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The behavior-diversification proto-cognition theory of play in animals and humans.

Abstract

The way we play today is the result of an evolutionary process much older than mankind. In contrast to many other researchers who believe that play did not contribute to anthropogenesis, we think that the behavior system “play” was crucial for the higher cognitions and consciousness of humans. The behavior-diversification proto-cognition theory (BD-PC-theory) of play tries to establish an unified theory of play in animals and humans on the basis of modern evolutionary psychology. Phylogenetic and ontogenetic aspects of play were integrated in this theory. Some consequences of the BD-PC-theory are outlined. Connections of play with other developmental dimensions of children are formulated, e. g. the contribution of play to the acquisition of a theory of mind.

1. Introduction

The philosopher Ludwig Wittgenstein (1953) tried to prove in his *Philosophical Investigations* that linguistic concepts cannot be defined via the extension of their features. As the prototypical example he chose the concept of play and showed that the defining features change when different games with rules are analyzed. No set of features exists that is applicable to every play, no set of features allows to distinguish play behavior from non-playful behavior. Different plays only possess what Wittgenstein (1953) called family resemblance, in other words the concept of play is a fuzzy concept (Zadeh, 1965). It is therefore not surprising that play researchers of various disciplines agree that an unambiguous definition of play has not been offered in the history of play research. The most prominent scholar on the subject, Brian Sutton-Smith (1997), even assumes that its ambiguity is the peculiar inherent quality of play.

But for many psychological concepts no obligatory definitions exist. Nevertheless researchers have built theories for the underlying psychological processes. Such theories also exist for play e.g. the classical pre-exercise theory of Groos (1899, 1901), the physical exercise theory of Peter K. Smith (1982) the cognitive-developmental theory of Piaget (1962), the arousal modulation theories of Hutt (1979), Shultz (1979) and Ellis (1973), to mention at least a few.

More recent psychological approaches of play differ to more classical ones with respect to their broadness. Compared to speculations and theories of the 19th century (e.g. Spencer, 1864, 1873; Gulick, 1898; Lazarus, 1883; Groos, 1899, 1901), which tried to explain the entire phenomenon of play, psychological approaches of the 20th century only focus on specific aspects of play. And the 20th century play researchers are correct when they criticize those earlier approaches for their one-sidedness. The early theories tried to explain the

entire phenomenon but mostly with a narrow focus on one psychic function. On the other hand the early approaches compared to the approaches of the 20th century show a closer match to what we would nowadays call an unified theory of play in animals and humans. An exception is Piagets (1962) play conception but he integrated play into his system of cognitive development and did not accept an independent value of play (Sutton-Smith, 1973).

But now the theoretical prerequisites are available to try once again the construction of an unified theory of play in animals and humans, an attempt that does neither neglect the variability of play forms and play behaviors nor the variability of play functions.

2. An evolutionary approach to play in animals and humans

The starting point of evolutionary considerations about play is the phenomenon that not only (young) individuals in the species *homo sapiens* show play behavior but also other animal species (Bekoff & Byers, 1998, Burghardt, 1998a). All mammals, some birds and perhaps even nonavian reptils (turtles [*trionyx triunguis*]; Burghardt, 1998b) play. This means that the behavior system "play" is much older than modern humans, it is even much older than the hominids (all members of the family *hominidae*), it already existed for millions of years when the first australopithecines (Wood, 1992) appeared. For a deeper understanding of play behavior and for a principle understanding of the adaptive function of play it is therefore necessary to study this phenomenon within an evolutionary perspective. It follows directly that play as a psychological phenomenon has to be studied within the framework of evolutionary psychology (Cosmides & Tooby, 1992; Tooby & Cosmides, 1992; Buss, 1999). Evolutionary psychology (EP) is a synthesis of modern evolutionary biology with modern (cognitive) psychology. It focuses on constructive features shaped by natural selection, constructive features of the psychic mechanisms controlling behavior. In a more narrow cognitive version (Cosmides & Tooby, 1997) EP can be defined as the description of information processing mechanisms designed by natural selection whose interplay form the human mind or its cognitive architecture respectively. EP, sometimes also called Darwinian Psychology (Plotkin, 1994; Cosmides & Tooby, 1987), should therefore be congruent with valid principles of classical and modern evolutionary biology.

