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The Significance of Play in Evolution

"Man only plays when in the full meaning of the word he is a man, and he is only completely a man when he plays." This famous statement by Schiller (*Letters Upon the Aesthetic Education of Man* 1794, quoted from BrainyQuote.com) is in some ways a riddle. Does man not have more important things to do than, of all things, play? What significance does it have that Schiller attributes such an important role to play? He specifically relates humankind to play. Should play not be relegated a peripheral role to more important and serious activities, such as taking care of daily needs, or the development of prosperity, culture and technology?

In the following, there will first be a description of play in the animal world. Which animals play, when and how do animals play? Then the significance of play in the human context will be explored. And finally, a thesis will be formulated on the possible significance of play in evolution.

Play in Behavioural Science

Study of the behaviour of animals when playing belongs to the domain of behavioural science, but if one looks more closely at interpretations of the biological aspect of play, they do not adequately address this remarkable phenomenon. Play seems pointless and redundant where "the survival of the fittest" is concerned. Repeatedly the attempt is made to give play an adaptive or fitness developing role, which however hasn't really succeeded in explaining it (Bateson & Martin 2013).

Play uses energy, thus costs valuable resources, but does not provide nourishment. It is dangerous, as playing animals are barely aware of their environment or of possible predators. With play-fighting there is the danger of injury. Animals use valuable time for these activities, which are clearly not required for survival, being focussed as they are on activities that serve no discernible purpose.

Often the assertion is made that movement and behaviour patterns are practised during play, which are needed later for the serious tasks of life, such as catching prey, fighting with rivals etc. This could be true: A few studies have been able to show that animals that had ample opportunity to play were later more skilled in these respects. Many more such studies were, however, unable to demonstrate this at all. Animals that were only able to play a little gained the necessary skills in other ways (Bateson & Martin 2013).

In the evolutionary comparison the question remains: Why should it, in the case of higher animals, be necessary at all to practise these important patterns of behaviour? The rest of the animal kingdom manages without practising in play. The behaviours required for survival are inborn and proceed more or less as fixed instincts (so-called »fixed action patterns«, FAPs), which seems much more sensible, because the behaviour patterns are instantly available when they are needed. If, on the other hand, they need to be practised first, much can go wrong. A frog does not first need to practise catching a fly, he can just do it. Why do many adult animals play even though they already possess all the skills required? Here even the usual cost-benefit calculations fail completely.

Behavioural scientists are aware of this problem of interpretation, and play is perceived as much of a riddle as before. Burghardt (1998:3) says: "The origins of vertebrate play are obscure". Or it is even described as a "biological paradox" (Fagen 1986: VII): "Animal play behaviour addresses a major biological paradox. Why do young and old animals of many species spend time and energy, and even risk physical injury, performing the apparently unproductive behaviours colloquially called play? What makes this useless activity so important that animals literally risk their lives for it? And, even more curiously, why are humans both enchanted and enraged by play?"

Many popular textbooks on behavioural research in animals and on the evolutionary psychology of humans omit the topic completely, thus simply avoiding the issue. This applies especially to books that are heavily adaptation orientated.

There are a few books worth reading that are based on recent behavioural research, and which describe the phenomenon comprehensively and well (Fagen 1981, Bekoff & Byers 1998, Burghardt 2005, Bateson & Martin 2013). Here the observations, assessment and analysis of play are at the forefront, even if no clarity about its evolutionary meaning can be gained: play seems to be absolutely illogical – but somehow fascinating.

Which Animals Play?

Today it is known that all mammals play more or less intensively *(fig.1–3)*.With many mammals play behaviour is limited to young animals. In the case of others, it can survive into adulthood, which is applicable especially to predators, rodents, primates and whales. Adult dolphins, for example, can be remarkably playful. Among bird species it is mainly the crow types which play. Many parrots also play. There have also been reports of falcons and some small songbirds playing.

The keas (*Nestor notabilis*) especially are famous and infamous for their boisterous play behaviour (*fig. 4*). They live in the mountains of New Zealand where they survive in a habitat, which, for a parrot, is unusually harsh. They use everything to play and can become a nuisance when they use the antennas on houses as gymnastics apparatus and in the process reduce them to little pieces. In movement games they stand on their heads, do somersaults, land the wrong way, use branches as swings and make snowballs with which they then play.

A number of film teams have had the rubber seals removed from their cars, and no backpack is safe from their attention. It has even occurred that film equipment is dismantled even before the team has had a chance to make any recordings. These birds also love to let the air out of car tyres.

There is a film by the exceptional filmmakers Hans Schweiger and Ernst Arendt, where it is possible to see this performance. They talk of the "highly developed sense of nonsense" of the keas: "they played tricks on us, and we were not always sure who was observing who".

On the other hand, other vertebrates, such as reptiles and amphibians, as a rule, do not play. There are, however, some notable exceptions. There have been reports of komodo dragons in captivity playing. It is possible to view a dragon playing on the internet (*fig. 5*)[1]. Turtles in captivity have been documented playing with a ball, a stick or with the hose in their pool. There are descriptions of fish displaying play-like behaviour (Burghardt 2005). It is quite possible that different observations will in the future yield surprising results. Perhaps play, in other forms than those observed in mammals and birds, is more widely spread than has been assumed until now.

Among invertebrates play apparently does not occur. But even here there is at least one exception, namely that of the ordinary octopus (*Octopus vulgaris*), which in captivity displays great curiosity and after finding interesting objects also plays with them (Kuba 2006).

Fig 1: Cats playing (drawing by Marita Rosslenbroich)

[1] http://www.youtube.com/watch?v=almJghl1VXk

Fig.2: A bonobo mother playing with her child. (from Burghard, redrawn by Marita Rosslenbroich)

Fig. 3: Panda bears playing on a slide. (redrawn by MaritaRosslenbroich)

Fig.4: A playing kea. (drawn by Marita Rosslenbroich)

Fig. 5: A komodo dragon in a zoo in Florida. The dragon plays with a ring, which is held by the caregiver. (scene from a video, drawn by Marita Rosslenbroich)

What is Play?

