this they started drumming the big drum they had in the village, as loud as they possibly could. The result was quite remarkable. The man eater, a big male leopard who was not afraid to enter a house in broad daylight and wait on the first floor for several hours to snatch a boy from a group of family members (man eating leopards generally attack humans in the dark) dropped the body of the boy as he was making his exit just past the village walls (unfortunately, the boy was already dead) and ran away. It is not easy to scare away a hungry man-eater and to make it leave its dinner behind, but this is exactly what the drumming did in this well-documented case.

Pygmies, who live in the jungles and are at constant risk of a leopard attack, also use drumming when they know a leopard is in proximity to the village. American artist and author Anne Putnam starts her book about her time spent with

Mbuti pygmies with the dramatic account of a leopard attacking a woman in a pygmy village in the middle of the jungle. Fortunately, this time the victim was rescued from a terrible end, and while villagers were caring for the wounded woman others started frantically playing on a big drum in order to scare away the hungry leopard.

Drumming in order to scare away predators and competitors is a much older practice than readers might think. It is a highly important fact that drumming behaviour, as a tool for intimidation, is present in all three of our closest living relatives – chimpanzees, bonobos and gorillas. In an insightful article about primate drumming behaviour Tecumseh Fitch proposed that there may be direct connections between ape drumming behaviour and the human passion for drumming (Fitch, 2006:2, 9). Apes drum on external subjects, usually on trees, and together with drumming they use other elements of aggressive behaviour (shouting, shaking tree branches, stomping on the ground) when they are facing predators and competitors.

If the extremely interesting suggestion by Tecumseh Fitch about the direct evolutionary links between the drumming behaviour of great African apes and humans is correct (and there are no reasons against this suggestion) then drumming must have existed in common human-chimpanzee-bonobo-gorilla ancestors and therefore must have preceded the appearance of the sense of rhythm. There is no question that drumming exists in many other animal species unconnected to humans (for example among rodents such as rabbits and kangaroo rats). Drumming behaviour can arise independently in different unrelated species, but the presence of drumming in apes, our closest living relatives, points to the presence of drumming behaviour being present on the level of our common ancestor.

An interesting conclusion can be made from the notion of the shared tradition of drumming among humans and African apes. As out of them only humans have the sense of rhythm, it becomes obvious that in our evolutionary history drumming appeared earlier than the sense of rhythm. Drumming even without rhythmic unity is already a potent warning and intimidating tool, but with the presence of rhythm and a synchrony within the group utilising simultaneous dynamic accents and coupled with singing/shouting, drumming becomes an excellent tool to put group members in an altered state of mind on one hand, and to intimidate the opponent, even the strongest of predators, on the other.

We will now discuss how animals react to loud noises. We will see that animals and humans have quite different levels of tolerance towards loud noise. Knowledge of this sphere is also quite important if we care for putting animals in a friendly and suitable environment.

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Killing sounds, or why dolphins do not like rave parties

Humans are incredibly tolerant to loud noises. We can work at the factories where the noise is over 100 DB and we can listen to and even enjoy rock concerts where the sound level is deafening. Of course, very loud sound can be a dangerous thing even for humans. Apart from gradually losing our hearing if we are exposed to prolonged loud sounds, extremely loud sound can also put us into shock. For example, the noise from a detonation of a bomb or mine can cause shock and concussion of combatants or civilians who were close to the explosion.

Most animals are terrified by loud sounds - rifles are used against predators for their loud sound almost as much as for their stopping power. Discharging rifles in the air is a very popular way to scare off predators. Some other much less threatening sounds can also terrorize the strongest of predators. Here is a story of a lucky Indian trader who escaped a grim death from some of the most famous man-eating lions, the Tsavo man-eaters:

"On one occasion an enterprising bunniah (Indian trader) was riding along on his donkey late at night, when suddenly a lion sprang out on him, knocking over both man and beast. The donkey was badly wounded, and the lion was just about to seize the trader, when in some way or other his claws became entangled in a rope by which two empty kerosene tins were strung across the donkey's neck. The rattle and clatter made by these as he dragged them after him gave him such a fright that he turned tail and bolted off into the jungle, to the intense relief of the terrified bunniah, who quickly made his way up the nearest tree and remained there, shivering with fear, throughout the night"(Patterson, 1919:97).

Most animals' level of sound tolerance is much lower than ours, and yet we are still in the infancy of understanding this profoundly important fact. You can sometimes find cases of chickens dying in thousands if their farms are close to a concert or festival site, or to aloud party.

I will recount a tragic story about our gentle aquatic friends, dolphins. This happened in Florida, at the Gulfarium Fort Walton Beach on the Gulf of Mexico in 1957. There was a need to repair the existing aquarium, and the responsible officers decided they could undertake repairs while a group of bottlenose dolphins were inside the huge tank of water. They knew dolphins would be distressed but they did not expect anything too extreme. So they started the repair works that involved loud banging on the tank body. The work was finished, the tank was repaired. What about the dolphins? In several weeks all six dolphins were dead. They died one after another, with similar symptoms. On examination they were found all to have developed severe duodenal ulcers (Garfield, 1972:374).

It takes a while for humans to learn their lessons - more than half a century later, in 2011, the tragic story was repeated. A loud techno party was organised in

Connyland, in the eastern town of Lipperswil, Switzerland, in an amusement park next to where an aquarium is located. Loud dance music went for 16 hours. The result? After three weeks of the party the 8-year old resident dolphin, Shadow, was dead. There was a heated argument over the internet as to whether the dolphin died from sound shock or from some other cause, for example a certain substance fed to the dolphin. Even if there were other possible factors involved, it is useful to remember that loud sound alone is a potent killer to dolphins.

Another tragic example of animals' reaction to sound shock comes from war-torn Yugoslavia. When NATO started bombing Belgrade on March 24th 1999, humans were not the only ones traumatized – the animals from the Belgrade zoo were also affected, probably even more so than humans. According to zoo personnel, as bombs exploded and the sirens sounded their alarm, animals started screaming and howling in desperation, while all the birds fell completely silent. As the result of the audio stress and resulting shock, animals displayed disturbing behaviours. A tigress and the Canadian and European she-wolves killed and ate their offspring. Many zoo birds also killed their young. A pregnant lion, constrictor, zebu and zebra all aborted. Probably the most shockingly, Prince, the zoo's favourite Bengal tiger who was hand-reared and was taken on walks through the city and on motor boats while he was still a cub, became so traumatized that he started eating his own hind legs.

We often do not realize how vulnerable animals are against the human-created loud noise – and humans are masters of making extremely loud noise, both with their voices and with the help of other devices invented over time. Even without amplifiers we can make sounds that can scare away the strongest of the predators. The famed "Wall of Sound" was not Phil Spector's invention. Our ancestors used it with great effect to secure themselves from predators and obtain food by chasing them away. Now as the times when we were in danger of predator attacks are gone for good, and that we have much better tools to make much bigger sounds, we need to consequently be more responsible with this deadly weapon.

Humans cannot stand silence – while traumatized by complete silence for only half an hour a fellow human started eating his left hand.

Animals cannot stand loud sounds – while traumatized by loud sounds, many animals ate their young and a tiger started eating his legs. These are sad parallels.

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Let us now arrive at a conclusion: there is no question that humans have an incredibly wide range of audio signals with which to intimidate predators and competitors. They drum, they shout, they sing, and not only sing, but sing in harmony - and not only sing in harmony, but sing in the most dissonant, startling, attention-grabbing harmonies. And finally, humans have the sense of rhythm, which was not only an important tool to make their audio display more impressive, but through a specific battle trance it created a psychological transformation from a group of selfish individuals to a closely knit unit of warriors where members were ready to sacrifice their lives for each other and for the common goal.

I do not want to go into the discussion of the amazing variety of war-cries that combatants have universally used and still use in all human cultures. From the popular war cry of Sioux Indians "*Hokahey*" (loosely meaning "today is a good day to die!"), to the "Oorah"of the American Marines and Russian troops during the Second World War, and to the famous Moslem "Allah hu Akbar," the battle cry in various cultures as a rule is shouted at the top of one's lungs in order to raise the spirit of your side and intimidate the opposite side.

The Haka is probably the most widely known example of such a display designed to unite the ranks of a combat unit (or in the famous modern case a sporting team) and to intimidate the opposition. The better that the synchronization is, the stronger the impact of such display is to both sides (performers and their enemies). When we were discussing the power of rhythmic synchronized display, my friend Kristof Kotecha, who provided me with very useful information on man-eating lion habits, sent me his vivid description of the reaction of South African rugby fans witnessing Haka in action for the first time:

"I'm not a particularly avid rugby fan, but when an international match was scheduled in Durban in 1990 prior to the World Cup of 1991, I watched the game together with several my friends. This was the first game after our exclusion from international competitions. Our proud South African Team was facing what we thought were "headless chickens" because they called themselves Kiwis (we did not even know if it was a name of the fruit or the bird)… Well, what would have been a straight-forward win for the springboks (South African team), was becoming a nightmare from the very first minute before the match started when the Kiwis (or as they would call themselves the Maoris) performed a tribal dance with highly noisy rhythmic group singing and their leader with a shaven head except for a small patch on the forehead. The whole stadium was thereafter hallucinated and our South African players too. On that day New Zealand destroyed us 26-0 or something like this, on our own soil! The most humiliating defeat ever, but thankfully not in official competition as it was a friendly."

I would like to add here that, apart from helping winning a friendly rugby game, this kind of highly synchronized intimidating display helped countless of generations of our distant ancestors to win life-and-death encounters with predators and with rival human groups.

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Olfactory Display, or Why do Humans Have Body Odour

Apart from visual and audio signals, aposematism as we may remember also includes an olfactory display, or the display of various smells. Non-aposematic animals try to stay as clear and as odourless as possible. Primary examples of such animals are all species of cats, which are legendary for their cleanliness. Of course, cats are clean not because of some innate strive towards cleanliness – it is their lifestyle and their hunting strategy, based on stealth and stalking, that requires such strict hygiene. A smelly cat has much less chance of hunting success as prey animals can smell their presence.

Male lions have several aposematic elements unusual for other cats, such as their highly visible mane. Also, very unusually for cats, they are less concerned about their cleanliness. As a result, male lions are well-known as probably the worst hunters among the big cats.

Aposematic animals, unlike clean cats, try to advertise their presence by all possible means, and spreading body odour around is one of the most popular means of advertising your presence. This is why virtually all aposematic species have some body odour, some not so strong but some quite overpowering. Body odour, apart from being easily noticeable, also plays the role of negative advertisement, and its message is "see how badly I smell? Do you really want to eat me?"

Also, very importantly for our discussion, in the moments of stress aposematic animals tend to intensify their body odour.

So what about us? Do we have body odour? Some readers might consider our species quite clean and odourless, but in fact we naturally have quite a strong body odour. If you doubt this, imagine yourself staying without a shower for a couple of months, or better, a couple of years. Amazingly, most likely you will not notice your own body odour, but you will definitely notice that people around you are watching you with suspicion. People possibly will also try not to stand too close to you on public transport and in lifts. And now imagine our ancestors who did not have a shower not only for couple of years, but for their whole lives. They stayed unwashed for tens of thousands of generations let alone their own individual lives. It is obvious that our distant ancestors had quite a strong body odour, and we have indeed inherited this body odour from them.

Body odour is directly connected to the sweat that our body produces. Actually, the sweat itself is virtually odourless, but the bacteria that lives on the skin and thrives on the sweat is the real cause for our body odour. It is well known that human bodies have an unusually large number of sweat glands and that we produce more sweat than most other animals. The best known explanation for the function of sweating is thermoregulation, or cooling down the body's temperature. It has been also suggested that sweating can be a pheromonal signal to conspecifics, signalling various states (e.g. fear, sexual arousal, aggression).

