

Doctoral Dissertation

- Exposé -

Evolutionary Roots of Creativity and their Relevance for Business Innovations

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1. Abstract

1.1 Research Question and Importance

Within this research the development of an integrative evolutionary theory of creativity is attempted. This theory will subsequently be applied and verified in the context of business innovation. Although extensive research has been carried out on the field of creativity since the early 1950s the results do not provide a consistent overall explanation of creative behavior. The absence of a consistent explanatory framework has prevented deeper understanding of creativity as well as its focused application in business innovation.

1.2 Theory Base and Significant Prior Research

Evolutionary psychology is employed as a research framework to integrate explanation of creativity as a trait as well as a process. Darwinian trait approaches to creativity of Lorenz (1977), Eysenck (1995), Csikszentmihaly (1996) and Miller (1999) are considered and approaches to creativity as a process from Campbell (1960) and Lumsden and Findlay (1988) are discussed. Explanations of business creativity from Hesse and Koch (1998) as well as from Massey (1999) are reported and new findings from Simonton (2005) are taken into account.

1.3 Research Approach and Methodology

The social brain hypothesis (Brothers, 1990; Dunbar, 2007) and theory on the evolution of stress response to social threats (Flinn, 2007) are used as theoretical framework to integrate process and trait aspects of existing evolutionary explanations of creativity. New product development with idea markets (virtual stock markets) are used for applying and verifying the theory.

1.4 Potential Outcome and Importance

Theoretical integration of process and trait aspects will provide deeper understanding of creativity as well as extended possibilities for its application. Testing the theory within the recently developed framework of idea markets (Soukhoroukova, 2007) will offer new insights on the creative potential of markets as well as on the motivation of its participants. Ten consistent hypotheses are derived and tested on behalf of the developed model of creativity: (1) **Cooperation**: The possibility to cooperate and collaborate in idea finding should significantly increase the quality of creative outcome. (2) **Incentives**: Incentives not related to the idea (e.g. money for participation in the idea market) should not have any positive effect on the creative outcome). However, incentives related to the idea should foster creativity, if they are generated consensually. (3) **Social Values**: Those participants acquainted with the social values of the trading group should generate higher quality creative ideas. (4) **Groups**: Groups already existing before the idea market should generate significantly higher quality creative ideas due to their deeper understanding of their shared values. (5) **Group Size**: Group size should have marginal utility to overall creativity of participants. Beyond 150 participants additional participants should contribute significantly less relative to overall creativity. (6) **Shared Goals**: Shared goals should foster overall creative outcome of idea market participants. (7) **Group Values**: Creativity should directly reflect cultural group values. This should be significant in cross-cultural comparison of idea markets with the same task. (8) **Stress**: Stress-resistant participants with lower cortisol-levels should generate more and higher quality creative ideas. (9) **Gender and age**: Male participants should be more active and thus develop more creative ideas than female participants. At the same time males should show more short-term (advantage-taking) trading than females and thus show less quality of creativity than women. Creativity in business context should be highest with participants at or around the age of 30 years. (10) **Trading**: Overall trading frequency should correlate with overall creative outcome of all idea market participants. Short-term (advantage-taking) traders should have lower quality creative ideas than long-term (value-creating) traders.

2. Research Question

Today creativity is almost generally appraised as cornerstone and basis of business innovation processes, whereas innovation is considered to be a twofold process consisting of the creative generation of a new idea and the subsequent implementation of the idea into a valuable product (Sawyer, 2007; Taylor & Greve, 2006; Wildner, 2006; Herb, Herb & Kohnhauser, 2000).

Although extensive research has been conducted on the key factors determining creativity at work (Amabile, 1988; West & Anderson, 2002; Woodman, Sawyer & Griffin, 1993; Amabile, Conti, Coon, Lazenby & Herron, 1996; Klein & Sorra, 1996), the results only display a great variety of fragmentary knowledge. Apart from few rudimentary exceptions (Taylor & Greve, 2006) this research allows no deeper understanding of the structural relation between creativity and innovation quality. More important, the research on creativity is generally suffering from an inability to explain creativity in a consistent and universally valid way (Unsworth, 2001; Runco, 2004; Horn & Salvendy, 2006; Kaufman & Sternberg, 2006, p. 2 f.). Until now the only two generally accepted components of creativity are novelty or originality on the one hand and appropriateness or correctness in the given context on the other (Sawyer, 2006, p. 33; Wilpert, 2005, p. 233; Amabile, 1982, p. 999).