The classical assumption of natural selection by Charles Darwin (1859) is still a main basis of evolutionary psychology. Darwin's argument includes to following steps: 1) the number of individuals of a species grows faster than the necessary resources that are available (principle of Malthus, ⁶1826; orig. 1798), 2) individuals of a species vary in structural and behavioral features, 3) the variations can be inherited, 4) if individuals of a species acquire a competitive advantage in the acquisition of resources caused by variation this will increase their chance to reproduce. It follows that the variation will manifest itself gradually in the population or a subpopulation of that species. In modern evolutionary biology the reproductive success of an individual, including the ability to survive until reproduction, is called fitness. Darwin's (1859) principle of natural selection is equivalent with reproductive fitness, sometimes also called Darwinian fitness.

An important modification of the classical approach to fitness (which had certain shortcomings) was developed by Hamilton (1964a and b) with his theory of inclusive fitness. Inclusive fitness is the sum of direct (reproductive) fitness and the so called indirect fitness, which is the reproductive success that can be acquired through the reproduction of genetic relatives. It follows that not only the reproductive success of the individual itself but also its actions and their consequences that influence the reproductive success of its kin are relevant for the survival of the individual's genes. The concept of inclusive fitness allows to explain e.g. genetic altruism and the spread of an altruistic gene. Important works of Trivers (1971, 1972) explain the conditions for reciprocal altruism in animals which are nonkin and for the natural selection of sexual differences in parental investment in offsprings. Kimura (1983) showed that gene frequencies can also change randomly over time and that therefore

specific features can manifest themselves in populations even if they are not adaptive. Wilson's (1975) book on sociobiology did not offer a new evolutionary theory but was a synthesis that integrated humans and cultural tools produced by humans into the range of phenomena ultimately to be explained by evolutionary principles. More or less this was the state of the art in evolutionary biology when the revolution of evolutionary psychology started. We want to introduce the topic "evolutionary psychology" in the version of Cosmides and Tooby (1992, 1994) by five main defining principles used by Cosmides and Tooby (1997) to capture the evolutionary origins of the human mind.

Five principles of modern evolutionary psychology

The first principle assumes that the human brain works like a bio-computer and its neural circuits enable the production of behavior which is adapted to a specific environment. The next principle states that the neural circuits were designed by processes of natural selection (they are solutions of adaptive problems). We possess a specific set of neural circuits because this set produced better solutions compared to an alternative set when confronted with adaptive problems, by improving the inclusive fitness. The human brain is therefore a naturally constructed computer system which solved adaptive problems in information processing. Adaptive problems are only such problems which occur very often in the evolutionary history of a species, they are "evolutionary recurrent situations" (Cosmides & Tooby, 1994).

The third assumption states that only the results of some (integrated) high-level neural circuits can be processed consciously. This means on the other hand that the majority of processes operates automatically. The consciousness of the modern human mind is only the "tip of the iceberg" of its cognitive architecture (Cosmides & Tooby, 1997). This principle has much in common with Minsky's (1986) "society of mind" which states that the human mind is an assembly of autonomous distributed agents (circuits) without any symbolic meaning, but the interplay of the agents leads to the emergence of the higher cognitive achievements of the system.

This is followed by the idea that different neural circuits are specialized to solve different adaptive problems. Cosmides and Tooby (1994; Tooby & Cosmides, 1992) argue that different adaptive problems need different solutions and those solutions can only be achieved by very specific functional distinct mechanisms. These specialized modules increase the inclusive fitness, but something that fits for one domain does not fit necessarily for another domain. To solve that problem many distinctive domain-specific modules evolved. Cosmides und Tooby (1994) assume that therefore the amount of domain-specific cognitive mechanisms approximately equals the amount of types of adaptive problems.