The aposematic nature of hominid and early human defence systems suggests that sweating and particularly excessive sweating could be a crucial factor for

creating a strong body odour in our ancestors. The fact that in moments of anxiety or fear humans produce much more sweat and body odour than they do regularly also points to the aposematic nature of human sweating, also since when we are scared there is no need for thermoregulation.

Humans do not only have body odour, we have even developed special morphological means to achieve more effective and stronger body odour. Have you ever thought why humans have patches of hair around their armpits and genitals? It is notoriously difficult to explain the evolutionary function of these seemingly random patches of hair. Some suggested that they were designed by sexual selection to attract the opposite sex (see Kohl and Francoeur, 2002), which is difficult to believe considering how models try to get rid of any remnants of bodily hair, and how people try to conceal their body odour with the use of different unnatural scents. One of the most popular ideas is that pubic hair allows one to identify a human's level of physical maturity. This is also quite suspicious as, unlike many other animal species, humans (and a few other primate species) have sexual desires from a very early age. The idea that humans start feeling libido only when they are physiologically ready to become parents is a misconception with religious undertones. Some suggest that presence of body hair helps to reduce friction when we move our arms when running, and also during sexual intercourse. This suggestion also does not seem to be very realistic. If we allow the idea that humans are aposematic animals, and that having strong body odour was one of our many ways in which to communicate our "warning flags" by different modalities, then it becomes clear that the patches of hair must have been developed for what they are still best at: producing a stronger body odour.

I therefore suggest that these hairy patches on our body appeared as the result of the response to natural selection's pressure on our ancestors to produce stronger body odour. Humans have strong body odour as we needed it during the millions of the years of our survival struggle in the open forested areas and grasslands of Africa.

We have a beautiful cat, Socky. Our other cat, gizmo, died tragically in 2010 at an early age of 10, on the same day our son turned 20 and our marriage turned 22. Like hundreds of millions of other cat lovers, we all cuddle Socky a lot, and we often express our amazement at how it is possible that she is always cleaner than us despite the fact we shower every day and she has never had a shower or a bath in her entire life. This is the difference that comes from the evolutionary rules of natural selection. This is the difference between the representative of stealthy and cryptic predator species, cats, and aposematic species like us humans. Cats need to stay unnoticed for survival, but we needed to advertise our presence by all means, including body odour.

Humans keep a wide array of different animals as pets, some are aposematic (like skunks and peacocks) and some are cryptic (like cats of different sizes). Aposematic pets have their positive and negative sides: they are generally beautifully coloured, as they need to be clearly seen – think of the same skunk or a peacock. On the more negative side of things, aposematic animals might emit disturbing smells (skunk), or a particularly unpleasant voice (peacock). We humans

are clever primates and we have already learned how to get rid of skunk odour glands, and if we ever learn how to get rid of peacock's loud and unpleasant voice, they may also become more popular as pets.

One more suggestion - there are some genetic conditions that cause excessive sweating and may cause excessive body odour. Hyperhidrosis is the medical term for excessive sweating and facial blushing. It is not difficult to imagine the embarrassment and anxiety of people with this condition. Luckily, there are ways to get rid of this condition permanently, which was of course not an option for our ancestors. I think it is possible to propose that this condition could have been much more widespread in earlier periods of our prehistory, when a stronger body odour meant stronger aposematic defence. Therefore, for millions of years our ancestors would have been selected for their stronger body odour. Later however, with the change of lifestyle and improvement of overall species security, we lost the need for excessive perspiration and strong body odour and this feature started gradually disappearing.

We enjoy virtually all the traits that natural selection and our evolutionary granted us as aposematic species: we love our proud bipedal posture, we enjoy our long legs, we enjoy our long head hair so much that if we start losing it, we desperately search for ways to retain or regenerate it; we cherish our talents as singers and composers and pay money to become better at music, we love dancing and can dance for hours to driving rhythmic music, we love body painting, enjoy tattoos, wearing masks at the masquerades and carnivals, we love artistic transformations, and of course we love our clothes (some even too much). In short we love who we are, but there is one element of our evolutionary legacy we try to conceal by all means – our body odour. We shower daily and use plenty of deodourants and various perfumes to mask our natural body odour. It has been many thousand years since we needed our body odour to fend off prowling predators. Many other more effective means of defence and security came into our lives - controlled fire, shelters, and man-made weapons are much more effective than body odour. We should still remember that we needed our body odour for millions of long years and that this evolutionary legacy is not going to easily disappear.

Behavioural Signals, or Stop for Your Life

Behavioural signals related to aposematism are also basically to convey two messages, (1) that the animal does not need to get away from the predator, and (2) if the predator decides to attack, it will soon find out this was a very stupid idea. To convey these messages, aposematic animals walk awkwardly and do not run. When approached by predators or competitors, they also behave very aggressively and they start displaying their warning signals through all possible means (visual, audio, olfactory, behavioural). And last but not least, aposematic animals quite often live in big groups.

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Whatever You Do, Don't Run! Aposematic animals, as I have just mentioned, do not run fast. On the contrary, they often walk awkwardly, giving a clear message to predators that they do not need to run for their lives. Many aposematic animals even stop when they face predators. Earlier, when we were discussing human defence strategies, we have already mentioned how bad humans are at running. Of course, we enjoy watching our best athlete runners, and in the London Summer Olympics that start the day I am writing this, one of the highlights and big showdowns will be the competition between the already legendary Husain Bolt and rising star Yohan Blake. From an animal's point of view, even our human champion runners do not come anywhere close to the speed of the many mediocre-running animals, let alone the fast ones. Forget cheetahs, antelopes or big cats - even the presence of an awkward knuckle-running chimpanzee in the London Olympic final race would have embarrassed the best human sportsmen. Despite our high regard for our athletes, we must accept that humans are bad at running.

Now think of human walking. Of course, our walking style does not seem strange or awkward to us, but if we try to look at our bipedal locomotion from a more objective perspective, we will find that it looks as slow and awkward to animals as a chimpanzee's bipedal walk seems to us. If you look at the "sexy" walk of the models on the podium, you will possibly agree with me that for an objective viewer this kind of "catwalk" walking style must seem particularly awkward and sluggish.

The title of this section is taken from a book by professional safari guide from Botswana Peter Allison. The full title reads: "Whatever You Do, Don't Run: True Tales of a Botswana Safari Guide." The idea of the book and title is very simple: only food runs! So your best option for survival if you meet a big cat or other dangerous predator is to stay still and not to run away.

This advice might sound crazy to some readers. How can it be a good idea not to run when you are facing a dangerous animal like a lion? Some might even remember the joke about a tourist couple who have found a relaxing place during their African safari, and are sitting somewhere next to a river with their feet in the water. Suddenly a lion appears and starts growing menacingly looking at them. The girl starts quickly putting on her runners. "Will not help" says her boyfriend philosophically, "you cannot outrun a lion." The girl, finishing putting on her runners, quickly answers, "I do not need to outrun the lion – I only need to outrun you."

This joke is possibly correct about some boyfriend-girlfriend dynamics. In regards to the lion's behaviour, this joke makes one grave mistake: if the lion from the joke was a real one, and was faced with two human subjects on his territory, one staying in one spot and another running away, the lion would definitely go after the one running! This may sound strange to you, but those who know big cat psychology would agree with me. Here is a first-hand story from a book by Colonel Kesry Singh, professional warden and author of the book "One man and thousand tigers". In this story Colonel Singh wrote how a small party of people, not expecting

to see a tiger at all, was within a few minutes attacked twice by two different tigers. Have a look what has happened:

"On the day after the festival called Dashera we Hindus of the military castes have a tradition that one should go out and hunt something. Because of this conventional obligation I set off at about eight o'clock one September morning with my then employer, the Maharajah of Gwalior, and a small party. It was in fact His Highness' intention to shoot nothing more than a buck or two for the table and, so having fulfilled the duties of his station, return. Because of this he took nothing but a light, small bore rifle with him.

I took the party (we were in a shooting brake) directly to a place called Kuleth about ten miles drive from the palace. This was a preserved area for game and we had no difficulty in coming up with a small herd of black buck consisting of two bucks and their does. Someone in the party had a shot not the Maharajah, I think and missed, as a result of which the black buck galloped away behind a small hill. We followed in the brake, but after a short distance the going became too rough for the vehicle and we had to dismount and continue on foot.

In addition to the Maharajah and myself, the party consisted of a lad called Serje Rao Shetole and two military officers, Colonel Bhow Sahib and Captain Sultan Hussain he who shot the bold tiger that seized his elephant's tail (see page 24). After we had walked a short distance I asked the two soldiers to go off in a slightly different direction towards a point where I hoped they might get a chance if the buck broke back, while the rest of us continued in the wake of the little herd.

Shetole, who was formally engaged to the Maharajah's daughter, walked between his prospective father-in-law and me. He was not more than about twelve years old and naturally quite inexperienced, so that I did not instantly take notice when he whispered that he could see a tiger.

All boys begin by seeing tigers all over the place when they are first taken out after large game, and besides this we were in open country dotted with small bushes, the last sort of terrain where one would expect to find a tiger. In Rajasthan it is essentially a creature of the jungle and close cover.

However, when the boy muttered his absurd fancy to me I muttered back, mildly teasing and making a joke of The Maharajah wanted to know what we were being so confidential about, and when I told him stopped short and asked Shetole to show us what he had seen. Shetole walked back a few paces and when we had joined him pointed to his right where, about a hundred yards away, a tigress, accompanied by two smallish cubs, was sitting on her haunches watching us.

Had I known as much then as I know now I should not have been so confident that we should not encounter a tiger away from tiger-country; nor should I have allowed the boy to point, or any of us to look directly at the animal. As it was we all followed his outstretched arm with our eyes and stared blankly at the tigress, who as soon as she realized that her cubs had been seen let out a regular roar and came for us in great bounds, at the same time lashing her tail in great semi-circular sweeps

like an angry domestic cat. Meanwhile though we had not much inclination to worry about them at the moment the two cubs must have slipped into some low cover nearby, for we did not see them again.

There was no tree in sight and the nearest vegetation more than boot-high was a small thorn bush about three feet tall, a pace or two to our left. As we moved to step behind this meagre protection the unfortunate Shetole, thinking perhaps that we were going to take to our heels, turned and began running back the way we had come. This of course attracted the tigress' attention and she changed course and went after him. Throwing away the little rifle he was carrying, the boy ran as fast as he could until after a few yards he caught his foot on a stone and pitched head first into a clump of dwarf thorns.

This fall was, to put it mildly, providential, for the tigress who was still some little way away lost sight of him and at once turned back towards us. For our part the Maharajah and I, having nowhere to go, stood firm beside our ridiculous bush and awaited events. The Maharajah had the small bore Mauser with which he had intended to shoot antelope and I had the case with his cartridges. As she came the tigress made an absolutely deafening noise and I for one was convinced that here stood a couple of sportsmen who would never harm another tiger. However, seeing us stand firm, she suddenly stopped short about fifteen feet away and crouched as if for a final spring, twitching her tail, swaying her snarling head from side to side, and now and again tearing at the ground with the extended talons of her forepaws. We for our part kept watching her without moving. It was a very bad moment indeed.

After she had been terrifying us in this manner for perhaps half a minute I suddenly swung the cartridge bag round my head and shouted, telling my employer to fire at her. This no doubt relieved my feelings and mercifully for all of us the Maharajah disregarded the ill-conceived advice. As it was, my behaviour proved to be the right course of action, for having no doubt come to the conclusion that we stood at bay and were not unduly frightened of her, the tigress suddenly remembered her cubs and wheeling abruptly round went galloping back to where she had left them.