As a reason for this conceptual deficit of creativity some consider that the experimental findings have been extensively applied to correlates of creativity, but not creativity itself (Runco, 2004, p. 679). Others don't see creativity as the unitary construct as most researchers generally perceive it (Unsworth, 2001). Most disillusioning though seems to be the argument, that it should be ultimately impossible to articulate general criteria for creativity due to its dependency on social context (Amabile, 1982, p. 1001).

To avoid these limitations we will analyze creativity from an evolutionary psychological point of view. The aim will be to develop an overall consistent theory of creativity integrating the two aspects of creativity: as a trait and as a process as well. We then want to verify and apply this theory in the context of business innovations. Here we want to examine possibilities to use group creativity in the context of new product development within idea markets.

3. Importance of Research

Constant change has become a hallmark of our modern world and innovation is not just fashion any more but has become an integrated part of standard business assignments. Companies consider innovation as the only sustainable way out of stagnant markets (Twardawa, 2006) and as long term company “survival insurance” (Herb, Herb & Kohnhauser, 2000, p. 13). On national and international level innovation is referred to as the “engine of cultural evolution” (Runco, 2004, p. 658), providing substantial economic growth and welfare to whole societies (Sawyer, 2006, p. 287).

Although this is a matter of common knowledge and the social relevance of innovation is publicly visible, e.g. in arts, music, engineering, science, as well as in consumption, in the latter field the vast majority of all product innovations fail (Wildner, 2006, p. 72; Herb, Herb & Kohnhauser, 2000, p. 13). There are mainly two explanations for this failure: firstly, the insufficiency and opaque character of innovation. Secondly, a general lack of consumer orientation in product innovations (Wildner, 2006, p. 82; Naderer & Balzer, 2007, p. 397).

Taking into account this high level of failure it should be very useful to take a deeper look at the role and character of creativity in product innovations. It is possible that business focus has shifted to organizational questions of implementing innovation into new product development. But the creative and inventive part as the actual first stage of the overall innovation process is neglected. Another possible explanation could be the structural inability of certain types of companies, e.g. large manufacturing companies, to creatively integrate consumer expectations in their new-product development processes. The recently upcoming ‘Open Innovation’ companies could be an indicator for this phenomenon. They offer large manufacturing companies the service of integrating consumers actively into product innovation processes in order to achieve significantly greater product success (Naderer & Balzer, 2007, p. 398).

We will analyze the role of creativity in new-product development from an evolutionary perspective. Thereby we will try to provide new insights to the question of the origins of product ‘appropriateness’ with regard to consumer motivation and consumer expectation, which will eventually help to improve existing business innovation processes.

4. Theory Base of Research

Following Feynman's (1974) demand for scientific integrity we will choose our theory base according to its explanatory capabilities with respect to the research question. We will avoid any mismeasuring constructs (Gould, 1996) as well as concepts which are either not fully defined or not fully open to scrutiny. Plainly spoken the framework has to fit the research problem, delivering a valid answer to the question imposed.

We have to look for an explanatory framework powerful enough to reach beyond the current fragmentary 'definition' that defines creativity as 'generating new and appropriate products'. The only way to solve this problem is to overcome its inter-temporal relativity (Sawyer, 2006, p. 288 f.). An adequate explanatory framework thus has to find a non-relative point of view, from where we can apply an effective methodology.

4.1 Anthropology as potential Theory Base

One such possible point of view could be anthropology as a scientific discipline of cross-cultural comparison. If we applied the anthropologist's view on the problem, we probably could eliminate the variance in our findings on creativity resulting from intercultural differences. But we would not be able to solve the problem of inter-temporal relativity. Furthermore, we would probably be unable to answer the teleological question about the underlying purpose of creativity. Due to these limitations we have to cease from anthropology.