The last principle states that we are a kind of "mammoth-hunters in the subway"¹. We are adapted to an *environment of evolutionary adaptedness* [EEA] that existed circa 200.000 years ago in the savannahs of East Africa (Cann, Stoneking & Wilson, 1987). In contrast to the second principle that refers to the entire evolutionary history of modern humans this last principle states that the cognitive architecture which secured the survival of hunters and gatherers in the Pleistocene is still at work nowadays. There was not enough time in evolutionary dimensions (variation qua mutation, inheritance and selection) to change the cognitive architecture of *homo sapiens* fundamentally. The distinction between adaptation and adaptiveness (Symons, 1992) is important in this context. The cognitive architecture and different types of behavior it produces are an adaptation to an EEA but this does not imply that architecture and behavior are still beneficial for survival and reproduction in modern environmental niches, it does not imply that variations in those features still possess adaptiveness.

¹ "Mammoth-hunters in the subway" is a retranslation of the german book title of "Stone age present" by William F. Allman (1994).

To summarize the principles it could be said that the correct metaphor of the human mind is not a general purpose machine that manipulates abstract signs formally (Newell & Simon, 1972); the correct metaphor is a neural network out of which domain specific modules emerge which are the result of selection processes in evolutionary history.

The behavior-diversification proto-cognition theory of play in animals and humans

This introduction on evolutionary psychology now allows us to explain the core structure of our behavior-diversification proto-cognition theory [BD-PC-theory] of play in animals and humans². We begin with the behavior-diversification part of the theory. The basic assumption is that the behavior system “play” was selected in evolution because of its potential to generate behavior variants. Once upon a time a vertebrate species existed and in this species a mutation appeared which caused a very curious behavior that probably was not observed in any other species before. The curious behavior was to produce random sequences of acts which are originally part of other behavior systems (e.g. fight, flight, hunting, nutrition, reproduction). The behavior acts are sequenced in a combinatory fashion across the borders of behavior systems. Individuals of that species which possess this behavioral feature are able to retrieve a repertoire of behaviors more effective than other conspecifics. If this species lives in an EEA (much older than the environments that shaped the hominids) with variable changing niches – but with changes on which can be reacted with responses on a behavioral level – these individuals have an advantage in fitness (an adaptive advantage). Individuals which possess the feature “play” show higher reproductive success. Over many generations the feature will manifest itself in the genetic pool of that species, all members of the population or isolated subpopulation will play. This is the first part of BD-PC-theory.

This part of the theory is not new. The central assumption of *behavior diversification* in BD-PC-theory is close to ideas formulated by Sutton-Smith (1997, 1978) using labels like *adaptive variability* (Sutton-Smith, 1997)³ or *adaptive potentiation* (Sutton-Smith, 1978) or ideas formulated by Fagen (1981) like *functional flexibility*. Both authors want to express that playing species adapt to their environments with the aid of flexible behavior patterns and may even change their environments in this process (Fagen, 1981). One major difference seems to be that Fagen (1981) and Sutton-Smith (1997, 1978) believe that play behavior *uses* different behavioral elements whereas the BD-PC-theory assumes that play behavior originally *is* identical with the combination of behavioral elements of different behavioral systems. The other approaches look at diversification as a play function, for the BD-PC-theory diversification is the defining element of play when it first appeared in evolution.

Fagen’s (1981) approach is restricted to animal play, he does not try to integrate animal and human play forms. For Sutton-Smith (1997) and the BD-PC-theory animal play is only the starting point for assumptions integrating animal and human play. Both approaches agree that the evolutionary function of play is not practice (Smith, 1982) or pre-exercise (Gross, 1899) but behavioral adaptation. But for BD-PC-theory it is not an enlargement of adaptive behavioral potencies (Sutton-Smith, 1997) it is a behavior system that increased inclusive fitness. Therefore we think, Sutton-Smith’s (1997) main mistake is, to take the evolutionary function of play too metaphorically⁴. Our conceptualization of adaptation via behavioral diversification is to be understood in a strictly literal sense.

² A broader introduction into the BD-PC theory can be found in Ohler (2001).

³ Brian Sutton-Smith’s (1997) book “*The Ambiguity of Play*“ presents a meta-analysis of the discourse types in play research. This book is very inspiring, but for the argument in the present article only his five last subchapters of the last chapter of the book are especially relevant. In this sections the idea of the *adaptive variability* of play is developed systematically.