Play is understood as consisting of any movement, manipulation of an object and social interaction which occurs outside of the context of an actual problem. Play is behaviour which is not related to an immediate need or demand, and within this autonomous situation contains a high level of flexibility. Play behaviour is typically spontaneous, voluntary and intentional. It is obviously amusing and pleasant, and the animals enjoy it.

Typically play occurs in a so-called "relaxed field", which means only once physical needs have been met. Animals will only play if they are healthy, have enough food and don't feel threatened.

One can roughly divide play among animals into locomotor play, predatory games, object play and social play. Burghardt (2005) adds another category for the keas: "demolishing play".

Play consists of the normal components of behaviour available to each kind of animal, such as running, climbing, object manipulation, hunting behaviour and many more. In play these are fragmented, repeated, exaggerated and combined in new ways, through which play acquires a high level of flexibility.

Forms of play:
In animals
locomotor play
predatory games
object play
social play
In children (based onSmith 2010)**:**
locomotor play
object play
social play
word play
activity play
fantasy, make-believe, games with rules, role play

The Emergence of Autonomy in Evolution

It is possible to conclusively integrate the phenomenon of play behaviour into an understanding of evolution, which became apparent in the context of research on the autonomy theory of evolution (Rosslenbroich 2006, 2007, 2012, 2014).

This theory states that the evolution of animals and humans did not only occur as a result of adaptations, but that the major transitions in evolution are characterised by an increase in individual autonomy. This includes the emancipation from immediate environmental factors, the increase in inner stability, the adjustability of bodily functions and also an increase of behavioural flexibility within the environment.

For the evolution of nervous systems it has been shown that the principle of decoupling was of decisive importance. In the simple nervous systems of lower animals a stimulus is instantly followed by a reaction. The stimulus, which is perceived by sensory cells, and the reaction are functionally close. With the development of complex nervous systems more neurons are included between stimulus and response. This enables reactions to be modulated by varying degrees, so that they no longer have to follow directly, but can be self-determined in many ways. This ability to modulate is initially small, but is increased with the development of larger brains and centralised nervous system. As a result behaviour becomes more flexible, self-determined and autonomous.

Play behaviour only occurs in animals that have the most extensively formed central nervous systems, which means also those that are the most intelligent. These are the animals that develop the most flexibility in their behaviour, that are thus the least determined with respect to their behaviour. This occurs to a limited extent in animals; mostly behaviour, even among more evolved animals is determined more or less by instinct. However, the degree of flexibility in behaviour can be significantly increased, together with the increased ability to learn, the increased potential for imitation and the solving of problems.

This flexibility can then be increased in such a way that it becomes an undirected end in itself, which is a prerequisite for play. In this sense play contains a degree of freedom and can be related to other tendencies in the emergence of autonomy in evolution. It is the next stage of development among comparable self-determining and autonomous animals.

This flexibility however does not occur only in the capacity of the nervous system. It is also typical that a high degree of flexibility and a certain diversity in movement becomes possible: many mammals perform highly complex and downright acrobatic movements during play, of course strongly dependent on the constitution of the relevant animal. It then follows logically that the common octopus displays play behaviour. Among invertebrates it is the animal with the most concentrated central nervous system, and due to its eight arms, is astonishingly mobile.

During play, movements are “re-invented”, and behaviours or fragments of behaviour occur, which in other contexts could be meaningful, for example, flight, attack, or prey capture actions. In play they can be combined in new and many versatile ways, so that they can be individually shaped and therefore become very different.

The time during which young birds and mammals are looked after by their parents is an opportunity for the young to play. During this time they are relatively independent of the struggle for survival.

However, there is a more mental form of flexibility in this equation: play contains modes of behaviour which are feigned, for example mock fighting. The animals thus have to be able to feign behaviour and also to recognize feigned behaviour in their game partner. The animal needs to show the play partner that the actions are "only" a game. In the case of dogs this is shown in the well-known bow, in which they go down on their front legs while keeping their back legs straight.

In animals it has also often been observed that game partners who, compared to the other animal, are more powerful or dominant, hold back ("self-handicapping"), as if to make the game fair. This requires a certain degree of cognitive ability and in this respect may be related to the capacity of the central nervous system.

"Individualized" games have been described, especially in the case of primates, where there are even fewer narrowly predetermined sequences of behaviour. If play in any way has the character of practice, then the modes of behaviour resulting from it later are also definitely more individual. These "creative components" allow for the formation of very individualised abilities or habits.

It is remarkable that play always elicits happy interest in people. Who hasn't been captivated by the boisterous play of young cats or dogs? Many pets are played with, and to watch animals playing is always an aesthetic experience for us. Play in animals touches us like this because it is reminiscent of our extensive human behavioural flexibility. Eibl-Eibesfeldt (1999: 416) wrote:

> "Because in play the activities can be distanced from the normally pre-determined instances (urges), the animal creates a relaxed field, and is able to experiment with possible movements and to interact dialogically with his environment. This ability to distance himself stands at the root of what we perceive as the particularly human freedom of action."

If one takes into account the emergence of autonomy in the course of evolution, then the development of play is no longer a paradox, but instead can actually be expected to follow on in the sequence of evolutionary transitions.