4.2 Evolutionary Psychology as potential Theory Base

A more adequate framework for our research context could be evolutionary psychology.

There are at least two possible aspects of creativity which can be studied with an evolutionary approach. One approach is analyzing creativity as a trait, suggesting that creativity might be an evolutionary adaptation. The second approach concerns the process of generating creative ideas. This process could be explained as a random variation, selective retention and

subsequent transmission of thought. Whereas the first aspect fits very well as a subject for an evolutionary study¹, the second could become a problem. The evolutionary model could only be applied to the process of generating creative ideas if the variation of thought leading to creative ideas was random and unguided by the conscious mind. However, most creativity researchers think that the actual creative stage in the process of creativity – incubation - is guided “by conceptual structures, by association networks, or by unconscious processes of evaluation” (Sawyer, 2006, p. 63-67, 94). This could potentially contradict with the Darwinian model of variation. However, in the next paragraph we will show in detail that this is not the case.

4.3 Applicability of Evolutionary Psychology to explain creativity as a process

In the following we will demonstrate that the creative variation process is genuinely unpredictable as well as sufficiently random to be explained with Darwinian principles. This will allow us to apply the evolutionary model to the creative-idea generating process. Therefore, we will first point out the character of randomness within the biological evolution.

4.3.1 Randomness in Biological Evolution

Although all new genes originate from mutation², the extent of evolutionary variation of natural populations does have its origin in recombination³ (Mayr, 2005, p. 128, 133). This

¹ Simonton describes this approach as “primary Darwinian theory of creativity” (Simonton, 2005). A concise overview on the actual discussion about the evolutionary character of creativity as a trait can be found in Sawyer (2006, p. 89 f.).

² Our approach does not follow Simonton (2005), who is integrating mutation in his “secondary” Darwinian theory of creativity. We do not see mutation as a valid evolutionary analogy for creativity. Mutation occurs spontaneously or by effect of mutagenic environmental influence (Kilian, Kothe, & Zitzmann, 2006, p. 99). Thus it plays a role on the biochemical level rather than on the level of biological variation processes. Mutation provides the chemical basis (base sequences) for the actual adaptive process of biological selection. Simply put: Although all genes emerge from chemical mutation processes, the extent of phenotypic variation in biological evolution results from recombination. The idea of a “mutation pressure”, being around before 1900, has proven

recombination leads to the development of a genuinely new set of genes. However, it is very important to keep in mind, that genes themselves are not random at all. Genes are by no means disordered⁴. Altogether we can sum up the biological variation processes leading to evolution as a randomization of non-random, but rather well-arranged genetic patterns⁵.

Having provided a basic understanding of the principles of biological evolution we will now try to apply these principles to the domain of psychology, using them as a framework to explain the process of creativity. In doing so, we will follow the majority of psychologists, who believe that the combination of mental elements in the incubation stage of creativity is guided by unconscious processes (Sawyer, 2006, p. 64, 94). Nevertheless, our distinctive point will be to show, that the outcome of these processes is genuinely random and unpredictable, just like the random recombination of genes in biological evolution. Thus it will be our challenge to resolve this paradox of ‘predictable unpredictability’.

wrong. The frequency of a gene in a population is a function of natural selection, not of the frequency of mutation (Mayr, 2005, p. 128). Support for our view can be seen in the various anti-mutagenic mechanisms that have evolved (Yang, 2008; Sachdev & Davies, 2008; Ke et al., 2008). Although similar principles as in biological evolution might play a role in the emerging of highly structured base pairings this is not a question of biological evolution because base pairings do not reproduce other than by genes.

³ This complex process, called meiosis, consists of two cell divisions, leading to the final haploid gametes. During the first cell division sister chromatides of homologous chromosomes connect. Then the overlapping parts of the chromatides break apart and re-connect with the sister chromatides. This process leads to new gene couplings and is called ‘Crossing-Over’ (Mayr, 2005, p. 134). During the second cell division the chromatides of all chromosomes separate and randomly reassemble in reduced, haploid form. This recombination guarantees that every fertilized ovum contains a unique and absolutely new combination of parental genes.