⁴ This can be shown in various formulations e.g. “[play is P.O. & G.N.] ...some kind of reinforcement of realistic adaptive variability” (Sutton-Smith, 1997, p. 224). Sutton-Smith (1997) undermines the evolutionary appeal of his approach to play by assuming that play reinforces other prior and „real“ adaptive functions of variability.

We can now continue with the proto-cognition part of the BD-PC-theory. The individuals of the first species with a fixed play allele in its genome differs from the individuals of that species before this mutation occurred. The neural circuits and control-mechanisms which generate play-behavior are now part of the psychic architecture of the playing species, the individuals of the species now possess a play module. The module is distinct from other neural circuits that were selected in the course of solving other adaptive problems (Cosmides & Tooby, 1994). It is always triggered when specific environmental cues occur, resembling the adaptive problems in the EEA. In correspondence with the adaptive problems that were in function during the establishment of the play module, it will be triggered always when *non-reducible novelty* appears in the stimulus-field of an individual of the playing species. If environmental cues are associated with non-reducible novelty⁵ individuals of that species will respond with the activation of the play module. As a result those individuals will execute the typical combinatory behavior sequences transcending the borders of behavior systems.

If a specific feature is fixed in the genome of a species it will only be extinguished again if it causes detrimental effects on the individuals of the species under the conditions of a change in the biotic and/or a-biotic environment. This was not the case with the play module of our hypothetical first-players. Would it be extinguished humans and other animal species would not play nowadays.

We make a jump in the evolutionary period of time. The evolved play mechanism is preserved even in species with higher developed cognitions. We have now approximately reached the complexity of cognitive systems that can be observed in mammals like the canines (Bekoff, 1998, 1995). The general principle of the play module still is: If it is active, it varies the units of those other systems systematically, that are activated at the same time. But the module is now – in contrast to the situation of the original first players – not restricted to circuits controlling behavior but can also operate on cognitive modules.

Then a species occurred – probably either a common ancestor of the families *hominidae* and *pongidae* (of humans and great apes) or an ancestor in the hominid line – that possessed a cognitive architecture (Anderson, 1983) with a capacity allowing a qualitative new type of mental representation. Up to this point in evolution all species only were capable to operate cognitively on the base of primary representations (Leslie, 1987; Perner, 1991). The contents of primary mental representations – also called cued representations (Gärdenfors, 1995) – are always related to entities that are available in the present situation of the representing organism. Maybe the entity is really present in the stimulus field of the representing organism or at least some cues in the environment exist, which refer to the represented entity (cat sitting in front of a mouse hole, where a mouse has disappeared). Primary or cued representations are always tied directly or indirectly (via still present cues) to the perception of the representing organism. Primary representations may be selective, they may not represent every aspect of the environment but they do not represent aspects that are not at least indirectly present. At this point in the evolution of representational systems no individual of any species was capable to represent entities that are only imagined.

In this situation the play module would enable a quantum leap in the functioning of the representational system. Our premise is, that a species with at least a few individuals has evolved, which possess a cognitive architecture capable of producing a new type of representation. When those individuals have activated primary representations that trigger the play module – genuine novelty or inconsistencies within the represented content may be the causes – the play module will work in its well-established fashion. It will force to combine

⁵ In assuming that epistemic novelty causes the play mechanism the BD-PC-theory strictly contradicts all variants of an activation theory of play (e.g. Hutt, 1979; Shultz, 1979 or Ellis, 1973). At least in its evolutionary origin the play mechanism was not triggered to increase the activation-level of a central nervous system to an optimal level. The play mechanism was only triggered when the activation level was rather high, for it is always a stressful situation for the organism to cope with epistemic novelty.

every unit in the activated part of the cognitive system with every other unit. This systematical combination of units in primary representations will lead to the emergence of a semiotic function that was not realized before. A new relation between elements is established: a mental element is able to represent another mental element.