Play in Humans

Pretend play is especially characteristic of play in humans. This ability develops at about the age of 2 and then is carried out extensively over many years. A prerequisite for this is the separation of two participating representations within consciousness: In the case of objects there is the image of the object which corresponds to reality, and the fantasy version of the same object (the bathtub as a "ship", the "cake" in the sandpit). In the case of actions, the action that relates to the real experience of oneself, and the action that is played, which is clearly experienced as "just a game". More elaborately this form of pretend play can in older children (e.g. 6-8 years old) be completely decoupled from objects, body parts or other people (drinking from a cup, combing hair, without having anything in the hand; playing with an imaginary friend and acting out a pretend action together). This decoupling is a developed act of consciousness and lies at the origin of a self-conscious

inner life. Insofar as playing animals can distinguish play from reality, one must assume that for them there is also a certain rudimentary decoupling of these two representations. In the case of the great apes there have even been individual cases where pretend actions separated from objects have been described, although only seldom and only in cases where the animals are in the care of humans (Smith 2010).

In the case of humans the possibilities for decoupling obviously go far beyond what is possible with animals. Humans can isolate contents of consciousness so removed from sensory impressions or actual experiences, that they can be symbolically brought into consciousness. As a result they can be generated flexibly and developed further. These symbolic representations then become the foundations for self-awareness, awareness of the other person as someone capable of consciousness, empathy and finally also of language, which in the current form is symbolic language (Carruthers 2001, Smith 2010, Rosslenbroich 2014).

Gärdenfors (2003) distinguishes representations that are elicited directly by a signal (“cued representations") from others that are detached (“detached representations”). He divides the latter again into “dependent representations”, which depend on outer perceptions, even if the stimulant is not directly present, and “independent representations”, which are not based on outer perceptions at all, such as in the case of fantasy. His theory is that this is also the sequence in which these abilities evolved (cued representations → dependent representations → independent representations). The development of thought is describable as the differentiation of more and more representations. When a variety of representations can be inwardly reflected on – there are therefore also a number of ways to achieve a given goal – the possibility of choice comes about. Now motifs that are decoupled from each other can be contemplated. All these capacities can be involved in the various forms of a game.

This results on the one hand in the possibility of fantasy play, and on the other it exercises a dynamic flexibility in dealing with imaginations, memories and ideas by means of fantasy games.

In fantasy games new ideas or “hypotheses” can arise, which are then explored, contemplated and developed further. The possible consequences are “played out” before ideas are rejected or accepted and put into practice. The process is thus closely related to every form of planning and design. New concepts, ideas, sequences and chronological orders are thus formed and reflected on independently of time and space. Fantasy games are therefore a basis and training ground for the development of creativity. (Bateson & Martin 2013, Nowell 2014).

Certainly children play the most and most extensively, but adults also play. In this case games are often formalised and subjected to a whole variety of rules, such as in sport. The boisterous romping and tussling of young children is rare among adults, but is taken up happily when interacting with children. When adults want to tussle, they sometimes give themselves a complicated system of rules, such as is found in Judo, which is then also placed on a higher cultural level. Games can be highly abstracted, such as in chess, although movement games are also enjoyed at every age. By these means our highly dynamic and extensive repertoire of movements are continually combined and varied in new ways. In other games, rules and agreements are

determined, such as in hide-and-go-seek or in ball games. This relationship of fantasy and movement shows that neural processes are always closely connected to the processes in the body as a whole,and that the origin of emerging flexibility cannot be sought in the brain alone (Fuchs 2009).

Games can develop considerable importance for societal life. The Soccer World Cup of 2006 had the dual function of presenting Germany as modern and hospitable, and thus presented a way to clear any reservations that some may have retained due to history. However, things can take on a life of their own, which is also seen in soccer, where the identification of people with the game is abused for profit.

It is therefore clear that play is fundamental to our humanity. There are similarities in some animals, but play does not have the same importance for any other living being as it does for humans. This is not only true during childhood and adolescence. Play encompasses an extensive part of human culture. From card games to athletics, from gymnastics or high diving, through to the Olympic Games, we cultivate our autonomy and flexibility.

Extended Adolescence

Humans have an exceptionally long period of childhood development (Kipp 1980), in which there is much latitude for the development of the "relaxed field". In anthropology there are two phases in particular that are described, which in comparison to other primates are very extended (Nowell 2014): Firstly there is the toddler phase, which comes after weaning to the cutting of the first molars, which adds approximately 4 years of relative growth. These years enable additional experiences in behaviour, which considerably extend plasticity in development. Secondly there is the period of adolescence, from puberty to the end of growth. This allows for an additional period of learning, practice and transmission, but also for the modification and individualisation of cultural ability in particular.

Studies with functional magnetic resonance tomography have shown that during these extended times of maturation the activities of the prefrontal cortex display especially marked development (Case & al. 2000, Neubauer & Hublin 2012). The prefrontal cortex is connected with abilities such as attentiveness, memory, logical thought and planning, thus with higher mental functions and flexible associations (Neubert & al. 2014). It thus suggests that play influences the maturation and of the formation of pathways in these areas.

And yet our synapses and pathways develop later than those of, for example, chimpanzees. They emerge during early childhood development and increase as a result of our experiences, which considerably increases plasticity. In the case of chimpanzees many connections are already fixed at birth. We have 98.8% the same genes as chimpanzees, but it clearly is an important difference that the gene expression which is connected to the formation of synapses is delayed. In the case of apes this stops at about birth. In the case of humans it continues for about 5 years, and to some extent for much longer. However, new synapses are not always simply being formed. It is rather the case that an excess of synapses and neural pathways are formed, and only those that are used then stabilise. Pathways that have not been stabilised in this way regress (Casey & al. 2000, Liu & al. 2012).

Humans have much more time for this whole process to occur. Especially during this time, if fortunate enough to be protected, there is an inordinate amount and intensity of play, which is not evidenced in animals (Smith 2010).