When she was some eighty or ninety yards away the Maharajah coolly raised his Mauser and took a shot at her. Fortunately it was a clean miss. Speaking very quietly I begged him not to shoot again, since if she was hit the chances were that she would return and make an end of us without further ceremony. Unless the shot were more accurately placed than is usually possible with a rapidly moving target it was highly improbable that one of his small calibre bullets would kill or disable her.

We were undoubtedly well shaken, for it was a moment or two before we remembered Shetole. After a little looking around I saw a thin leg sticking out of a thorn bush and going up to it bade the owner come out. It did not move, so I lent down and touched it, at which it reacted with a sort of extraordinary tremor. The poor boy told me afterwards that he was sure in his panic that the tigress had taken hold of him.

Shetole soon realized who had arrived but his head and shoulders had been pushed so far into the bushes that he could not extricate himself without help. When we finally got him out he stood looking round in amazement and asking what had happened. Rather abruptly I told him this was no time for explanations and that we were going to make for the car as quickly as possible. All I wanted from him was his rifle. But this was exactly what he had not got, having thrown it away in his flight.

So now we began to quarter the ground, hunting for the missing weapon. It would have been disgraceful not to have recovered it, but I began to feel a bit anxious lest our loitering should again attract the tigress whom we could still hear nervously coughing and growling some distance off. Owing to the generally open nature of the ground we soon saw the gleam of the metal lying a few yards away in the direction of some thin cover from which the warning sounds were now coming. It was rather nervous work, but advancing quietly in a group and taking care not to stare or point ahead we approached near enough for me to pick it up, after which we walked sedately away. During the whole time we were looking for the rifle we were careful to make no sudden or rapid movement.

Unfortunately the boy's rifle was no better adapted for stopping a tiger than the Maharajah's. However, I saw that it was loaded and having given the cartridges to the boy tucked it under my arm. Then we all set off in the opposite direction with the idea of working our way round to the car.

But our troubles were by no means over. We had only been walking for a few minutes when we again heard the menacing cough of a tiger not far off. Uncertain of the direction from which it came we halted and looked circumspectly round. After a little the unpleasant realization that the noise lay directly ahead was borne in on us and about a minute later a very large male tiger emerged from behind some low cover, perhaps a hundred yards away, and almost immediately charged. It was like some dreadful dream. I remember that the thumping of his pads as he galloped towards us over the hard baked ground sounded oddly like the ringing noise of hoofs. This was no doubt due to his exceptional weight.

As before we stood close together waiting for him, and this time the lad stood between us solid as a rock. Again, exactly like the tigress whose mate he undoubtedly was, the animal stopped about fifteen feet away and menaced us, swaying his great snarling muzzle from side to side close to the ground and switching his tail, making up his mind to pounce. To forestall this I took a quick aim between his swinging ears and fired. Providence was with us that fantastic morning, for not only did I miss, but the report and the cloud of dust raised by the bullet which hit the earth close to his head, as well as the shout which I let out, evidently discouraged him. After another two or three snarl he turned and cantered back to his cover.

The extraordinary way in which we had been attacked twice within a matter of minutes by two unprovoked tigers, coming from different directions, had given us something of the sensation of being surrounded; moreover our constant changes of direction had left us a little disorientated. We knew that the tiger was certainly ahead of us and that in all probability the tigress was still somewhere not far off to our rear.

On our left we could see a low hill and on our right a river. The best chance seemed to be to make for the hill, although there was enough cover there for the tigers to stalk us, in the hope that the country on the other side would be open and we should be able from the higher ground to find a route back to the shooting brake. In fact this proved to be the case, and within an hour we had reached it unmolested. Bhow Sahib and Sultan Hussain who were waiting for us were chagrined to see us return empty handed."

As it turned out, tigers were new to this territory and they were trying to establish their family's range. Unfortunately, their intended territory was dangerously close to a human habitat, and soon after the described events, violence started. Conflicts were first with the cattle, but later the male tiger started killing humans. We know that these tigers were aggressively defending their cubs and their territory, and still by standing firmly and not running away from the aggressive display of the tigers, these inadequately-armed humans saved their lives. The only person to put himself in danger was a little boy who tried to escape from the charging tiger by running.

Another interesting detail in this vividly described story is the aggressive and clearly aposematic display of the tigers. The tigers did not want to attack and kill them, they merely wanted to keep intruders away from their family territory using their aggressive display, which included roaring and turning their heads to different sides. This is a well-known means with which predators display their fearsome canines to an opponent – by turning the head sideways. Lions also try to intimidate their competitors (mostly other male lions) exactly the same way, by turning their heads to different sides in order to give a better view of their teeth. In the situation depicted by Colonel Singh, the tigers' display was of an aposematic nature. The tigers wanted humans to leave them alone, so running away from tigers could have been a mortal mistake and was, swiftly transforming the aposematic display to a hunter's reflex to chase after a running target.

Peter Byrne, a professional hunter and author who spent several years in Nepal and India, made a very interesting suggestion. In his book, dedicated to the legendary hunter and conservationist Jim Corbett, he wrote that it is very dangerous to ride a bicycle in the region where tigers are living. The reason is that bicycle speed is faster than human walking speed, so from the animals' point of view a human riding a bicycle looks like running. And for predators, as we can recall, "only food runs."

Byrne gives an amazing account of a West Bengal postman who was delivering all his mail for many years on foot. In 1952, in accordance with the postman's increasing age, he was given a present - a bicycle. The postman was very proud of his bicycle but, as it turned out, it almost cost him his life. About six months after first receiving the bike, the postman came to the office one afternoon with visible signs of frustration, left his postbag and bike at the office and went home on foot. People in the office were very surprised by his behaviour and, when he came back

the next morning, they asked him what frustrated him yesterday. Here was his explanation:

"Sahib, he said, "a tiger chased me. It was very frightening. He came out of the bushes and rushed after me and I thought that I could outrun him but he came faster and faster, growling, with his mouth open. The trail is very narrow and so I had to look ahead to see where I was going and could not look back to see him or I might have fallen off. But I could hear him getting closer and closer."

"My God," said Benjy. "Then what happened."

The old man gave us a reproachful look, one that we ought to know what happened, without his telling us.

"I applied the brakes and stopped and got off the bicycle and turned to face him."

"And then?" I said.

This time the look was even more reproachful, clearly indicating that I, who am supposed to be something of a *shikari*, obviously knew nothing about tigers.

"Why then, sahib, he saw that I was a man and not an animal, and stopped and looked at me and then walked away." (Byrne, 2002:292-293)

Many of us would have taken our hats off to the brave postman who had the guts to stop his bicycle and turn towards a chasing tiger - but the old man obviously knew what he was doing. Byrne logically explained this phenomenon and suggested that big cats may be more prone to attack humans on bicycles because they cannot identify the humans by their usual size, upright posture and their usual slow walking, which seems to me absolutely correct. To finish the story, Byrne remarked "the old man, incidentally, spent the remaining of his working days collecting the mail on foot" (Byrne, 2002:293).

Although puma (mountain lion) attacks on humans are rare, cases of pumas chasing and attacking humans on bicycles are well-known of in the USA. In January, 2004 a puma killed and partly ate a mountain biker at Whiting Ranch Wilderness Park in Orange County, California. Only days apart, in the same region, a30-year old woman from Santa Ana was pulled off her bike by a mountain lion. After a tug of war between her friends and the puma, she was rescued by other bicycle riders and was taken to the hospital in a serious condition (Mountain lion kills bicyclist, 2004).

So remember, whatever happens, don't run – seriously.

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Flight, fight or freeze

Have you ever had a nightmare where a terrible monster is approaching, and in the moment in which you need to run away faster than you have ever ran, you suddenly lose the ability to move at all? You are frozen with fear, you are covered with heavy drops of the sweat, and then death seems imminent. What a relief it is when you finally wake up, realizing it was just a bad dream.

Most importantly for our topic, this kind of freezing and losing ability to move happens not only in nightmares. Many victims of violent assaults also report that they were totally immobile while they were subjected to the assault. Some start blaming themselves for being so passive (this is quite usual, for example, for rape victims). Psychologists know very well that this kind of self-blaming is not justified, as freezing in a moment of great danger is one of the most widely-known survival strategies, designed by the forces of natural selection. This response is not a result of our conscious decision, it is fully instinctive.

Many readers would know about the "flight or fight response" in dangerous situations. According to this mechanism, we "fly" from the danger as fast as we can if we have time for this, however if it is too late to run away, we "fight". Apart from these two choices, in a number of animals lies another life-saving strategy – to freeze. So there are actually three options to go with the saying: flight, fight, or freeze.

This might seem quite silly to many readers. To freeze means to stop moving, so the predator does not even need to chase or to fight you, right? How on earth could such behaviour possibly enhance your chance of survival?

To fully understand why this is so, we must remember that most of animals' (and humans are also animals) behaviour was formed during millions of years of trial and error in billions of deadly encounters with predators and competitors, and if there is an instinctive behaviour that seems silly to us, it means that we are in fact being silly and are not understanding the higher wisdom of natural selection. We need to be vigilant and remember that **whatever animals do instinctively, they do it for survival**. Therefore, animals that freeze in critical situations often save their lives with this behaviour. How?

First of all, we must note that there are at least three different behavioural models of freezing that use different strategic aims, and that all three of them were designed by the forces of natural selection in order to increase the chances of survival against predators and enemies. The first one involves freezing at early stage, the second one is based on immobilization, and the third one involves freezing at the last stage of an interaction with a predator.

> **(1)** Some animals freeze before they are noticed by the predator, so by freezing they are trying to avoid detection. Therefore the first strategic aim of freezing is crypsis-based and not an aposematic behaviour. This is exactly what rabbits do: they freeze to stay unnoticed, but start running away as soon as they know that a predator has noticed them. The second strategy of freezing is playing dead. An animal with

this type of behaviour drops down once it has identified a critical situation, and assumes all the characteristics of a dead animal: closed eyes, rigid body, and even the smell of decaying meat. This behaviour is based on an aposematic strategy that tries to convince the predator that the prey has been dead and is in an advanced state of decomposing. The Capybara is a famous example of this kind of deception, and crows also can deceive predators by playing dead.

(2) The third strategy of freezing is also based on the principle of aposematism, but unlike the previous case where the aposematism is of a passive nature (with a message "Do you really want to eat me? You see, your food has gone off!"), the third strategy is an active case of aposematism, in which the prey animal is trying to demonstrate that it does not need to run away. For animals using this strategy freezing means displaying to the predator that they do not need to resort to the "flight" option. In this case, unlike the crypsis-based freezing, animals freeze in the last stage of interaction with the predator – which is when the predator has spotted them and is already approaching.

Animals may use more than one of the above freezing strategies – usually the first and second strategies together, or the first and the third ones. They may freeze when they notice a predator and then later play dead, or they may initially freeze when noticing a predator and later, if the predator approaches, stay frozen and stand still. Humans are quite unique in that they can utilize all three behaviours in different contexts. We may freeze in order to stay put if we notice a lion, tiger or an armed robber in the vicinity. Sometime humans also play dead in order to survive (particularly with bears and shooting sprees). The most interesting for us is the third type of freezing, when we literally cannot move our limbs when suddenly faced with mortal danger (in much the say way venomous snakes and other aposematic reptiles also do not run when they are facing predators). Therefore, even when we are screaming with fear inside and want to run, the most innate and primitive layers of our brain release the strict order to our body "do not move!" – So we freeze. Of course, freezing is not a 100% survival strategy, but we need to remember that alas, there are no 100% survival strategies against predators in nature (apart from killing them). Freezing apparently must have been more effective in some situations than fleeing or fighting was.