⁴ They are highly structured sequences of base pairings which are linearly arranged on the chromosomes (Mayr, 2005, p. 137; Kilian, Kothe & Zitzmann, 2006, p. 98). A molecular biologic analysis has shown that many sequences of human base pairings can be traced back to early bacteria and are highly stable (Mayr, 2005, p. 125). Genes are inherited together as a group and are frequent on chromosomes (Kilian, Kothe & Kitzmann, 2006, p. 98). And although they can be broken up in the process of Crossing-Over, this does not happen randomly: More distant genes happen to be decoupled more often. Finally, some genes are influencing the segregation of alleles of heterozygous cells during meiosis so one of the alleles has a more than 50 percent chance of getting into the gametes (Mayr, 2005, p. 129). And of course we have to bear in mind that in almost all species sexual selection is not a blind process but there are certain preferences of a certain phenotype.

⁵ It is important to emphasize that we do not resolve the problem of “blind vs. non blind” evolutionary processes by establishing a continuum like Simonton (2005). Here we maintain to assume a genuine blindness or randomness in evolutionary processes. We will later present detailed evidence, that this randomness in the form of unpredictability is also an essential and indispensable key element of creative thought.

To better understand the mental processes of this “least understood stage in the creative process” (Sawyer, 2006, p. 61) we will start off from the theoretical perspective with the strongest explanatory power so far: the creative cognition approach⁶.

4.3.2 The Creative Cognition Approach

This approach tries to explain creativity by analyzing how our mind combines concepts (Finke, Ward, & Smith, 1992). Its distinctive assumption is the existence of a series of basic cognitive processes like idea producing, filtering and exploration processes that are together causing creativity. Generative processes, for example, are supposed to be responsible for information retrieval, association and combination. Subsequently filtering processes applying criteria like novelty and aesthetic appeal evaluate which of the ideas will be retained and explored. Finally, exploratory processes modify and elaborate the ideas, considering their implications and limitations and eventually transform them if necessary (Sawyer, 2006, p. 65). The most important finding within this approach corresponds with the view of psychoanalytic theorists, that mental elements are “integrated” rather than being “merely added or combined” (Rothenberg, 1979, p. 12). According to this finding, the integration of elements in higher-level structures changes the character of the single elements. That is why the emerging higher-level structures cannot be understood by simply analyzing their single components.

4.3.3 Gestalt School of Psychology

This notion is, of course, not new and leads us directly to one of the key insights of Gestalt school: ‘the whole is greater than the sum of its parts’ (Koffka, 1913; Köhler, 1913; Wertheimer, 1925). This oracle either seems to contain very much or nothing at all. To make

⁶ The association theory of Mednick (1962) does not reach the explanatory power of the creative cognition approach as it cannot reflect the complexity of creative ideas. Association theory remains on the level of frequency to describe creative ideas. According to this theory an idea is more creative (unique) when the association is more remote due to a flat curve of associations (Simonton, 1999). This explanation misses out on the qualitative differences between creative and uncreative ideas, especially on the complexity of thought.

it accessible for our understanding we will draw on the guiding interpretation of a Gestalt expert. Metzger (1963) explains that the mentioned statement refers to a change in perspective: In our mind the whole does not arise from its parts, but the parts arise from the whole according to special 'laws of Gestalt'. Examples for these laws are often provided by visual illusions demonstrating our innate mechanisms of depth perception, pattern recognition and active complementation of missing parts in complex structures (Metzger, 1963, p. 12; Vollmer, 1994, p. 50 f.). Compliance with these laws can be summarized as 'gute Gestalt' (Shimony, 1971). This leads us to the point being central for a deeper understanding of the mental processes underlying creativity: the active, constructional character of our perception. Although only in a tentative way, Gestalt theory already recognized this constructional character of perception by providing numerous examples of ambiguous pictures which are challenging our visual perception. Basing on these examples they stated that formation of perception cannot be understood as an assembly of single elements to a whole, but in the opposite, as a process of interpretation of the single element in the context of the whole (Metzger, 1963, p. 317 ff.). As an evidence for this assumption they refer to differences of the perception of complexity between adults and children as well as between modern and primitive societies.