With this rudimentary novel semiotic function the first secondary representations (Povinelli, 1998a; Perner, 1991) are established in the course of evolution. Secondary representations – also called detached representations (Gärdenfors, 1995) or decoupled representations (Leslie, 1987) – refer to entities that are *not* available in the present situation of the representing organism and *not* present in its stimulus field. The elements of secondary representations are *not* triggered by cues in the environment. The content of secondary representations consists of mental elements referring to mental elements. Now entities can be represented that are only imagined. Secondary representations are the prerequisite for all cognitive operations that allow hypothetical and/or counterfactual thinking (Mitchell & Riggs, 2000).

This means that the play module is responsible for the quantum leap to the first secondary mental representations in phylogenesis, of which some authors think that they are fundamental for the difference between humans and all other primate species (Povinelli, 1998a; Gärdenfors, 1995). The capacities of the new representation system in its original state were surely very small. Only a rudimentary anticipatory planning was made possible. But for the individuals possessing such a system nevertheless suddenly the possibility emerged to play cognitively with behavior alternatives and not just to pick alternatives at random and to act blindly based on trial and error. If this allowed an individual to avoid at least one tragedy from birth to reproduction the direct fitness of that individual was increased enormously. Again, over many generations the feature will manifest itself in the genetic pool of that species, all members of the population will have secondary mental representations at their disposal.

We can now take a closer look at the consequences that should be expected from this phylogenetic pattern for the ontogenesis of human children. Ontogenesis is not a recapitulation of phylogenesis as assumed by some authors of the 19th century (Haeckel, 1924; for recapitulation theory of play: Hall, 1920; Gulick, 1898) but they possess an analogue developmental logic (Langer & Killen, 1998; McKinney, 1998). This would mean, that early pretense play which appears at around 12-13 months in humans should be the ontogenetically first psychic domain in which secondary mental representations are realized. Even in ontogenetically later play forms, e.g. constructive play, social play and games with rules, the combinatory diversificative depth structure of activities triggered by the play module remain in function but with different surface features in the behaviors executed in the different play forms. These are the central assumptions of BD-PC-theory of play which tries to explain animal and human play within a unified evolutionary framework.

Some inferences from behavior-diversification proto-cognition theory of play

We will infer some propositions from BD-PC-theory, to show that the theory allows the deduction of some psychologically very interesting and also empirically testable hypotheses. A main consequence of BD-PC-theory concerns the underlying neural substratum of the evolved play module. A distinct neural topography realized as a distributed neural network should exist, which is always active when an organism is playing. This should be found in the central nervous systems of all playing species and should also be identifiable across the different play forms of humans when they are playing. To assume a distinct neural topography associated with play does not exclude a partial overlap between those brain areas active in play and those involved in other behaviors. The combination of different behavior acts is the original defining feature of play. Therefore neural circuits associated with those other behaviors will also be activated during play. Nevertheless if a play module exists there should also be a unique neural fingerprint of that module.

The human brain with a mammalian cerebral cortex but a much more developed neocortex compared with all other species should show different connections of the neural circuits active during play with areas of the association cortex. The unique neural fingerprint of the play module should show enriched connections to the association cortex in humans. This would match the differences in the behavior of humans towards other species: some play forms are only executed by humans. On the other hand our argument emphasizes that the play module is evolutionary much older than the appearance of the first primates. Therefore it should not be located dominantly in regions of the brain that are unique to humans and perhaps even not in regions that are unique to the mammalian brain. The play substratum should show connections to evolutionary older regions of central nervous systems.

There really exists some evidence, that this risky inference of the BD-PC-theory is not totally speculative. Siviy (1998) researches the neurobiological substrates of a social play form in mammals: the rough and tumble play of juvenile rats of different strains (Siviy, Baliko & Bowers, 1996). The parafascicular area of the thalamus (PFA) seems to be an area of the brain that may be a candidate for the unique fingerprint of the play module.

“... PFA might be a major interface for integrating somatosensory information encountered during play and relaying this information in a manner that facilitates the motor patterns used for playing” (Siviy, 1998, p. 234).

Analyses of immediate-early genes, that indicate brain areas that were active in behavioral sequences enacted before, showed that rats in the experimental group (30 minutes of rough and tumble play) had increased values in PFA but also in areas of the cortex and of the hippocampus. Siviy (1998, p. 234) states that “future studies that use this technique could attempt to isolate different components of play in order to reduce the background noise”. This effect and other neurobiochemical studies of the Siviy group (e.g. Siviy & Baliko, 2000; Siviy et al., 1996) to find the neurobiological substrates of mammalian playfulness indicate that the play module stated by BD-PC-theory can be proved on a neurophysiological level.