Research on animals has shown that experiences that are made during play have a substantial influence on the formation of synapses and neural pathways. For example, young laboratory rats were raised in three categories: The animals in the first group had only one playmate, the second group had more. The animals in the third group each only had the mother for company and thus there was not much impulse for play, as adult rats do not play with their young. An investigation of the brains showed that there were substantial differences in the formation of the prefrontal cortex, with clearly fewer pathways in the animals that had only played a little or not at all (Pellis & Pellis 2009). The authors formulated, “that not only does the brain form play, but games also form the brain”. They even compared such deficits with cases where pathological damage to the prefrontal cortex could be observed.

One can assume that this is also the case in humans. Added to this is the development of more flexible motor skills, which also have to be trained. In this case this would indeed involve practising skills. But the decisive factor is the training of motor and neural flexibility, the ability to react to situations and tasks independently, creatively and with versatility. The same cognitive resources that are involved in make-believe games in children make possible creative thinking and planning in adults. In both cases there is experimentation with imagined possibilities and assumptions (Carruthers 2002).

Children practise social skills in this way. However, this is not about learning particular rules of behaviour in dealing with each other, but instead concerns the ability to react to relevant individual situations. Social interactions are, after all, nowadays less determined by particular codes of behaviour, instead each instance needs to be approached flexibly and individual situations need to be adjusted to. It is thus often easier for adults to build up contacts and befriend each other while participating in a play or in sport. Children in the same way learn to flexibly interact with the cultural structures of their environment: Whereas in former times they played with horse and wagon, or with tin soldiers, today they play with cars.

The fact that this skill is acquired by means of a highly flexible form of learning, also forms the premise that social and cultural behaviour in principle remains changeable. One could say exaggeratingly that play also has a subversive character, because what people practise in play, can in principle also be changed. Perhaps this is a reason why some educational systems try to suppress play in children. The excessively strict raising and education of children in some Asian countries, especially China, leaves no room for play, and thus potentially supresses contrariness, resistance and social autonomy.

Here in Germany we then also have to ask what the consequences are when schools allow ever less time for free play: school until late in the afternoon and then homework afterwards, leaving no time for free play. Added to this is the flooding with “toys” that leave no space for fantasy-filled, self-determined play. The urge to play is filled

with surrogates, such as computer games, about which psychology has already provided proof that they have a negative impact and cannot replace free, physical play.

The author Susanne Gaschke of the German weekly newspaper *"Die Zeit"* has written extensively about the situation of children in modern times and has asked the question:
"Are we at the moment raising the most uncreative generation of all time?" The deprivation of play may be a substantial contributing factor: "Cultural scientists view [...] unstructured play in children as the initial step for the later cultural achievements of adults: jumping and rough-and-tumble become dance and sport, playing with building blocks develops into art and architecture, role play becomes literature and theatre. Will children whose "middle childhood" has been abbreviated, still be able to develop the problem solving ability and creativity which a modern, highly-complex society requires from its citizens, employees, entrepreneurs, artists, researchers and politicians? We are in the middle of a long-term experiment, of which we will only know the results in decades to come." (Gaschke 2011)

Other authors also see grave consequences in the fact that children have ever fewer experiences of free play with other children. The psychologist Peter Gray (2011, 2013) postulates that the decrease in such experiences contributes to the increase in anxiety, depression, suicide, feelings of helplessness and narcissism in children, adolescents and young adults. Free play acts as a medium through which children develop autonomous interests and competency. It promotes the ability to make decisions, solve problems, develop self-control and regulate emotions, as well the ability to find friends, get along with others and experience happiness. Brown & Vaughn (2011) are of the opinion that play stimulates imaginative ability, "strengthens the soul" and makes life more fulfilled and meaningful. It strengthens emotional and physical health in children and adults, and preserves curiosity and flexibility.

Extensive play could indeed be seen as the medium which makes possible societal development, innovation and creativity. Play also brings about a reality of one's own: one of possibilities. Only a societal establishment that has no interest in this will try to suppress play or make it alien. Even the disciplines of sport are institutionalised, formalised or used for commercial purposes to such an extent, that there is the danger that they lose their actual play character.

Play can also have a general effect on learning. When something is pleasant and satisfying, it is easier to learn. This obvious intuitive insight has been confirmed in comparative trials and been proven neuro-physiologically (Nowell 2014).

Perhaps it is important that during the course of our lives we continue to play. George Bernard Shaw wrote: "We don't stop playing because we grow old, we grow old because we stop playing." (Quoted from Bateson & Martin 2013:5) Newest findings indicate that the structure of synaptic connections even remain extremely flexible and changeable throughout life. Neuweiler (2006, 2008) demonstrates that, in contrast to the earlier image of a stable contact point between neurons, another picture of a very dynamic structure has now been developed. The connections can change within a very short time, and as a result the brain is a flexible network and its behaviour

can only be measured or predicted in restrictive conditions. Today it is also ever clearer, from a neuro-physiological point of view, that the brain, or even our physiology as a whole, contains the possibility to continue learning and to form new nerve cells and new synaptic connections into old age (Robson 2013). We have a highly developed neural flexibility which clearly contradicts the widely-held neuro-genetic determinism (Gilbert 2000).

Friedrich Nietzsche (1886) wrote: “A man’s maturity: that is to have rediscovered the seriousness he possessed as a child at play.”

The Dutch cultural historian Johan Huizinga (1939) even developed a philosophy according to which humans developed their abilities especially through play (Homo ludens = playing man). Man discovered his individual characteristics in play and thus developed according to these experiences into what he is. Play is seen as a prerequisite for freedom of action and individual thought. His concept of play is however rather broad, and therefore threatens to become imprecise.

We live in a society which is based on competitiveness, rivalry and efficiency, ideologically supported by a theory of evolution that is one-sidedly focused on selection. Play has an ever smaller role in this. Parents and schools are ever more focussed on preparing children for the demands of a meritocracy, and to plan their time according to this. Play becomes a superfluous waste of time, needed occasionally, but otherwise unimportant. The confrontation with available media does the rest; the perverted version of play on offer is cut off from any social context involving close contact with others, of movement and sensory experience of the world. Even in the case of sport, which can after all be seen as a form of play, the principles of a meritocratic society and competitive thinking have been imported, so that the actual nature of play is often lost.