4.3.4 Innate Perception Mechanisms

Lorenz (1959) provides support for this assumption by describing our perception mechanisms as evolved orientation adaptation, allowing us to perceive objects in our changing environment in a constant way. Evidence for these innate constancy mechanisms has been provided both in animal (Vollmer, 1994, p. 88) as well as in human visual perception (Singer, 1997, p. 59). Lorenz (1977, p. 149 ff.) also describes these mechanisms of constancy as important roots of our ability to abstract thinking. Most important, however, Lorenz (1959) also refers to these mechanisms to explain the creative finding of new scientific insights. To prove his point he draws a parallel between the experience of simple orientation processes and the "Aha"-experience resulting from finding a creative solution (Lorenz, 1959, p. 146; 1977, p. 42 f.). In addition, he emphasizes the unconscious, surprising and inspirational character of creative findings. Accordingly, we happen to experience this inspirations not coming from inside ourselves. Lorenz (1959, p. 147) perceives this inspirational character of creativity as resulting from the 'ratiomorphous' work of our pre-adapted perception system.

These constancy mechanisms might play an important role in creativity - like genes play an important role in biological evolution. Yet, there are serious objections against an unreflecting acceptance of these basic mechanisms of perception to be the only components of creativity. Lorenz (1959, p. 132 ff.) partially anticipated these objections by describing four major weaknesses using these perception mechanisms as guiding principles in science, namely: (1) their tendency to overshoot in discovering regularities, (2) their tendency for perseverance against error, (3) their inter-individual variance and difficulty to acquire by learning, and ultimately, (4) their vulnerability to rational analysis and control. Especially the first named weakness can easily lead to superstition (Lorenz, 1959, p. 136) or confusion between truth and aesthetics (Bischof, 1997, p. 91).

While speculating about the adaptive function of our visual perception system, Singer (1997) makes a very plausible point: It could be an advantage if parts of our innate visual perception system were able to adapt flexibly to the existing environmental conditions. Exactly this has been proven by inducing strabismus through an early developmental surgery on the eye muscle (Singer, 1997, p. 60). Because neural response from the eyes has been constantly uncorrelated, the connection between the relevant neurons has been destroyed. This provides support that the neural network underlying creativity is probably more flexible than assumed by Lorenz. Another apparent support for this view can literally be seen in optical illusions which are confusing our visual recognition system. Although most of them are already quite familiar to us (Spitzer, 2003, p 56, 61), sometimes we happen to find new ones (Robertson, 2002, p. 14). Then it is interesting to see, that we really do not recognize anything until we get a cue. Afterwards we cannot manage to not see what we once have recognized (Spitzer, 2003, p. 62). This irreversibility also supports an active, constructional character of creative processes for the visual domain.

4.3.5 Genetic Epistemology

According to a recent reference of Greenberg (2003) in the context of animal innovation, early development should be a promising stage to focus on for understanding the origins of innovative behavior. Combined with our understanding of the importance of an active, constructional approach to creativity in the following we will analyze in detail the genetic epistemological approach of Piaget (1974) for suitability as an evolutionary framework of

creativity. Piaget provided a radically constructivistic approach to creativity which stems from his observations of children's learning behavior. Using his concepts of assimilation, accommodation and equilibration he is able to explain the mental development including the emergence of logic and mathematics (Piaget, 1974, p. 54 ff.). Of special interest for our attention seems to be the fact, that every new insight within the child's mental development is a genuine new construction which is not at all predetermined. Neither the recognizing subject nor the representation of its surrounding is preexisting according to Piaget. This leads to the radical insight that the recognizing subject is actually constructing itself by assimilating the concepts resulting from its interaction with the environment (Piaget, 1974, p. 35). Support for this view has been provided by recent developmental psychological research: Trevarthen and Aitken (2001) argue that the child's sense of "self" and individual consciousness arises from a primary shared intersubjectivity between mother and infant. This view of the child as active constructor of itself and its personal world is also shared by the clinical psychologists Josephs and Ribbert (2003). In the same direction are pointing the neuroscientific findings of Focquaert and Platek (2007) who could show that organisms do not have to be able to recognize themselves, to develop a sense of others. Piaget defines the actions of the subject as origin of orientation, coordination and learning. As we have seen, the first actions are performed without awareness of the self. This supports our assumption of creativity as a trait⁷ which we will later analyze in detail.