Freezing often comes together with other aposematic intimidating tactics, like loud screaming, erecting the hair on the head and the body, sudden precipitation, and even urinating and defecating in the moments of great danger to life. All these instinctive actions are part of the biological defence mechanisms to advertise one's unprofitability as prey to the predator. In dealing with predators our ancestors possibly had an instinctive response based on fight or freeze – this is why in critical situations in which humans are terrorized by a sudden fear, they freeze and are sometimes unable to run away from the danger. Taking into account predators' responses to running humans and stationary humans, our instinctive freezing makes prominent evolutionary sense.

Robert Frump describes this reaction in a personal experience when hearing the roar of a lion in a safe enclosure in Kruger, South Africa: "The wave of sound reverberates first in my breastbone, then locks up some part of my brain and freezes me midstep like a lizard caught in the open on a flat rock. I am not frightened – just frozen. I have no clear idea how that happened" (Frump, 2006).

Frump identifies this instinct as an "automatic antipredatory measure hardwired into our systems" which I believe is true. Frump considers freezing as a part of cryptic behaviour – but this depends. When freezing happens before the predator sees the prey, this explanation is justified, but if freezing happens when the prey has been spotted by the predator, then the freezing most likely is of an aposematic nature. In this latter case freezing works as a signal to the predator that the prey is not afraid and has no need to run for its life. Another example is when you approach a hedgehog: it does not run away, but instead freezes. The hedgehog is an aposematic animal and by freezing it tells all potential predators to stay away.

Human freezing behaviour is one more reminder to us that our ancestors were also aposematic animals who tried to stand their ground against the most feared predators. Even when they were overwhelmed by fear, the freezing instinct was ensuring they would not run away. This was a result of millions of years of evolutionary fine-tuning of our aposematic strategy. The everyday struggle for survival taught to our ancestors that running away was a faulty strategy, usually leading to death.

Some animals are made by the natural selection to flee as fast as a breeze; they are sure-footed and can run long distances to stay clear of predators. Some particularly fast-running animals cannot even fight back, therefore fleeing is their only safety strategy. Think of some lightweight antelopes (for example, Thomson's gazelle) and you will understand what I mean by this category. Other prey animals have both fighting and fleeing abilities, so they can give a powerful kick to a predator but they can flee fast as well. Zebras and wildebeest are from this category. And then there are also some prey species which are built like a tank. As a rule they cannot run fast, but instead have devastating physical strength and fighting ability. These animals are often left alone by even the lion prides and tigers. Different species of African and Asian buffaloes, rhinos and elephants are from this category. None of these animals use freezing as a survival instinct although they do stand their ground firmly.

If we remember here the survival tips from a professional hunter for the moment where you suddenly find yourself facing a lion or other dangerous animal, "whatever you do, don't run," we can better appreciate the wisdom of natural selection: even if we want to run away with all our instincts screaming, natural selection does not allow us to do this. As a wise adviser, natural selection whispers in our ear the best survival advice in critical moments.

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On aggression, avoiding aggression and bravery

Conrad Lorenz made history by noting the survival significance of aggression in nature and in human society. There is no question about this: in the natural world most of the animal species need to be aggressive towards other species, and often even towards their own species. Not only are predators aggressive, but even the gentle herbivores are thought to be aggressive, as they are aggressive towards plants. If you think plants are happy to be eaten, you must remember that they too use different strategies in order to survive being eaten such as thorns, bad taste and poison.

Despite the obvious importance of aggression, the role of true (physical) aggression was a bit too exaggerated by most of evolutionary scholars. In Darwinian times it was believed that aggression and competition was the only driving force behind natural selection – not only were species against each other, but even each individual animal was in a constant war against every other animal from its own species. Natural life was perceived as a continual struggle against all – for food, for territory, for mates.

I already pointed out that one of the central aims of this book is to argue that although direct physical aggression is an important and unavoidable part of life and natural selection, **avoiding unnecessary violence** is even more important than direct physical violence. No animal species tries to fight every single animal around them (both of different and their own species). Such total and continuous fighting would have had disastrous consequences for any species and any individual animal because of the unavoidable injuries. Natural selection wisely substituted the direct physical violence with ritualized fights. Ritualized fights may look like real fights to us, but in fact they are devoid of any use of real lethal force. Similar to modern states that do not want to use their deadliest lethal weaponry in any conflict of interest, animals also try to resort to lethal violence only when it is absolutely necessary.

As a result, non-physical forms of aggression and violence are used in nature much more often than physical forms of aggression and violence. In real life it is often more important for animals to show their aggression by screaming and taking aggressive poses rather than resorting to lethal forms of physical violence. Such non-physical violence, or intimidation, is effectively less costly than violence. Therefore when two animals (of same or different species) face each other as antagonists, it is important for both of them to show that they are tough and are not going to back down, although at the same time neither of them actually want to resort to physical violence.

As a result of this strategy of survival, humans (both from individual humans to the world's biggest states) use the strategy of intimidation much more often than they do real physical violence. We are more used to seeing more scenes of angry people shouting at each other and abusing each other verbally and with gestures, at protests or otherwise, rather than the use of a lethal violence.

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We are masters of intimidating behaviour without using real physical aggression. In some cases our behaviour would hardly seem threatening to us, but to animals our behaviour can seem extremely intimidating. My wife's maternal grand-grandfather's encounter with a bear in the forest is a typical example of such behaviour, of when a scared human instinctively behaves aggressively. Still a young man, he looked up a tree and saw a bear on the tree branches, staring down at him. Profoundly frightened, he followed his natural instinct and screamed as loud as he could (I am sure that simultaneously, and subconsciously, he raised all the hair on his head and body, and widely opened eyes). The bear, frightened from the sudden reaction, defecated from the tree branches, fell out of the tree and ran away. The bear reaction proves that it is not only humans who defecate or urinate when experiencing great fear or shock.

But of course, apart from this kind of instinctive reaction that seems aggressive to most animals, humans are also quite courageous in situations that many other animals would not behave as fearlessly in. Virtually unarmed members of pastoralist tribes in Asia and Africa, for example, routinely defend their cattle from much bigger predators (like lions and tigers) with their brave behaviour and hollow threats, like shouting and waving their arms.

Courage is an expensive virtue – fearless warriors die more often than their more cowardly compatriots. Possibly most importantly for our discussion, bravery is a very important element of the behaviour of all aposematic species. As we have already discussed, aposematic species do not run away from a threat, but on the contrary often face the threat and try to behave aggressively even in the face of much bigger and stronger opposition. This is the very nature of aposematism. If we had to have a contest to find the bravest animal, many readers would possibly bet on lions or tigers winning, and this is understandable in the light of our reverence towards these majestic big cats. But despite my love and high regard of the biggest of the big cats, I have to state that lions and tigers could not really compete in courage with some other aposematic animals. Take for example, a Norwegian Lemming, a small rodent that we discussed earlier as one of the aposematic species. Unlike lions and tigers that usually run away when seeing bipedal humans in the wild, lemmings, which are more than 1000 times smaller than lions, do not run away from approaching humans – they instead try to jump up and bite them. Of course the aggression from lions and tigers seems to us much more impressive over that of a small rodent who could only scratch our fingers or leave tooth marks in our shoes. However you may agree with me that bravery should be measured by taking into account the size and power of the conflicting animals, thereby rewarding animals for "biting off more than they can chew". We all know the famous epithet "lion heart" for the bravest human warriors, and most of the readers would probably laugh if I were to suggest using another epithet for particularly brave fellow humans – "lemming heart." If taken objectively, and particularly in the light of their respective size and weight of the 200 kg lion and 130 gram lemming against a human, the lemming must be declared as much more courageous than the lion.

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Battle trance and collective identity

We have already mentioned several times probably the most important survival tool of our human ancestors – the specific altered state of consciousness which I called in my 2011 book the "battle trance." This is a mental state that allowed hominids and humans not to feel any fear or pain in a critical situation and to show absolute, selfless dedication towards the interests of kin, military unit, religion, or state. In this state of mind humans lose the feel of their individuality, and literally obtain a new, collective identity. In this new state they feel themselves as a small element of a much larger entity. In this state humans stop questioning orders or judging behaviours of their group members; instead they follow others in the most literal and rigid way. In this state humans act in total disregard of their "common" sense. This change of personality can be so intense that, after experiencing the battle trance, group members may experience partial or full amnesia and may not remember their actions. The state of battle trance was appearing in groups of hominids and humans in the most critical moments of survival, chiefly in combat situations against predators or enemy human groups.

The presence of the altered state of consciousness is quite well known, particularly within the military. Barbara Ehrenreich wrote: "The difference between an ordinary man or boy and a reliable killer, as any drill sergeant could attest, is profound. A transformation is required: The man or boy leaves his former self behind and becomes something entirely different, perhaps even taking a new name. In small-scale, traditional societies, the change was usually accomplished through ritual drumming, dancing, fasting, and sexual abstinence -- all of which serve to lift a man out of his mundane existence and into a new, warrior like mode of being, denoted by special body paint, masks, and headdresses" (Ehrenreich, 1997:10). "Recruits obtain the first taste of collective identity in the peace time, during the long drill sessions. It is the rhythmic unity of a large group of humans, stomping together, that gives the feel of enlarged ego, or more precisely, shrinking of ego and becoming a small part of a much bigger entity" (MacNeil, 1995). This feel of a new larger unity is the force behind the unquestioning following of military commands, sometimes even in cases where the orders are to shoot civilians. Many scenarios throughout history have also taught us that a small number of drilled soldiers can defeat a much bigger army of undrilled and unprepared opposition.

Let us now try to trace the hypothetical origins of this specific altered state of consciousness. The origins of this mental state in mammals most likely were developed from the female dedication toward her offspring. When parental (particularly motherly) care became crucial for the survival of a new generation, natural selection wisely re-evaluated the grand scheme of the hierarchy of instincts, and put the instincts of survival for the newer generation higher than the instinct of self-survival. Of course this happened via the process of natural selection, in which the genes of dedicated mothers were propagated to the next generation better than those who would think of their own survival first and not of their young. This is why the dedication of mothers in many animal species is total and absolute – for the

millions of years mother animals were risking their life for the life of their offspring. Even today, the most dangerous situation for a hunter is to deal with a nervous mother who is defending her cubs. In this case if a mother attacks, they usually do not waste time on giving or perceiving an aposematic display and go straight into lethal violence.

The simplest case of putting a human in a state of battle trance still arises when a child is violently and suddenly attacked in the presence of a parent. In this extremely emotional moment humans cannot think rationally. There is a momentary switch in the brain that turns a rational and thinking human into a furious bundle of nails and fists without any reservations or fear for his or her own health and survival.

Many scholars believe that this kind of self-sacrificial dedication can happen only with members of one's own kin. This is the "kin selection model" of altruistic behaviour, proposed by William Donald Hamilton, but the situation is not as simple as it may seem. The complexity is brought by the fact that such selfless actions may be directed to save someone totally unrelated to the fighting person. Humans are known to fight without fear for their pet dogs and cats, receiving horrendous bodily injuries in the process.

Sex and hunger are often considered as the strongest instincts, but escaping predators is stronger – and helping loved ones to escape danger is even stronger than the instinct of self-survival and escape from imminent death. In truly critical moments of life and death, humans often behave for the good of others, sometimes even without any rational explanation for their motives.