Creativity

Bateson & Martin (2013) make an interesting distinction between creativity and innovation. Creativity, from their point of view, describes the general development of new ideas or new ways of acting, independent of a practical value or use. Innovation on the other hand describes the change in a practical procedure, which is then also taken up by others. Innovation develops something new that is useful. Bateson & Martin discovered that creative people are not necessarily innovative, and that innovative people often pick up ideas that were developed by creative people.

In this sense creativity is something more all-encompassing and more closely related to play, in that it is primarily independent of usefulness and application. New ways of behaving, new activities, new physical or spoken forms of expression, or new ways of thinking are often developed independently of their immediate usefulness and are thus closely connected with play.

A creative person discards established patterns. He breaks through rules and laws. He observes new relationships between thoughts, things or forms of expression, which previously seemed to have no relationship. He is able to

connect them in new ways, just as movements or thoughts can constantly be recombined during play. This unlocks possibilities that were not present before, without regard to whether they are justifiable or worthwhile.

History is full of highly creative people who also displayed a certain playfulness. Mozart is certainly a good example of this, and his playfulness is also evident in his music, even to the point of regular musical jokes. Picasso was known for his playfulness. M.C. Escher said of himself that he loved to play with certainties, perspective, and spatial directions. This is how his pictures of impossible stairs or streams originated.

The philosopher of science Thomas Kuhn compared scientific work with play. Certainly this does not apply generally, but even among scientists there are ample examples. Alexander Fleming, the discoverer of penicillin, was known for his playfulness. His boss wrote disparagingly that he conducted research as if it were a game and that he viewed everything as a big joke. When Flemming was asked what he was doing, he would say that he was playing with microbes. It was so amusing to him to break the rules and to find something that no-one had ever thought of before. Max Delbrück, one of the founders of modern molecular biology and Nobel laureate, formulated a "principle of moderate slovenliness": one should be careless enough in the laboratory to allow the unexpected to occur, but not so careless that one can no longer say what it was (examples from Bateson & Martin 2013).

Play can also be completely internalised. We speak of make-believe games, for which one should perhaps allow more time than our acquired craze for efficiency allows. This must have been one of the components in the early development of Albert Einstein (Isaacson 2010). As a child Einstein took a long time to learn to speak – so long that his parents consulted with a doctor and the maidservant called him "the dimwit". His independent disposition and his resistance to authority, according to his own conviction, contributed to his scientific creativity. The fact that he took so long to learn to speak was because he thought in pictures rather than in words. He loved his visual "thought experiments". What we would call daydreaming an Einstein would call thought experiments.

Most of his great scientific achievements arose from such imaginary adventures: How would a light source look if one could walk next to it at the same speed? If a person on a station platform sees two flashes of lighting at the same time, would another person in a train passing by also see them simultaneously? Would someone standing in a closed elevator that is going up beyond the gravitational attraction of the earth, have the same perception as someone in a closed elevator which remains within the gravitational field of the earth?

His slow learning allowed him to break his head over everyday phenomena that we accept as given. Throughout his whole life Albert Einstein retained a particular child-like enthusiasm and ability to wonder. He believed, as he later wrote in a letter, that people like him did not age, but instead retained their child-like curiosity faced with the great mysteries of the universe. He wondered his whole life about the astounding natural phenomena that most adults accept as given. What is a magnetic field? Why does the needle of a compass jerk and then show north? He always tried to imagine facts in pictures. What would it be like to ride on a ray of light? What does a field of gravity look like?

Most of all he was enough of a rebel to question every finding, no matter how self-evident it was. He always proclaimed that the foolish belief in authority was the enemy of truth.

Early Hominids

Through studies on fossil finds of early hominids, such as Neanderthals or *Homo erectus*, it can be shown that these hominids had a shorter physical developmental phase than *Homo sapiens*. This could be discovered especially from comparing the growth of teeth. The adolescents reached adulthood significantly sooner. By comparison, there was a slowing-down and an extension of maturity in *H. sapiens*, which lead to a longer time in which learning and play could take place. (Nowell 2014).

The difference already existed in the first migrants of *Homo sapiens* who arrived in Europe more than 40 000 years ago from Africa, and colonised the ice age landscape for the next 30 000 years. These so-called Cro-Magnon people for a long time lived parallel to the Neanderthals (*Homo neanderthalensis*), who then died out.

Today it is well known that the Neanderthals already displayed extensive cultural ability. The new migrations of Cro-Magnon, however, brought a cultural explosion, of a kind that no other form of human had been capable of before. Besides elaborate and meticulous stone work, small carved or engraved figures of astonishing skill and artistry appear in the archaeological sites from the time of their arrival in Europe.

This new creativity is obviously connected with the change in physical organisation, to which belongs the increased period of adolescence. How far the capacity for flexible inner picture-formation extended in the case of Neanderthals can of course not be reconstructed. However, they did not leave behind any art comparable to that of *Homo sapiens*, other than artistically worked stones. The formation of extensive autonomous representations and symbolic thought were presumably not accessible to the Neanderthals, which one can surmise from the type of cultural objects left behind by them (Nowell 2014).

Compared to modern man Neanderthals had faster pre- and post-natal brain growth. The shape of the skull was also different from that of modern man. In the case of young Neanderthals the skull was arranged in a round shape, but gradually became elongated with a flattened forehead. In the course of individual development the Neanderthals thus gave up the early round form of the skull, which could probably be related to the less concise development of the prefrontal cortex (fig. 6). This occurred in a phase during which modern man develops the most important neural connections. As a result it can be assumed that the neural connections in the Neanderthals were different from those that we now know in modern man, and that this lead to the difference in cognitive abilities. The extended prefrontal cortex of *Homo sapiens* especially lead to significantly increased mental abilities (Coolidge & Wynn 2005, Gunz & al. 2010, Neubauer & Hublin 2012). Neanderthal children probably also played, but there was not as much time for development given to them, and it can therefore be assumed that fantasy play was not yet possible to this extent.