As another consequence of this constructivistic view of mental representation learning results are highly related to the subject's learning context. This becomes vitally important for the first social interactions.

Of course this extreme constructivistic approach provides an excellent starting point for an evolutionary explanation of creativity. One key element of Piaget's view on creativity is his assumption of genuine unpredictability of the results of creative constructions, especially as every new construction enables new, unpredictably possibilities (Piaget, 1974, p. 135 ff.). With this approach we can also prove the Gestalt approach to be right, that the single element has to be interpreted from the perspective of the whole. The reason can be found in the structural and informational higher level of the whole, which cannot be converted to the level

⁷ The very general character of creativity as a trait does not oppose to this assumption as we can easily also assume intelligence as an evolutionary adaptation. A good general explanation for the adaptive emergence of creativity is provided by Lorenz (1977, p. 191), who emphasizes, that explorative behavior requires only a slight shift of our appetite behavior in the way that not the final consummatory act but already the learning situation itself becomes satisfying.

of its components by simple reduction (Piaget, 1974, p. 144). Piaget also emphasizes, that the construction of higher level structure describes a general process of increasing complexity.

Although we have already advanced substantially in our pursuit of finding an adequate framework for an evolutionary explanation of creative processes, we still have one major step to go. This step comprises the integration of modern neuroscience which can potentially offer us a genuine evolutionary theory of neural Darwinism. We will then verify if we can explain the creative process in Darwinian terms, conciliating predictable processes with an unpredictable outcome. Ultimately, we will close this paragraph by drawing our conclusions from the presented theory and provide an outlook and possible connection to our following challenge, an adequate evolutionary framework for creativity as a trait.

As mentioned, Piaget's (1974) radical theory of genetic epistemology already provided us with a powerful theoretic framework to explain the evolution of new knowledge. The presented would be sufficient to draw parallels between the variation and selection mechanisms of biologic evolution and the process of generating creative ideas. We could describe the basic actions of the child as variations and the assimilations between their representing schemas as selection processes (Piaget, 1974, p. 40). Although certainly possible, it seems more promising to do the same with actual neural concepts rather than only theoretical descriptions of mental processes. Therefore, we want to step up to integrate the most relevant results of brain research.

4.3.6 Neurological Research Results

The most central finding of brain sciences refers to the brain's general architecture. Almost all genuinely human abilities like perception, thought, memory, language and planning are functions of the cerebral cortex (Singer, 1997, p. 37). An analysis of the fine structure of the cerebral cortex shows that the underlying architectures of these abilities are in all cases neural networks. From a functional point of view it can be stated that the main task of these networks is the detection of consistent relations between incoming signals as well as the neural representation of these signals through cells responding exactly to these signals (Singer, 1997, p. 38). Taking our visual system as an example we notice that the overall architecture of these detection networks is decentralized. This can be proved by pictures of upside down human

faces with 180° rotated eyes and mouth: These faces appear consistent, attesting a lack of higher order instances of consistency control (Delacôte, 1996). Hence, the arising question is how we can build coherent representations of the world without such a center of convergence. Singer (1997, p. 44 ff.) assumes synchronized dynamic binding mechanisms to be the solution. That means that neurons can represent various attributes depending on the constellation of their activation with other neurons. Neurons which are consistently and repeatedly activated together start forming ensembles and will in future be activated together as an ensemble. Yet, as Lorenz (1959) found, this does not mean, that our neurons are a *tabula rasa*. Only those constellations having and having had vital relevance for our behavior do have a chance to be represented by neural ensembles (Garcia, Ervin, & Koelling, 1966; DaSilva, Rachman, & Seligman, 1977).