Another inference from BD-PC-theory, touches the question whether great apes should show early pretense play or not. Early pretense play in humans starts at about 12 to 13 months of age with play acts like the following performed by a child in our lab at the University of Passau: The child crawls and articulates “bow-wow” pretending to be a dog. Another example is our own daughter Rahel who exhibited at the age of 12 months and 8 days the complete early pretense script of feeding a doll with pretense meal.

The BD-PC-theory says that early pretense in humans should be the ontogenetically first psychic domain in which secondary mental representations are realized. But whether great apes should also exhibit early pretense not only depends on the BD-PC-theory but also on the state of the art in the animal “theory of mind” discussion. Some researchers think that great apes are *mindreaders* (Whiten, 1998 and 1997; Fouts, 1997), which means that the apes consider other apes to be intentional agents that possess the same mental states like themselves. Those researchers tend to conclude from field studies with anecdotic proofs that at least great apes are able to deceive intentionally. Those researches interpret the fact that great apes recognize themselves in mirrors (pass the mark-test; Gallup, 1982, 1983) as a secure clue that they possess self-awareness. Some other researchers think that great apes are only *clever behaviorists* (Tomasello, 1999; Povinelli, 1998b and 1996; Reaux, Theall & Povinelli, 1999). Despite the insightful and complex problem solving strategies great apes show in their physical interaction within the environment they are not able to capture their social world on the basis of intentional concepts. Those researchers like to refer to laboratory studies with human experimenters as the intentional counterparts of the apes, which fail in those situations to make intentional attributions. The researchers believe, that the deception activities even of great apes living in the wild are only the result of complex reinforcement schedules (Heyes, 1998) and that the results in mark tests are only evidence of a kinesthetic self and not of a mental self (Povinelli, 1998b).

If this last picture is true, humans should be the only species possessing detached (secondary) representations. If this picture is true, it is left open by the BD-PC-theory whether great apes should show early pretense play or not. Maybe there is no early pretense, therefore great apes do not acquire a *theory of mind/mindreading* later on. Maybe they show early pretense but are not developed enough to ever reach the *mindreading* stage of about 4-year-old children. Great apes as *clever behaviorists* may show early pretense or not. The BD-PC-theory can cope with both outcomes. But if the first picture is true and the struggle of the researchers will end with the consequence that great apes are really *mindreaders*, BD-PC-theory will make a strong inference: Great apes should necessarily show early pretense play. Whether great apes show early pretense play is also not definitely clear in the literature (Ohler, 2001; Tomasello & Call, 1994). The data of Jensvold and Fouts (1993) seem not very convincing to us (Ohler, 2001). We think that the definite answer will be found in the Gombe National Reserve and not with apes trained in ASL (American sign language).

The reason why the BD-PC-theory makes the strong inference that great apes will show early pretense play if they are mindreaders, is that the theory favours what we call a “pole-position-approach” of early pretense play, phylo- and ontogenetically. Therefore we assume that early pretense play is the first domain in which decoupled representations will emerge in the cognitive development of human children. This again is not mainstream in cognitive developmental psychology. Most authors think that early pretense play is only one of at least a few functions that can be executed on the basis of the most recently developed representations in ontogenesis (Leslie, 1987; Perner, 1991). In contrast to that mainstream perspective we offer a so called leading edge position of early pretense play, or like Wygotzky (1973, 1978) put it, we think that play is a zone of proximal development. If this is true play should allow the training of theory of mind tasks, another inference that can be drawn from the BD-PC-theory and that was confirmed in our research (Ohler, 2001).

The BD-PC-theory of play in animals and humans can give play research a new direction. It makes a contribution to one of the most important psychological riddles still to be solved: How does the process of anthropogenesis work, how do we become the cognitive animals we are? Additionally the BD-PC-theory allows to integrate play research into the new emerging field of a developmental evolutionary psychology (Bjorklund & Pellegrini, 2000).

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