We humans often prize ourselves as thinking animals, but in the most critical moments of life when our life is in imminent danger, we cannot think rationally and we just follow instincts. This is why we can sacrifice our life not only for our children (biologically the most obvious reason), but for our loved ones, for our friends, for our country, or even for our religious ideals. Despite the bad publicity humans are generally getting, we are wired by the powerful forces of natural selection to be concerned primarily for the safety of our loved ones, not for that of our own. Humans often behave the most altruistically when in the most critical situations for survival. Altruism and compassion, although often laughed at and dismissed as unwanted and dangerous features for individual success, are at the very core our human hierarchy of instincts (Keltner, 2004). It is good news that there are scholars who take human altruism and compassion seriously into account – even such ostensibly unconnected spheres such as compassion and business are sometimes the topic of scholarly discussion (see for example, on the internet: The Compassion and Business Conference, organised by Stanford University's Centre for Compassion and Altruism Research and Education, scheduled to start in less than a week on April 30th, 2013).

Unfortunately, apart from the selfless dedication towards the health and life of others, the battle trance has a negative side as well. The negative part of the battle trance is that in this selfless and altruistic state, humans can perform the most horrendous violent acts as well, such as shooting civilians or participating in mass

murders. This may sound unbelievable to some, but self-sacrifice and mass murder are two sides of the same coin, the coin that puts the interests of your group, your collective identity higher than anything else, including the interests of your own survival, common sense, and the basics of human morality.

Any useful behaviour must be rewarded in order to stay in one's memory. Just being useful in the long term does not help the memory and does not really incite behaviour with altruistic elements. We need the feeling of pleasure, a notorious "instant gratification." If you have ever trained a dog or a cat you would know how long it takes to teach them to behave appropriately in certain situations. But who was training animals or our human ancestors many years ago to teach them the basics of social behaviour and instill an altruism that actually goes against their instinct of self-survival? And what could have been used as a reward in the process? The trainer was of course: natural selection. The reward (apart from staying alive) was a neurochemically induced incredible physiological pleasure, feelings of euphoria as their personal selves dissolved into collective identity. In this state of collective identity one suddenly felt larger, stronger and without any fear or pain. This coveted feeling can be experienced if you have been a member of a religious group, or a military unit, or a sporting team. This is the feeling that many humans experience when their state declares war, or when they listen to their national anthem after their national team wins. By its intensity this is not a battle trance yet, but the thrilling feel of belonging to a bigger social entity is based on similar mental mechanisms. The battle trance is just the ultimate, most dramatic expression of this mental state in the spectrum of collective identity. The battle trance is able to totally override our selfish interests up to the point of sacrificing our lives for the lives of others or even merely for some abstract ideas.

Now let us discuss the reward used while teaching altruistic behaviour to naturally selfish individuals. In the book "War is a force that gives us meaning" Chris Hedges persuasively wrote about the feeling of war and battle being akin to a "powerful drug," something that is well known to many veterans of combat operations: "The rush of battle is a potent and often lethal addiction, for war is a drug" (Hedges, 2003:3). This incredible feel of euphoria is achieved by the release of different neurochemicals into our brain. I am not going to discuss all the neurochemicals that possibly induce this feel, but the participation of neurochemicals is obvious. According to the available literature, oxytocin might be the most important neurochemical that was (and still is) activating the feel of belonging to a larger entity. Known as a "trust hormone," oxytocin is a perfect tool to feel the strength of social bonds, bonds that may lead to leaving your own self to obtain another, collective identity.

Oxytocin is released in our brain on number of activities, such as (1) giving birth, (2) breastfeeding, (3) grooming, (3) dancing together, (4) singing together, (5) praying, (6) sexual arousal and orgasm. Through the increase of trust and reducing of fear oxytocin seems to facilitate even the healing of wounds (Gouin at al., 2010)

It is not accidental that oxytocin is sometimes referred as the "trust hormone" and sometimes as a "love hormone." If we have a look at these activities, we can

notice that they all represent moments of life when we are closely connected to other members of our society.

(1) Release of oxytocin when giving birth establishes the positive bond between mother and her offspring (Lee et al., 2009). The presence of oxytocin at birth must have played a particularly important role in the animal species where the vigorous care given by the mother was crucial for the survival of the offspring (particularly within mammals and birds).

(2) Breastfeeding is another crucial activity that links mother and child in the most intimate and personal way, via body contact and receiving/giving food from one organism to another.

(3) Grooming each other establishes a strong social bond between the grooming individuals, and the time spent in grooming each other directly correlates to the strength of the social bond between the individuals. Studies of primates provide ample evidence of the strength of grooming as a social bond (for example, see de Waal, 1989, 2001)

(3) Dancing together in united rhythm, particularly in religious rituals and before combat situations, establishes a strong bond between the participants (McNeil, 1995). We should remember here that dancing together in united rhythm is a uniquely human behaviour, as the sense of rhythm and the ability to be entrained, according to our present knowledge, is not present in any other animal species. Even a human dancing to an internal or external rhythm alone can experience this feel of entrainment and belonging to a larger entity, as rhythm is one of the strongest agents of social bonding in humans;

(4) Singing together, as a rule, is also united rhythmically, and like dancing it also creates the feel of entrainment. Also similarly to dance, a lone singer can experience the feel of establishing a connection with a larger entity (for example, with God). Poetry and mantras, due to their **rhythmic** nature, are particularly powerful in creating a feel of belonging to a much larger entity.

(5) Sexual arousal is another important activity that is mostly connected to the interaction of more than one individual and the release of oxytocin is very natural for sexual arousal and orgasm.

Such human social sentiments, like patriotism and religious belonging, are primarily based on this ancient instinctual desire to experience the intoxicating feeling of collective identity. Situations stressful for survival are powerful incentives to induce the battle trance and collective identity, and to enhance fervour. This is the reason why feelings of group identity, religious fundamentalism and patriotism are becoming particularly strong in the moments of big national or religious upheavals, including wars and natural disasters.

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The very fundament of human religion is based on the feel of collective identity. This is why every human religion is offering to its followers an understanding of our humble role in the larger picture of life, where individual lives are only small particles of a Grand Scheme. The exhilarating religious feel of belonging to a larger-than-life cause has its roots in the ancient rituals and the altered states of consciousness of the battle trance. This is also why the ritualistic actions that lead to the induction of the battle trance are so universal and so similar to religious rituals.

Let us now sum up the characteristic features of the battle trance, based on seven elements:

(1) Battle trance is a neurochemically induced altered state of consciousness where humans lose their individual identity and acquire a group identity;

(2) Battle trance usually appears when we find that someone or something (a person, group, animal, country, idea) we love is in a mortal danger;

(3) This state is characterized by total neglect of fear, pain, and humans can experience an increase in physical strength;

(4) Instincts of self-survival and self-preservation, as well as notions of calculated "common sense" do not apply in this state of mind. In this state humans are unable to judge or question their group members' or their own behaviour;

(5) People can have a full or partial loss of memory of the events conducted in the state of the battle trance;

(6) This state can be achieved instinctively and instantly when sudden danger arises, or alternatively it can be induced by ritualistic actions, using rhythmic singing, chanting, dancing, body painting or use of masks.

(7) People can go into the battle trance both individually and in groups, of both men and women.

Next we are going to discuss the emotions involved in attachment and love. As we will see, love is the central force that gives us courage and determination to fight for others, so to discuss the mechanisms of the state of the battle trance and collective identity without discussing love and sexuality is simply impossible.

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Human sexuality, homosexuality and bisexuality, or who can defeat 300 Spartans?

It is becoming increasingly obvious that human sexuality is much more than a mere tool for procreation. Contrary to the popular misconception that humans develop their sexuality during the puberty, humans have sexual desires from the moment of their birth. Some suggest that even while in the mother's womb a baby is already having orgasms. Humans can also have lifelong desires towards the individuals of the same sex, or sometimes even towards inanimate objects, which does not make any sense in procreation.

Hardly any other sphere of human psychology and behaviour commands such widespread public and scholarly interest as sex, and yet it is still so badly understood. Even after the Freudian theory, which put sexuality in the very centre of human psychology, the famous Kinsky Report came as a shock to many. For us the principal question is whether sex was a vehicle for competition between humans for mates and procreation (Darwin, Miller), or if sex was a tool for cooperation between the early hominid and human groups until the late introduction of monogamous families. American Evolutionary biologist Joan Roughgarden proposed that sex was primarily used for social cohesion, and even suggested the original altruistic model of "social selection" which she believes should replace the selfish model of "sexual selection" (Roughgarden, 2004). She was severely criticized by colleagues but it is certainly true that love is probably the most altruistic emotion, a cornerstone of human sociality. It is not accidental that in all religions the climax of religious feel is presented and described as "love." I do not want to go into details of this incredibly interesting sphere, but in relation to our subject I propose that the intense feel of attachment that love produces between humans has very strong connections to the powerful state of the battle trance. The issues of homosexuality and bisexuality are of crucial importance to this discussion – let me briefly address them.

As a young person raised in the largely homophobic Soviet Union, where homosexuality was a criminal offence, I also considered that sex between individuals of different sexes was the only normal and natural way of interaction. Sexual arousal between the individuals of the same gender seemed a dead end for survival and an unjustified waste of human feelings. This logic seemed so obvious that hardly any argument was given – because of this homosexuality seemed like a corruption of nature. As part of the Soviet intelligentsia, I was against the criminal charges that state put on homosexuals, but still considered it to be somewhat against the "rules" of nature.

Much later, after my migration to Australia and the widening of my spheres of interest into evolutionary topics, I found out that this simply was not true. Plenty of animal species are apparently engaged in homosexual relationships. Elephants, penguins, bison, giraffes, foxes, dogs, cattle, goats, horses, domestic cats, lions, chimpanzees and bonobos, dolphins, and whales are only a few representatives of the strong list of 500 species that definitely exhibit homosexual behaviours. A larger list of about 1000 more animal species may soon be added to the list of confirmed homosexually-behaving species. This list includes not only mammals, but also fish,

birds, amphibians, reptiles, and insects (Bagemihl, 1999). These findings shatter the "Sex for procreation only" idea to the very core. How can animals be homosexuals and waste their precious energy and resources on such an evolutionarily useless thing as homosexuality? Possibly with animal homosexuality we are dealing with only several individuals who do not represent a healthy portion of the population? No, we are talking about the behaviour of absolutely healthy animals – the whole species, not just deranged individuals. Homosexuality is present in every phylum of life, making this behaviour well-established and absolutely "natural" for natural world. The idea of calling something "unnatural" when most of the natural world is engaged in this kind of behaviour is against the primary law of science – the law of accepting existing facts.

The presence of homosexual behaviour among animals was mostly neglected for many decades. It was not until the 1990s that scholars started noticing the widespread presence of homosexual behaviour in the natural world (Bagemihl, 1999; Terry, 2000). It seems quite safe to propose that our knowledge of the homosexual behaviour in animals will rapidly progress during the next few decades. It is therefore likely that there will be many more animal species to "come out of closet" of homosexuality and join the growing list of homosexual animals.

Here we must make a very important correction. I probably should have said from the very beginning that it is not homosexuality that is so prevalent among animals, but rather **bisexuality**. All these lions, elephants, penguins and cats as a rule are interested in sexual partnership both with individuals of the same and different sexes.

Another quite amazing fact about animal sexual relationships is that for many animals, homosexual relationships seem to be much more important in their life than their straight heterosexual relationships. Elephants are an excellent example for this. When male elephants are in a homosexual relationship together, they form an intense friendship that can last for their whole lives. On the contrary, the same male elephant's interaction with fertile females has a very fleeting nature and it is over basically when the heat is over. As a result, male elephants are much closer to their homosexual partners than to their female mates. The social function of sex in such species is virtually impossible to reject. A crucially important characteristic of homosexual behaviour is that it is prevalent amongst social animals, particularly with birds and mammals.