An important question remaining is: How does this system decide in the case of two equally activated populations of neurons? Singer (1997, p. 63) assumes that competition represents the driving force and all neurons are striving for a coherent state, converging to one conscious solution. This notion of competition between different neuron populations has been taken up by Edelman & Tononi (1997) in their ‘theory of neural group selection’ (TNGS). According to TNGS selection between neuron populations takes place by synaptic reinforcement. The theory also distinguishes between developmental and experience driven selection and assumes an innate limitation of selection by innate “value systems” (Edelman & Tononi, 1997, p. 202). Similar to our prior discussion they describe these values as structures which have been selected throughout evolution due to their positive contribution to the fitness of the phenotype. Findings of Damasio (1998) are supporting the existence of a valuing system and suggest that it is located mainly in the limbic system. He assumes that emotions⁸ are guiding the creative process (Damasio, 1998, p. 86).

Crucially important for the suitability of this theory in the context of creativity will be its capability to explain variation. TNGS meets this requirement by referring to interaction between neuronal populations (Edelman & Tononi, 1997, p.198 ff.). From a functional point of view the unpredictability of outcome of a complex system correlates with the number of its components and the intensity of nonlinear interaction between them (p. 221 f.). One key element in the emergence of variation within this theory consists in the quality of interaction between the neuron populations. The special character of this interaction accounts for the emergence of representational new system qualities. Edelman & Tononi (1997) call these interactions “reentry” and describe them as a bidirectional recurrent signaling between neuron

⁸ Emotions are also awarded a prominent role in explaining creativity in the research of Lubart and Getz (1997).

populations. This reentry has constructing, problem solving, and synthesizing function. Its constructing function can be seen in the emergence of various visual illusions (p. 217 f.). Its problem solving capability leads to the balancing of different responses from the same stimulus. And its synthesizing function derives from the reinforcing effect of numerous cycles of reentries between specialized areas (p. 199).

The most important source of variation has to be seen in the continuing active integration of all results of thought in new variation and selection processes. In this way the content of consciousness is dependent on the prior content of consciousness etc. and leads to genuine unpredictable outcomes (Pöppel, 1997, p. 94). This dependency on prior consciousness opens up the process to influences from our memory, which is always influenced by social learning (Heisenberg, 1997, p. 181). Only now, in this stage of 'higher order consciousness', we can assume creative thought to actually happen (Edelman & Tononi, 1997, p. 225). Edelman & Tononi (1997) are describing this form of consciousness as allowing a notion of past and future, giving rise to a reflection on the own consciousness as well as providing the creative freedom of speech (p.226). This represents the condition of a fully integrated person living "here and now" (Pöppel, 70, 92).

At this point we have already provided the basis for an evolutionary analysis of the process of creativity. However, we will still have to prove briefly that the creative process viewed from this perspective is, despite its non-random elements, sufficiently random to apply the evolutionary paradigm. Therefore, we recall our finding on the randomness of variation in biological evolution. We found the evolutionary biological variation processes to be a randomization of non-random, but rather well-arranged genetic patterns. Although we proved that the outcome of our creative thinking processes is genuinely unpredictable in all theoretical models applied, we always found innate limitations, either in the form of innate perception mechanisms (Lorenz, 1959), evolutionary relevant a priori selectivity (Singer, 1997), "value systems" (Edelman & Tononi, 1997) or emotions (Damasio, 1998). In addition, we can draw a last parallel of non-randomness leading in both cases - evolution and creativity – to genuinely random, unpredictable results: Although we do not mate randomly, the genetic composition in our children is or will be unique and genuinely random. The same can be found in creativity: Although we do not choose the subject and content of our creative behavior randomly, its outcome is genuinely random and unpredictable.

4.4 Conclusion and Outlook

Having thus provided the theoretical framework for analyzing creativity as a process we will close this paragraph by drawing our conclusions from the presented theories. We then will provide an outlook and possible connection to our following challenge, the development of an adequate evolutionary framework for creativity as a trait.