The artistic products of Cro-Magnon man reflect the newly developed ability to engage with images and abstract visual forms, and to inform themselves about them. It is during this time also that the cave paintings in South-West France and Northern Spain, which we admire so much today, arose. The images which mostly depict ice age animals, frequently with very characteristic details, often arose deep inside the caves, independently of any direct perception of the drawn motif. It can thus be assumed that these cave paintings were an essential practise area for increased autonomous handling of imaginations and inner pictures (Rosslenbroich & Rosslenbroich 2012).

Fig.6: Skull of *Homo neanderthalensis* (left) and *Homo sapiens* (Cro-Magnon, right). Especially compare the formation of the forehead.

The changes that Cro-Magnon man brought with him must have had a profound evolutionary significance. A longer childhood must have been important for the formation and maturation of neural abilities, the development of synapses, neuro-physiological pathways and the attainment of increased plasticity of behaviour through play, as well as further social and cognitive skills.

This does not in any way demean Neanderthals or the even older *Homo erectus*, because compared to other primates they had achieved considerable cultural artefacts, such as the skilled working of stone, command over fire, the manufacture of spears and much more. In the face of these cultural skills, it is not appropriate to speak of "primitive" forms. However, in the case of *Homo sapiens* there is a new level of autonomous development which increasingly enables the free internal mobility of images.

Cave painting, as well as so-called craftwork, with carving and engraving on bones or sheets of rock, also shows an impressive tendency to play with colours and forms. The experimental archaeologist Marc Azéma (2011) has managed to reconstruct the manufacture and usage of small discs of bone, which on the front and back show different postures of an engraved animal. These discs were evidently threaded onto a sinew and by winding up

the sinew could be made to spin very fast. The resulting speed at which the images spin has the optical effect that the legs of the animal seem to be moving (*fig. 7*). What is this if not creative play?

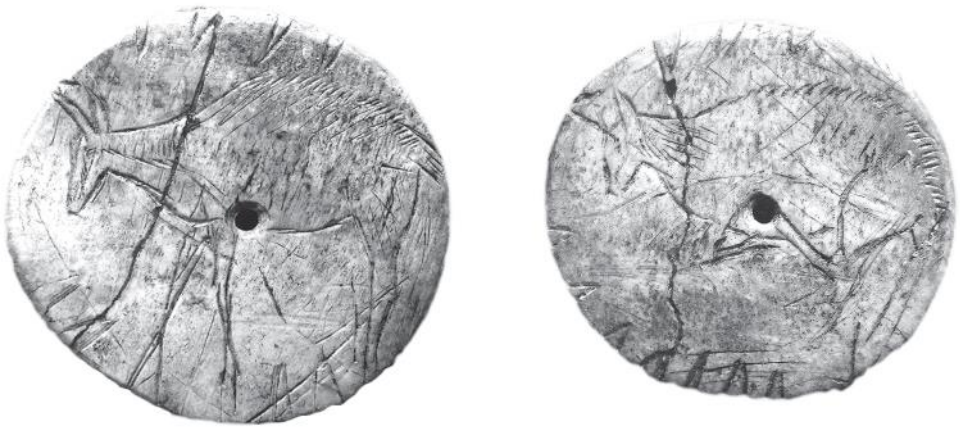

Fig. 7: Front and back of a bone disc from the early Palaeolithic (Laugerie-Basse, Dordogne). If one spins the disc very fast, it looks as if the represented animal is alternatingly stretching and brining in its legs. (Azéma 2011).

Phenotypic Plasticity

One can thus observe that play in higher animals gains increasingly in importance. It is precisely the more developed types in which at least the young animals, but often also the adults, play. And finally, in the case of humans, play takes on a significant role at every age. It can, however, be assumed that these organisms not only have the capacity for play, but that conversely play also influences their evolution.

In more recent biological-evolutionary concepts the phenotype is increasingly seen as more significant for these changes of type (overview Rosslenbroich 2014: ch. 12). The earlier assumption that evolutionary changes can be exclusively related to random genetic mutations, is in the face of recent insights in genetics no longer valid. Some authors in the meantime assume that the phenotype for such changes is more important than the genotype and that changes could take place on different levels (Pigliucci & Müller 2010, Shapiro 2011). Mary Jane West-Eberhard (2003) represents the thesis that the phenotype determines evolutionary changes and that the changes only become genetically fixed as a second stage.

Also interesting is Wolfgang Wieser's (1998) idea that with an increase in complexity of the structure of the organism over the course of evolution, the significance of the phenotype increases, which leads to a gradual emancipation from the specifications of the genotype. A "partial independence of the phenotype from the genotype" thus develops.

Wieser bases his observations on the three-fold model of the organism: The lower level forms the genome. The middle level the phenotypically visible form, including cells, tissues and organs, as well as molecular factors as bearers of function. The third layer is behaviour. While prokaryotes are still largely determined by the lower level,

or the genome, for more advanced animals, especially multi-cellular animals, the middle and third levels increase in importance. The phenotype becomes ever more flexible, which increasingly is made possible by its systematic function and it becomes less genetically determined.

The spectrum of possibilities of genetic programs, according to Wieser, becomes ever more rich, interconnected and differentiated, and with this there is an increase in possibilities for movement and for interactions between organisms and their respective environments. The bigger the range of possible reciprocal interactions with the environment, the more autonomously the phenotype has to be able to operate. For this purpose networks for processing information are built up, for which there are construction precepts in the genome, but nevertheless their relative activity only takes shape by means of interaction with the environment.