Raising questions over the historical and even causal link between sexual reproduction and the establishment of social bonds seems to me very natural. It seems to me that there is a good reason to believe that forging social bonds through physical contact between living organisms could have been the initial force that later gave rise to sexual means of reproduction. First and foremost we need to take into account that sociality and grouping was present (and is still present) among the most primitive living organisms, unicellular prokaryotes, species like bacteria, who lived hundreds of millions years before the appearance of the most primitive cellular organisms (eukaryotes) and long before the sexual means of reproduction. Prokaryotes, the most primitive known living organisms, show complex social

behaviour when they are in groups (Connell at al., 2010). See, for example, what West at al., wrote in 2007: "Our understanding of the social lives of microbes has been revolutionized over the past 20 years. It used to be assumed that bacteria and other microorganisms lived relatively independent unicellular lives, without the cooperative behaviours that have provoked so much interest in mammals, birds, and insects. However, a rapidly expanding body of research has completely overturned this idea, showing that microbes indulge in a variety of social behaviours involving complex systems of cooperation, communication, and synchronization." Therefore, social behaviour is by no means an exclusive characteristic to higher forms of life but on the contrary, sociality was present in the most primitive life forms that were formed on earth some 3.5 billion years ago. And let me repeat once again: sexual division did not exist at that stage of evolution.

The presence of sociality among the most primitive life forms of our planet provides strong support to the suggestion that sociality and bonding played a crucial role for the later development of sexual reproduction. The appearance of this "sex out of bonding," or if you like this way more – "bonking for bonding" hypothesis seems inevitable to me.

Let us return to human sexuality. It is still difficult to discuss this topic in its entirety and to identify the objective nature of human sexual preferences, as in some countries homosexual relationships are still a criminal offence and people committing this crime are put to death. We need to remember that all major western religions ban homosexuality as an unnatural, immoral activity. Even in the contemporary western society, where homosexuality and bisexuality have become more or less accepted, it is still viewed with a certain awkward social taboo. I remember when our conservative American acquaintance complained that the new democrat president of the United States (Bill Clinton) allowed homosexuals to enter American army in 1993. The conservative opinion, expressed by our guest, was that this would soon have disastrous consequences for the health and fighting spirit of the American armed forces.

If any readers of this book also think that allowing homosexuality among combatants can degrade the warriors' fighting spirit, I would like to remind them that many of the most successful warriors of human history were confirmed homosexuals, and that there were armies that were using homosexuality as a method with which to boost the fighting morale of the members. Sound unbelievable? Here are the facts. Arguably the most dedicated human warriors from the Ancient Greek history, the "Sacred Band of Thebes" consisted of 150 homosexual couples (300 warriors). So in order to become a member of their elite corps, a warrior had to have a homosexual lover – absolutely no straight warriors were allowed! And what was the result of this kind of policy, could they fight efficiently? Oh yes, they could fight.

The amazing force of the Sacred Band of Thebe warriors was tested against some of the toughest opponents in the history of human warfare: the elite Spartan warriors in the height of Spartan military hegemony. The soldiers of Thebes and Sparta were in opposing camps during the Hellenic Wars for hegemony, and they had to face each other in mortal combat. The Theban warriors had two engagements

against the Spartans which were crucial for Ancient Greece. In the first encounter, the battle of Tegyra (375 BC) the Thebans defeated the Spartan army. Even more sensationally, the Spartan army had out-numbered the Thebans 2-1. This battle had a tremendous symbolic significance in ancient history as the Spartans had never been defeated before in such circumstances. This is what the flabbergasted Plutarch wrote about this battle in the 17th chapter of "Pelopidas":

"For in all the great wars there had ever been against Greeks or barbarians, the Spartans were never before beaten by a smaller company than their own; nor, indeed, in a set battle, when their number was equal. Hence their courage was thought irresistible, and their high repute before the battle made a conquest already of enemies, who thought themselves no match for the men of Sparta even on equal terms. But this battle first taught the other Greeks, that not only Eurotas, or the country between Babyce and Cnacion, breeds men of courage and resolution; but that where the youth are ashamed of baseness, and ready to venture in a good cause, where they fly disgrace more than danger, there, wherever it be, are found the bravest and most formidable opponents."

Then there was the second battle, the strategically crucial Battle of Leuctra. It was fought four years later, in 371 BC, and again Spartan troops were outnumbering the Thebans. 300 members of the Sacred band of Thebe were again positioned straight against the Spartan elite force of 700, led by no one else but the Spartan king himself, Agesilaus the 2nd. Not only did the Thebans defeat the Spartan army (killing 400 of them), but they even managed to kill the Spartan king in battle, putting an end to the military dominance of Sparta.

This is how an army of homosexuals fought.

The Sacred Band of Thebes was an undefeated force in Greek history until the appearance of the ingenious military invention of the Macedonian phalanx. In 338BC The Sacred Band of Thebes had a tough war against the Macedonian army, led none less but Philip II of Macedon, together with his son Alexander the Great. This was the battle of Chaeronea (338 BC), in which the Thebans lost and were totally annihilated in a direct fight against the Macedonian phalanx. According to legend, Philip II, profoundly impressed by the courage of Thebans, built a monument, a huge statue of a lion, dedicated to the Sacred Band of Thebes (ironically enough, lions are also known for their homosexuality). The statue still stands at the original site of the battle, near the village of Chaeronea.

I am quite sure that many readers of this book know about the heroic deeds of the Spartans, their most recent (and somewhat embellished) portrayal being in the 2007 film "300" about King Leonidas and his 300-strong army of Spartans fighting off the Persian armies at Thermopylae, showing their inhuman fighting skills, legendary courage and dedication towards each other. On the other hand, I am not sure how many readers knew about the existence of the Sacred Band of Thebes before reading about them in this book. So, here is some food for thought: we have on one side the 300 Spartans, legendary fighters of Ancient Greece, portrayed in several blockbuster films, and on the other hand we have 300 fighters from the Sacred Band of Thebes, similarly legendary warriors, who on two crucial occasions, in direct fights, defeated

a more numerous Spartan army, but for some reason we do not have a single film on the 300 Thebans. I wonder if this neglect of the finest warriors of the ancient world is directly due to the widely-known fact of the homosexual love between those warriors in the Sacred Band of Thebes.

Possibly the most ironic part of this situation is that, according to some sources, Spartan warriors were also boosting their morale by homosexual love between warriors (Hanson, 1994: 124), albeit their homosexuality was not as much advertised in Ancient Greek history as the homosexuality of the Theban warriors. Ancient Greek historians and philosophers were divided on the issue of using homosexual love as the force of raising fighting morale – for example, Xenophon took a very negative view on this approach. The fact that in Ancient Greece military homosexuality was widely practiced (and even applied for practical reasons) is gradually coming out to the general public. I hope that I will be able to see a film on the legendary 300 Theban warriors and their fantastic wins over the famed Spartans in my lifetime. If this was to happen, the Thebans will win another important battle almost 2400 years after their demise – this time being the battle for liberating human sexuality.

Now let us look at the force that destroyed the Theban warriors – Alexander the Great and his father King Phillip the 2nd. I remember reading a review on a recent film about Alexander the Great that criticised the film for portraying Alexander as bisexual. Well, Alexander was not only engaged in bisexual love affairs but arguably the greatest love of his life, Hephaestios, was a young man and not one of his women. Furthermore Alexander's father, the King of Macedon Philip II, learned his military skills with Theban warriors, most probably as a young homosexual "eromenos" to an older and more experienced "erastes" warrior. The homosexuality (or more precisely, bisexuality) of Philip II of Macedon is quite well documented. With these interesting historical facts of both the defeat and annihilation of the legendary Thebans by Phillip II, and that of his fascination in the courage of Theban warriors, gives the topic interesting new overtones.

We can also recall here that Ancient Greek mythic heroes were also known to engage in homosexual activity. Possibly the greatest of them, Achilles, was also a homosexual (or more correctly a bisexual) and at least several ancient Greek writers mention this, including Plato. It was Achilles' famous rage over his slain lover Patroclus that changed the fate of the Trojan War and led to Achilles' own death. We know from history (and certainly from world literature) that some wars started due to the love between a man and a woman, sometimes members of different royal families. With the history of the Trojan War we have a fine example of homosexual love starting a war and changing the course of history.

I hope that after reading this short list of facts on the bravest fighters of ancient Greek history (both real and mythic), some skeptical readers will re-arrange their negative attitude towards homosexuality in the military. I do not think the western world will ever get to the point of accepting the Theban model of an elite military force consisting of only homosexual pairs, but the fact that homosexuals and

bisexuals can be excellent warriors seems to be proven by human history beyond any reasonable doubt.

Therefore we have good reasons to believe that homosexuality and sexual activity in general could have had an important function for bonding individuals both in animal species and in human groups. Sexuality-based bonding between individuals of same and different sexes was helping to foster the survival of the most socially dedicated animal groups, including our ancestors. This must be the reason why homosexuality and bisexuality were and still are so prevalent in social animals and in human societies. This is also why some of the most celebrated fighters of human history have been spurred on by homosexual love. It would be also logical to propose that homosexuality (and bisexuality) must have been much more prevalent and more acknowledged in earlier, pre-Judeo-Christian religion human societies as there were no strict moral and religious guidelines, obstructions and condemnations to this absolutely normal condition and behaviour of living organisms. If we recall that social interactions through physical touch were present among prokaryotes, a time when there was no sexual division of living organisms, we will come to the interesting conclusion that the first instance of sexual behaviour came from the social interactions of asexual organisms.

In the light of homosexuality (or more correctly, bisexuality) being so prevalent and so important in fostering bonding within social animal groups, it is more probable that it was sociality that triggered the appearance of sexual behaviour, first as a means of bonding among the prokaryotes, and later leading to the formation gender differences and the sexual means of reproduction among the evolving eukaryotes. According to this suggestion the initial body-touch- based bonding sexual games must have been naturally limited to homosexual activities. As gender segregation and development of sexual means of reproduction came much later, the initial sexual-bonding games were conducted between the same sex (or more correctly – genderless individuals). According to this suggestion both homosexuality and bisexuality has been an important part of natural selection in many animal species, particularly in that of social animals. Here I must note that the idea that sexuality and sexual reproduction were initially formulated as a means of social bonding was first proposed by Nino Tsitsishvili, an ethnomusicologist and evolutionary musicologist, during an informal conversation on June 29th, 2012 as a probable origin of the sexual division of live organisms.

Taking into account the uniquely social human nature, it is not accidental that homosexuality is so prevalent in human societies. Only later, with the development of much larger social groups, the creation of such unnatural entities as states and major state religions, human pan-sexuality became the central element of the religious "sin." It is possible that this targeting of sexuality as a "sin" or "taboo" was a tool, instinctively designed by states and major religions to divide the members of smaller, blood-related human bands from each other and to unite them in their imagined societies of ethnic states and Empires. What we know for a fact is that most major religions ban virtually all sexual activities that do not lead to conception. Homosexuality, bisexuality, sexual activity among teenagers, transgenerational sex, fetishism, promiscuity, group marriage and masturbation were all declared anti-

ethical and unnatural. Various punishments were designed, many based on the public execution of all parties involved. It was not accidental that in the atmosphere of considering sex an original sin, the complete absence of sexual activity, or keeping celibate, became a sign of particular moral virtue and wisdom. Some founders of major religions were portrayed as living their life completely without sex, or without sin. Some religious heads are supposed to live their lives without sex, and at least one founder of a major world religion is believed by its followers to have been even conceived without any sexual means of reproduction.

If we take into account that sexual activity is widely used in the natural world for the establishment of bonds in social species, we will understand that many of these bans imposed on human societies by major religions must have led to severe and lasting psychological trauma within certain humans. We need to keep in mind that humans are by their nature more sexual than most social animals, even the ones who practice homo- and bisexuality. The extent of sexual activity in humans is apparent when we take into account that human children are universally engaged in sexual games and have sexual desires from an early age. Unlike the young of many other animals, who do not exhibit sexual interests and desires until adulthood, humans have sexual arousals virtually from the time of birth, and children have been known to be engaged in sexual games, masturbation, and even sexual intercourse. In some societies (for example among Bushmen) sex between children was considered very natural [Ref :]. Of course, when European missionaries came in contact with Bushmen and learned their traditional behavioural rules, the sexual freedom was a clear sign to the missionaries of their moral decay and barbaric state of society.