Gerhart & Kirschner (1997) show that during the course of evolution the significance of regulatory factors for the control of transcription has increased. There are thus instances which on the phenotypical level regulate what is expressed out of the existent genome and what is not. The phenotype thus acts with increased autonomy, by means of the regulatory factors.

A further example of increased independence of the phenotype is the circumstance that the individual switch pattern of the brain can only be genetically programmed in broad outlines, whereas the phenotypical formation crucially depends on the usage of neural pathways. A similar phenotypical flexibility exists also with regard to the fine structure of vascular supply in tissue.

The behaviour of the third level on the other hand connects the phenotype with its biotic and abiotic environment. Social systems especially arise as part of this environment, which, as more or less flexible forms of organisation, can bring about new patterns and thus also new evolutionary tendencies (Tomasello 2009). Genetic prerequisites play a role in the sense of genetic norms of reaction, but are integral to the context of the system and are in part dominated by it. Ernst Mayr (1988) already formulated the assumption that changes in behaviour mostly precede changes in organs. In the case of humans these possibilities are furthermore individualised, so that there is an extensive unfolding of the repertoire of individual phenotypical behaviour patterns, which constitutes the comparatively fast changing historicity.

Play in its various forms stands at the centre of these tendencies and possibilities for flexibility and autonomisation, compared to fixed patterns of behaviour. In the case of organic beings interdependencies always have to be considered (Schad 1982, Rosslenbroich & Heusser 2010), and therefore play, by means of phenotypical plasticity, could also have a reaction on organic prerequisites and their evolution. One could probably say: Autonomy enables play, and play expands autonomy.

This fundamental process can be examined in exemplary fashion in the activity that counts as one of the top achievements of human autonomous ability: playing the piano. This requires uncommonly precise mobility of the hands and their control by means of the will, as well as an extensive mental concept and ability to imagine music. And then thirdly, the highly differentiated ability to hear by means of a highly developed sensory organ, which includes its neural processing.

As presented above, humans are in principle able to separate these processes from each other and thus achieve flexibility. This means that the mental imagining of the music, for example a melody, can also be evoked independently from a performance at a piano, as when “a melody is going round in one’s head”. Or alternatively we can also, without a musical picture, press the keys of the instrument and allow ourselves to be surprised by what we hear. And in the same way we can hear music without mentally taking it in, so “without listening” or moving one’s fingers. A further motor isolation beyond what is required here, is what has to be practised by every piano student if the two hands are to become independent of each other, namely to be able to play different voices, for example melody and accompaniment.

Beyond this possibility these elements are then voluntarily brought together and influence each other, even becoming a new unity. These neural processes lead to increased agility of the hands, and through this activity of the hands the corresponding area of the brain is also trained extensively.

Especially Fuchs (2009) indicates the connection of these two, and in his book works out that the neural processes are closely related to all the processes in the body, so that the brain can only be understood as an “embodied” organ, which mediates our relationship with the world, to other people and to ourselves, and which connects perceptions and movements to each other. A prerequisite is the high plasticity of the brain, by means of which it is able to transform recurrent connections of the organism with a given object into sensory-motor connections, which are based on their relative functions. Through this the brain becomes a matrix of preconfigurations, created from predetermined patterns, which provide potentialities for mobility. It becomes “an organ of possibilities”. Fuchs refers to an example taken from the investigations into the psychology of music by Bangert & Altenmuller (2003), which show that through practice on the piano both tone and neural movement sequences are practised at the same time. It is then enough to hear the relevant melody to make it possible to remember the movement patterns for the fingers. In pianists this leads to the phenomenon where their fingers start moving just from hearing a melody. In addition they also “hear” the melody before their fingers create it on the piano.

There are an increasing number of studies which show that by means of the complex processes gained by learning an instrument, other abilities are also promoted, including higher cognitive skills (Herholz & Zatorre 2012, Rickard & McFerran 2012). It remains decisive that we can voluntarily bring about these connections, and in principle also disconnect them. A pianist does not compulsively bang on the table every time he thinks of a melody. The relevant components can be deliberately recollected more or less separately from each other, which initially yields the basis for the necessary flexibility. Something similar probably occurs in acrobatics, dance or Eurythmy, which in this sense involves the development of the whole person.

The Game of Evolution

In the case of song birds the possibilities of play can also be expressed in song. Many songs of birds are so rich and flexible that parallels to the movement games of other animals can be drawn. This occurs in the soft, very variable, “study”, or “subsong”, characteristic of young adolescent birds, as well as in the autumn and winter song of many song birds. It is thus justified to also categorise it as play and describe it as play singing. The “subsong” or versatile songs of some kinds of songbirds can even be more variable and longer than the later territorial songs of adult males. The relaxed territorial song is also often described as musically richer than the excited conflict

songs which determine territorial boundaries (Lorenz 1935, Hassenstein 1969, Streffer 2009). The “playful use of voice in songbirds” in a relaxed environment is, according to Streffer, an expression of an increased level of freedom.

Even when the common buzzard or the red kite let themselves be carried by thermals at great heights, this occurs without any obvious immediate physical requirements, and in this sense is an expression of play.

If one were to look, it is obviously possible that one may find other areas in which play of this kind exists. Is it perhaps even possible to find this phenomenon in other areas which have not previously been seen as play? Could it be that nature ‘plays’ in ways other than through behaviour? Does nature possibly ‘play’ simply in the diversity of its beauty and form? If so, the many attempts to compulsively interpret every form or colour, every “mood” of nature as useful or beneficial, would become pointless. Nevertheless, changes in organisms are also due to the necessities of function, to enable the bearers to survive. And clearly there are patterns of form and function, boundaries and requirements according to which changes occur. But could it be that, within this framework, within this range of possibilities, there are also degrees of freedom, which are filled in a playful sense?