Many religions consider humans "naturally sinful." It is quite fascinating how we declare things that happen in nature unnatural and then consider the human-created rules being the highest authority. Well, the trouble is that even if we try to follow our own rules, we will still face serious problems as major human religions cannot agree exactly what activities should be classified as sinful and what should be counted as permissible. For example, is drinking alcohol, eating meat or marrying more than one woman a sin? Well, we know that existing religious and cultural contradiction is one of the forces that divide our world today, leading to aggression and resentment of the cultures of "others." On the other hand, the rules of the natural world are quite straightforward: sexuality is a great bonding force and is widely applied in nature in non-reproductive sexual activities. There are possibly no social animals that do not use sex for social purposes.

We are profoundly social animals, we cannot stand silence, we love singing together, dancing together, we even prefer watching comedies while hearing other people laugh, we talk to ourselves and have TV on all the time just to avoid any gap of silence, yet we are banned from the most natural things of our evolutionary heritage by our cultural and religious values. As a result of these unnatural bans, we suffer from the discrepancies between our natural desires and cultural norms, and as a result we try to fulfill our desires in our fantasies, in dreams, and through different forms of arts.

Imagine forcing bonobos to follow the human moral rules of sexual interactions and banning them from the bisexual and trans-generational promiscuity they actively follow today. This will be the shortest way to turn these happy and peaceful primates, possibly our closest living relatives, into deeply unhappy and aggressive animals. This is most likely what has been done to humanity. It is no wonder that Freud could explain virtually every human fantasy and allusion by means of our banned and thus unfulfilled sexual desires [Ref : Freud].

In a recent study of suicidal attempts in Israel, an alarmingly large percentage of religious homosexual youths attempted suicide, about 20 times more ratio than the general population (Study: Highest Suicide Rates Among Religious Homosexuals, 2012, 5 September). It must surely be the inevitable conflict between religious faith, with its condemning homosexuality as a sin, and natural homosexual desires that provides such a lethal psycho-physiological recipe for disaster to young religious followers.

It is quite obvious that human societies and cultures are gradually becoming more open, and many more humans will be able to fully open their sexual potential as we progress in time – but there is still long way to go. Remember that the Kinsky report was met with public disbelief, and a film about 300 Thebans is yet to be made. This will take long time, as moral codes instilled in our brains by our societies, traditions and cultures are not easy to change. Using myself as an example, even my strong scholarly understanding of the role of sex in nature and human evolution does not help, and I have to confess that it is difficult for me to imagine myself in anything other than a heterosexual monogamous relationship.

I hope that readers can see the clear link between human homo- and bisexuality and the phenomenon of the Battle Trance. We go in the battle trance easier and disregard our personal safety when we truly love those who we need to fight for.

"I love you:" The true meaning of the important words

Charles Darwin once asked a very serious question to himself in his diary: "What passes in a man's mind, when he says he loves a person?" (Desmond & Moore, 2004: 278). Unfortunately, Darwin never came back to discuss this non-trivial issue in his books, even in his book dedicated to sexual selection.

Now, from the new perspectives given above, from all forms of sexuality as the means of strong bonding between individuals to the all-consuming fatal passion of the battle trance, we can possibly now answer that difficult question that Darwin asked in his diary. So I suggest that when humans say "I love you" the message is very simple and at the same time very profound. It means the following:

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"Your life is more important to me than my own life. You give my life meaning, and I am ready to die for you."

And when we are ready to die for each other, we feel immortal, and that is the only true love. Only when you are in love you have the feeling that there is something in your life that is much bigger and important than you are, and when you have something bigger than your own life your life has meaning and you are not afraid to die.

Not many readers may agree that our words "I love you" have such a profound meaning to many of our fellow humans. They are most probably right – we do not often need to risk our lives in order to save our loved ones; our life became too safe for such heroic deeds to remain commonplace. But for our ancestors, with their everyday physical struggle for survival and with their constant interdependence on each other, the feeling of love and trust had indeed a very deep meaning. Possibly the closest that comes to the feelings of our hominid ancestors towards each other in contemporary life is the internal friendship and love that members of combat units have for each other. As Sebastian Junger remarked, "The willingness to die for another person is a form of love that even religions fail to inspire, and the experience of it changes a person profoundly" (Junger, 2010:239). We can probably argue that religion also has the power to bolster such profound feelings of love and attachment. These parallels are the result of the fact that both religion and war are based on putting humans into a collective state of mind.

For our hominid ancestors, love was not a romantic feel of heartache – it was a way of life, and this profoundly deep love was expressed without any words. According to Albert Mehrabian from UCLA (Mehrabian, 1971), an expert on verbal and non-verbal communication, there are three elements that we take into account when determining how much we like another person and the message they are giving us: words account for 7%, tone of voice accounts for 38%, and body language accounts for 55%. Human feelings possibly lost their depth after we started communicating with a higher focus on spoken language? Talleyrand, the mastermind of political games, was possibly correct when he said that we need words to conceal our true feelings…

Conclusions: Quantifying Human Aposematic index

We have now finished our review of the aposematic arsenal of humans. We have found that humans use plenty of aposematic signals in all possible modalities: visual, audio, olfactory and behavioural. Building up such a potent aposematic arsenal of warning signals required an array of morphological and behavioural changes during our evolutionary prehistory. We will now assess hominids' and early

humans' aposematic characteristics via the 'Aposematic Index' introduced earlier in the book:

Visual modality - Bipedal locomotion, longer legs, and a long tightly coiled bush of hair were utilized in order to be as tall as possible, to stay constantly visible and also to maintain a height advantage against all prevalent predators of the day. Apart from their towering height, our ancestors also widely used very bright colours (very popular among aposematic species as an aposematic tool). Not content with their natural ability to change face and body colours in excitement and rage, hominids came up with new cultural inventions: (1) body painting, (2) use of clothes, and (3) use of masks. Early hominids and early humans were visually very impressive – unusually tall for their modest weight, very colourful with their painted bodies, clothes and masks, and constantly maintaining their threat (bipedal) posture. In moments of need humans would raise their hands above their heads to seem even taller, and they could also make threatening body movements in perfect synchrony in groups, giving the impression of a much bigger super-organism. In the visual modality hominids and early humans had the highest possible AI score of 25%.

Audio modality – Our ancestors gradually became one of the loudest species in the world, employing several ingenious new developments. Unlike many arboreal species who become silent when visiting the ground, they became the only known singing species to live on the ground; they used humming as a constant background sound to maintain contact within the group and to advertise their presence, they started using the gift of their genetic drift – precise rhythm – and developed the ability to be entrained; they started singing in big groups, and developed the tradition of singing with the most effective audio tool: attention-grabbing dissonant harmonies. Furthermore, because of their flexible vocal apparatus, they became one of the best imitators of other animals' sounds and used this ability to their advantage. In the audio modality they also deserve the highest possible score, 25%.

Olfactory modality – If the high scores in the visual and audio modalities can hardly be contested, there will be readers that may be more conservatively inclined in acknowledging the presence of a strong olfactory element in hominid and early human morphology. I propose that the strong body odour that our ancestors were constantly emitting was designed by natural selection to advertise their presence – particularly during their precarious night-time sleeps in the open (we will discuss this later). I suggest that the development of powerful sweat glands and appearance of patches of hair in the armpit and genital areas were also part of the augmentation of our ancestors' olfactory tools. Apart from the constant strong body odour, our species is also known to drastically increase sweating and body odour during moments of fear, rage or excitement (this is very common for aposematic species). And as several other species do, humans also urinate and defecate in situations where their life is at risk. In the olfactory modality, the AI score for our ancestors is also the highest possible 25%.

Behaviour – An aposematic strategy includes several typical behavioural elements: slow locomotion, an awkward walking style, stopping, unusual threatening movements ("antics"), fearless behaviour in precarious situations, and

social lifestyle and aggregation in groups. Humans are fulfilling all these behaviour patterns admirably. We are one of the slowest species that ever walked the African Savannah, we walk strangely and awkwardly on two hind legs, we also often behave fearlessly in dangerous situations (like young village shepherds in Africa who shoo away hungry lions by raising and waving their hands and shouting), we live our whole lives in complex social groups, and we particularly like aggregation in large groups at special times, for example during religious or social celebrations (Ehrenreich, 2006). All these behavioural patterns suggest that humans have been aposematic species for all their evolutionary history. Therefore in the behavioural modality they also deserve a score of 25%.

This brings the total score of human AI to a perfect aposematic score of 100%.

There can be no doubt that humans are an aposematic species, and the large number of evident morphological and behavioural characteristics suggest that they spent most or all of their evolutionary history as an aposematic species. Humans are even more aposematic than the classic aposematic cases of skunk and hedgehog. At least in one of the behavioural characteristics (living in groups) the skunk and hedgehog deviate from the classic aposematic characteristics, unlike humans who stick to virtually all the characteristics of aposematic species.

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Humans as Aposematic Species: Implications, Paradoxes, Perspectives

If we accept that humans are an aposematic species, there will be plenty of implications, both in understanding human evolution and in understanding human psychology. Let me only scratch the surface of this huge topic, leaving it for those who will be interested to look deeper in this direction.

First of all, the acknowledgement of aposematism as a central force in the evolution of our species puts the theory of sexual selection in a precarious position. **The aposematic model of evolution is a potent means to explain practically all the elements of visual, audio, olfactory and behavioural display that are traditionally explained by sexual selection**. In this contest the aposematic model has a certain advantage, as it puts defence from predators and obtaining food as the central driving force behind the evolution of human morphology and behaviour. The model of sexual selection virtually neglects the need for defence from predators and places competition for female mates as the central driving force behind human evolution. It was very symptomatic that Darwin, the sole parent of the sexual selection model, suggested that humans could have evolved somewhere on an isolated island, in an environment without predators. As we know today humans evolved in Africa, arguably the most predator-infested continent of our planet, both in the past and in to the present day. Therefore, the need for a viable defence system from predators must have surely been paramount for our distant ancestors.

There are psychological reasons why sexual selection is so attractive to contemporary scholars. Today most humans live without any fear from being attacked and killed by predators. Obtaining food, the perennial problem for any animal species, including our ancestors, is not a problem for us anymore, at least in the developed world. On the contrary, too much eating is increasingly becoming a problem for the citizens of many developed countries. As a result of the change over the many years, the ancient need to save ourselves from predators and fight vigorously for our food has lost its urgency and survival relevance. Today we use our tall bodies, long legs, variously shaped (and coloured) head hair, beautifully curved eyebrows and eyelashes, well-crafted clothes, tattoos, our talents for singing, dancing in rhythm and other related elements of our cultural heritage mostly to impress peers and to attract the attention of the opposite sex. Gaining a higher position in society or in a certain group of people is the new focus and aim of our looks and behaviours.

It is a fundamentally flawed strategy to look at the life of our distant hominid ancestors from the perspective of our own contemporary safe and prosperous life, without taking into account their requirements for everyday survival for the millions of the years.

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Why we all like to be unique?

The aposematic model also has the potential to explain the well-known psychological strive towards uniqueness among humans. As we may recall, the strategy of aposematism encourages being more conspicuous and noticeable. Aposematic species and each individual within an aposematic species will naturally try to be more visible than others and louder than others. They like changing their appearance, they like bright and shiny colours; basically they strive to have something unique in their appearance – sounds, smells, or behaviour. According to this evolutionary strategy, **the more conspicuous and more aposematic you are the more protected you are**.

The situation with the cryptic species is radically different. According to this strategy, the more blended-in and inconspicuous you are the more protected you are. These different survival strategies profoundly affect how these animals look, sound, smell, and behave.

The drive towards uniqueness within each human individual may be a result of our aposematic evolutionary past. We are still aposematic animals. Every human artist, painter, composer, sculptor and musician tries to be unique, to attract attention, to have a unique style of expression. Great artists as a rule are expected to create their own unique style. Apart from the drive to be unique, the psychology of aposematism also leads to the extroverted nature of some of the most successful individuals. Among the public figures and political leaders many have extroverted characteristics that allow them to stand out from the rest. You often hear about the most popular girls "she gets all the attention wherever she goes." Grabbing everyone's attention is a typical aposematic feat. No doubt there are plenty of fellow humans who prefer to stay unnoticed or to follow others, but it is still this strive towards uniqueness that remains as one of the hallmarks of human psychology. We use makeup, clothing, high heel shoes, hair styles, perfumeries and singing and dancing to stand out and feel unique. Our ancestors were also doing the same. Their primary aim was to survive by attracting more attention. Our aim today is to be more successful by attracting more attention. Times and consequences have changed, although the principles of attracting attention remain the same.

This feature comes with a seemingly paradoxical contradiction. Despite the strive within each human to be unique, humans still prefer to be in groups. It might seem natural to have those who strive to be unique lead a solitary life, but it is a part of aposematic strategy that individuals still like to be in groups. The logic of being in groups for aposematic animals is not difficult to see: a group of colourful, noisy and smelly animals is much more noticeable than one colourful, noisy and smelly animal.

Another paradox of aposematic strategy is connected to the feel of freedom. We all strive towards individual freedom but, paradoxically, to feel the highest expression of freedom we need to lose our individuality, lose our ability to think rationally, and feel ourselves as a part of something larger. This conflicting strive on

one hand towards individualism, and on the other hand towards "groupishness", is the very essence of humans' aposematic psychic nature.

It is no coincidence that there are much more aposematic species among social species than there are among solitary species. In a way, every social species of animals might have an element of aposematism, as a group is always easier to notice than a lone creature.

I would suggest considering any social species to be aposematic by default, unless it has demonstrated otherwise.

Aposematism and the birth of beauty

We have one more thing to discuss here. Humans' internal strive to aposematism can also shed some light to the mysterious origins of our aesthetic sense.

Human life is a perennial strive to look beautiful and to live among beautiful things. We spend plenty of time and money to look more attractive, we design useful things to be not only useful but be aesthetically pleasing as well, we prefer to live in beautiful houses with beautiful gardens in beautiful suburbs; we prefer to drive beautiful cars, have beautiful partners and travel to beautiful faraway lands; One of the central functions of human art is also to impress by its beauty. Beauty is everywhere, or at least humans try to have their lives surrounded by beauty. The crucial questions are where this sense of beauty developed from, and why is beauty such a driving force in our lives?

I suggest that our nature as aposematic animals can explain the mystery of humans' aesthetic drive and our strive for beauty. Let me formulate my line of arguments:

Aposematism, as a survival strategy, is based on a system of signals designed to grab everyone's attention by all possible means (visual, audio, olfactory, behavioural); In order to grab everyone's attention, an aposematic display will use bright colours, big morphological ornaments, sounds, smells and unusual behaviours.

Aposematic animals and their displays generally seem beautiful to us as it is based on the use of brilliant and contrastive colours, ornaments, various sounds, smells and fearless actions;

We prefer people and animals who display more aposematic characteristics as we have a natural and innate appreciation of an impressive aposematic display (as our ancestors with better aposematic display were more successful in surviving, thus more popular among their counterparts). This is how and why aposematic appreciation became the basis for the modern human sense of beauty. Or, to put it simply, for humans "aposematic" eventually became "beautiful."

We like the dazzling colours and the size of a peacock's train as it is one of the most attention-grabbing visual displays there is; on the other hand this display can intimidate many potential predators and competitors;

We like the male lion's majestic mane, a potent aposematic element used to scare away rival lions and hyenas, and in most cases to help avoid unnecessary and damaging physical violence;

We like tigers' colourful appearance. Although most likely its dazzling striped skin was formed as a camouflage for concealing the tiger in the dense jungles, tiger colours (yellowish and reddish with black stripes) are known as very potent aposematic colours within many species – think of the colouring on wasps, snakes or even the many venomous frogs found in the Amazon;

We appreciate the brilliant colours of many poisonous snakes although we are well aware of the deadly venom that can come from them. If you travel to an exotic country or tropical forest, any local or guide will most likely warn you to keep clear off all animals that have brightly coloured bodies – this is very good advice, indeed. Remember, **in nature "very beautiful" often means "very dangerous"**!

Many animal species, predators among them, have learnt this lesson from countless conflicts with brightly-coloured and noisy aposematic species. It can be debated whether they understand and appreciate beauty as we do, but they definitely have a very acute sense of danger that is invoked by the sight of these brightly-coloured and noisy animals.

So the same displays, expressed in dazzling colours, sounds, smells and behaviours, aimed to grab everyone's attention, can carry two messages: "I am dangerous" and "I am beautiful." My suggestion is that for the most of natural world it is the first message, "I am dangerous," that they can comprehend, because this message is life-saving and essentially relevant to any species. Seeing beauty is perhaps possible for only humans.

Of course this is a generalization, and as most generalizations are, it cannot be correct in all cases. There are plenty of dangerous things that we do not consider beautiful (for example, a knife in the hands of a burglar, or a landmine), and there are beautiful things that are not dangerous (for example, a flower, or a kitten).

Can handicap principle be true?

Many aposematic displays were believed for a long time to have no survival value for their bearer. On the contrary, many believed that such splendid decorations made the animal's survival harder. It is time to change our views.

I suggest that the well-known idea that – some morphological additions and colours in animals do not have any survival value and are even detrimental for survival – is basically going against the law of natural selection. I have big suspicions

about the widely known idea of the "handicap principle." According to this theory, a signal has to be detrimental in order for it to be honest (Zahavi, 1975; Zahavi & Zahavi, 1997). Although it is quite attractive in its contradictory nature, this theory has some internal failure. To those who will be enraged with my suggestion, I can assure that I do not have any reservations to admit that I was wrong if anyone is able to demonstrate a colourful addition to any animal species morphology that is truly detrimental, and has no function whatsoever other than to impress females. I want to remind everyone that the tail of the peacock, by far the best known proof of the idea of the costly "handicap principle", apparently does not provide any proof to the claim. Peacocks have not only the dazzling display of their train, but also an extremely loud voice, extremely smelly droppings and extremely fearless behaviour, all clear signs of an aposematic species. The longest and the most vigorous study in this sphere came to the conclusion that a bigger and more colourful train does not give its bearer any advantages in attracting female attention. Therefore peacocks do not exhibit this "handicap principle," and if a clear case of any such animal species is found, I suggest it also be used for the cover photo of the new edition of Amotz Zahavi's highly interesting, but in my opinion controversial, book.

Let's get aposematic: We are going to party!

When a girl is dressed up to go out on the town, she will generally make plenty of efforts to look more attractive. After using makeup, she will have a face with bigger eyes, brighter red lips, and coloured cheeks. Now the clothes. The girl going to the party will very likely be standing on awkwardly high-heel shoes, both to seem taller and to have longer legs – both are powerful aposematic visual signals. She is most likely is wearing clothes that are more attention grabbing than a cozy robe, and of course do not forget to add some shiny jewelry like a necklace, bracelet or earrings.

A girl dressed up like this will look beautiful, or will at least be attracting attention. This is the reason behind dressing up – this attraction comes from the bright colours used in the dress, makeup and jewelry, and this image is extremely aposematic. A girl dressed up for a party will be able to scare away a stray dog better than the same girl who slipped out of home for a second to put out her rubbish bins.

Of course, many westerners, particularly of certain classes and demographics, have a different dress code based on stricter colours and the modest use of jewelry, but in earlier tribal societies the rule was simple: bigger and brighter was more beautiful. Well, let's not talk only about tribal societies; we can recall how medieval European monarchs looked in their official dresses.

Now, as we know the potent primary warning display of our ancestors, we are ready to discuss their secondary, or "real," defence strategy.

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Oops, Almost Forgot: Primate Behaviour as the Model for Early Hominid Behaviour

One small but important addition. In their fascinating and insightful book "Man the hunted" Donna Hart and Robert Sussman formulated the methodological background of their approach: "We only have two sources to draw on if we want to fill in the millions of years before historical times. These are *paleontological remains* – a sparse but fascinating fossil record – and the *living primates* – who are our closest relatives" (Hart & Sussman, 2009:5).

I agree regarding the paleontological remains. I have my reservations however about using living primates as the model of behaviour for our ancestors (see below), but before addressing it I would first like to add here two more important sources: (1) human morphology and (2) human behaviour. There are plenty of unique elements of both morphology and behaviour that set apart humans from all our closest living relatives. Humans are different from all other primates as they habitually use bipedal locomotion, have soft naked skin, have long hair on top of their heads and in their armpits and genitals, are the only terrestrial singing primates, have a sense of rhythm, sing in rhythmically coordinated choruses and dance in rhythmically united groups. All these features were formed during the last 6-7 million years of life of our distant ancestors on the open woodlands and savannah in Africa, and it would be natural to propose that most of them were developed as a part of an overall survival strategy.

If we are dedicated followers of the theory of natural selection, we should propose that most of these features could have been developed as a part of the early hominid survival strategy. Therefore we can state with confidence that, apart from paleontological evidence and primate behaviour, there are plenty of unique morphological and behavioural characteristics that must be considered as a rich source for filling in the millions of years of human/hominid prehistory.

Now let me briefly formulate my doubts about the use of primate behaviour as a model for hominid/human evolution. Despite the obvious phylogenic connections between humans and primates, we should not neglect the obvious differences in morphology and behaviour between them. It is very likely that the above-mentioned differences that set apart humans from all other primates (bipedal locomotion, soft naked skin, long hair on top of our heads, patches of hair in armpits and genitals, being the only terrestrial singing primates, being the only animal who can sing in rhythmically coordinated choruses and dance in rhythmically united groups) reflect the crucial differences in survival and behavioural strategies that human ancestors followed after separating from other primates. In this book I propose that hominids were the only primate species that were using aposematism as their central strategy of survival. No other primates rely on aposematism as their leading strategy of defence. I believe aposematism can explain most of these morphological and behavioural differences that separate our species from our closest living relatives.

This is why I am sceptical about the methodological notion that living primate behaviour can explain behavioural patterns of our ancestors. We look and behave

differently because we followed different survival strategies. As the Georgian sociologist Gigi Tevzadze once suggested, primates show us what humans were not (Tevzadze, 2013).

Therefore, despite the widely accepted fact that primates, and particularly apes, are our closest living relatives, when we are researching our evolutionary roots we should always remember that there is an array of human morphological and behavioural features that are not shared by any of our closest living relatives. These differences are the true indicators of the vast difference between the life strategies of that our ancestors and that of their closest living relatives. I suggest that it was our choice of aposematic behaviour that put a rift between future humans and our primate origins. Aposematism turned our ancestors into bipedal, tall primates with longer legs and shorter hands; it made us the only singing species on the ground, without canines or a hairy body. Even without our ability to think, ask questions or to use language and speech our primate ancestors were very different from our hominid ancestors. For the reasons outlined above, using apes as a model for early hominid life strategies can be grossly misleading.

The fact that we share 98% of our DNA with chimpanzees can impress us with the level of statistical closeness between the two species, but we should not forget that we also share 60% of our common DNA with bananas.