Perhaps belonging to this is the perplexing diversity of colours and forms among fish, butterflies and beetles that every observer experiences. Is nature here playing in some primary creative sense, so that the richness in creation is not merely in the service of an immediate purpose, but is rather a game of nature? Can the next innovative evolutionary step perhaps even be prepared and found by means of playing in this way with the existent possibilities?

Among snails and shells there is such diversity, to the extent of forms so bizarre, that the usefulness of these formations must remain puzzling to the observer. The beautiful colours and patterns of the cowry snail are, to crown it all, in the case of the live animal, often hidden by a fold in the mantle, so that they would normally not be visible. What does this mean? Diversity and beauty in the case of unicellular organisms already fascinated Ernst Haeckel. Could this be a game played by nature within the possibilities of unicellular organisms?

If one views the different stages of evolution, one gains the impression that in every instance, once a principle of organisation has been attained, that it has been played with. Ediacaran fauna was an early form of multi-cellular organism, which colonised some ocean beds before the development of metazoan phyla in the course of the Cambrian explosion about 540 million years ago. The organisms were predominantly flat, and therefore spread mainly on the surface, whereby they showed a virtuoso diversity in the possibilities for this surface formation.

During the Cambrian explosion the multi-cellular animals developed a level of organisation in which it was possible to form their bodies three-dimensionally, with three germ layers and increased outward demarcation. In the course of this all the animal phyla that are now known came about very quickly. Not all survived, but some continued evolving and resulted in the forms of animals known today. Did evolution play the possibilities that this new principle of formation offered during the Cambrian?

McShea & Brandon (2010) presented, in the context of the already mentioned newer deliberations on evolution, the concept that nature tends to always generate complexity. This can be the complexity of individual organisms,

of eco-systems or bio-diversity in general. Secondary to this it is then delineated, canalised and reshaped by the most varied processes. Could this also be described as a kind of playing out of the relevant available possibilities?

This "playing" would have occurred every time in the engagement with the requirements of the organisation, the environment and the necessity to survive. But filling in the range of possibilities and its expansion could have occurred in a kind of creative play by nature.

"Beauty is Perfection with Freedom"

Goethe (1794) tried to connect the concept of beauty in the multiplicity of organic forms to degrees of freedom:

"An organic being is so manifold in its exterior appearance, in its interior forms so manifold and inexhaustible, that one cannot choose adequate viewpoints with which to observe it, that one cannot develop adequate organs of perception to dissect it without killing it. The extent to which the idea: that beauty is perfection plus freedom, can be applied to organic nature. [...] To enable [...] an animal, unhindered, to satisfy even the most basic needs, it has to already be a perfect entity; only then, alongside the fulfilment of needs, there remains enough energy and ability to undertake random, to some extent pointless activities; already then we will be aware of its outer beauty.

[...] In these animals the limbs relate to each other in such a way that none hinders the other in its purpose, so that instead there is a perfect equilibrium between necessity and need, completely hidden from one's eyes, so that the animal seems to act only on the basis of free determination. One thinks of a horse that one observes moving its limbs in freedom.

If we progress to the human, we find him almost freed from the bonds of animalness: his limbs in a gentle subordination and coordination, are subjected to the will more than the limbs of any other animal, and not only formed for all kinds of activities, but also skilled for the expression of his spirit."

According to this beauty, is thus experienced when manifestations of life go beyond the necessity of preserving life. This we can already experience in the realm of potentiality:

"We call a perfectly formed being beautiful if we can think while looking at it, that as soon as it so wishes it might use all its limbs in a manifold, free manner [...]."

Several criteria related to play are mentioned here: Play presupposes a degree of freedom, it goes beyond the immediate need for survival, and we relate it to a positive experience, we find it touching when animals or children play with each other. We like it when the birds make sounds that are "playful". We like it when raptors allow themselves to glide elegantly to great heights, and we like to watch young cats boisterously romp about.

Could there be a connection between beauty and the free play exhibited by the power of nature? Do we experience nature as beautiful there where it extends beyond necessity and the demands of survival? Is there a relationship between play behaviour and the iridescent diversity of colours and forms in butterflies, snail shells, coral fish and bird feathers? Where organic possibility has allowed it, has the "free play" of forms, colours and behaviour perhaps promoted evolution?

Is it possible – by taking these deliberations further – to find a connection between diversity resulting from evolution, the "free play" of forms, colours and behaviour, where organic possibilities allow this, and play in behaviour as an expression of freedom in varying degrees?

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Born in 1957, Dr. Bernd Rosslenbroich studied Veterinary Medicine at the University of Gießen (Germany). For his PhD thesis (completed in 1987) he changed to the faculty of human medicine, where he conducted experimental research on the treatment of melanomas. After a half-year research fellowship at the Ohio State University (Columbus, Ohio – USA), he became a postdoc at an institute for comparative animal physiology at the University of Gießen. Besides teaching, his research work focused on reticulocytes during red blood cell formation (erythropoiesis).

After writing a review book on human chronobiology, he was offered a position at the University of Witten/Herdecke (Germany) at the end of 1989. There he was involved in a project to prepare research funding in the field of complementary medicine in Germany as a member of a commission of the Federal Ministry of Research and Technology. In 1998 he changed to the Institute of Evolutionary Biology at the same University, beginning his studies on the question of autonomy in evolution, based on his experience in comparative physiology. In 2006 he finished his "habilitation" (qualification as a university lecturer in Germany) on this topic. The thesis of his habilitation was published as a book (in German) in 2007. In the same year he was appointed head of the institute.

His to date most important book appeared in 2014: "On the Origin of Autonomy. A New Look at Major Transitions in Evolution" (Springer,Cham, Heidelberg, New York, Dordrecht,London).

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