Our presented neuro-Darwinian theory of creativity focused strongly on the process of creativity, not clarifying where the ideas come from that will be processed creatively. This ignores the contextual character of creativity being a domain specific trait. Only at the end our theoretical overview addressed the influence of social learning on the content of our ‘higher order consciousness.’ Unfortunately, it was also then, when our specifications slipped into mystical terms of fully integrated persons living in the “here and now”. This apparent difficulty to describe the origins of the content of our thinking we cannot overcome with an evolutionary process theory of creativity. Hence, we have to apply evolutionary thinking to explain creativity as a trait. Here our aim is to set up one comprehensive evolutionary approach of creativity. This should be capable of explaining creativity as a trait as well as a process. It also must be able to explain creativity on several social levels - individual, group and collective, market creativity meaning creativity in a Schumpeterian view (Silverberg & Verspagen, 1997). Being the most complex social being on earth we will draw on a social evolutionary approach to be able to integrate these diverse aspects of creativity.

For now we conclude this paragraph stating evolutionary psychology as our explanatory framework of choice for our research subject. Having defined our theoretical framework, we will now take a look at the already existing research on creativity within this evolutionary framework.

5. Significant prior Research

Ensuing we will present an as complete as possible outline of all significant research on creativity from an evolutionary perspective. We will do this in a chronological order, starting in the days of Charles Darwin:

The basic idea of applying the Darwinian principle of ‘trial and error’ to describe creative thinking had already been used by **Alexander Bain** in 1855, two years before Darwin's publication of the doctrine of natural selection (Campbell, 1960, p. 385). Then, in his 1874 work “The Senses and the Intellect”, he captured motivational indications for the adaptive character of creativity by describing the necessary energy to perform a creative ‘trial and error’ research:

“With reference to originality in all departments, whether science, practice, or fine art, there is a point of character that deserves notice. . . . I mean an active turn, or a profuseness of energy, put forth in trials of all kinds on the chance of making lucky hits . . . Nothing less than a fanaticism of experimentation could have given birth to some of our grandest practical combinations. The great discovery of Daguerre, for example, could not have been regularly worked out by any systematic and orderly research”. (Bain, 1874, p. 594 f.)

In addition, he also introduced the term ‘incubate’, later becoming a stage in the description of the creative process of Wallas (1926):

“The mind being prepared beforehand with the principles most likely for the purpose . . . incubates in patient thought over the problem, trying and rejecting, until at last the pro-per elements come together in the view, and fall into their places in a fitting combination.” (Bain, 1874, p. 594 f.)

Souriau (1881) seized the idea with a special emphasis on chance as the sole source of true innovation, coining the bonmot "*le principe de l'invention est le hasard.*"

The French mathematician **Poincare** then, in 1913, made a point on the rules according to which results of the creative, unconscious search enter consciousness. In this context he emphasized the processes of emotional selection⁹:

“And this is still very mysterious. What is the cause that, among the thousand products of our unconscious activity, some are called to pass the threshold, while others remain below? Is it a simple chance which confers this privilege? Evidently not; among all the stimuli of our senses, for example, only the most intense fix our attention, unless it has been drawn to them by other causes. More generally the privileged unconscious phenomena, those susceptible of becoming conscious, are those which, directly or indirectly, affect most profoundly our emotional sensibility (Poincare, 1913, p. 391).

Alchian (1950) introduced evolutionary-biological concepts into economic theory by interpreting the whole economic system as a selection mechanism. He compared economical markets to biological environments. According to Alchian (1950) under changed economical conditions favorably companies that fit to the new conditions can be found. In this context Alchian (1950) also drew an analogy between inventions and mutations. This was sharply criticized by Penrose (1952), who argued against the applicability of evolutionary concepts in economics due to the intentional, target-oriented acting of market participants and the absence of blind, random mutations.

Campbell (1960) provided the first fully Darwinian theory of creativity, using evolutionary principles of ‘random (“blind”) variation’, ‘selective retention’ and ‘reproduction’ to explain the generation of creative thought (p. 381). He was convinced that the creative person has no influence on the quality of his creative work and therefore attacked the mystified figure of the creative genius:

“Let a dozen equally brilliant men each propose differing guesses about the unknown in an area of total ignorance, and let the guess of one man prove correct. From the blind-variation- and selective- survival model this matching of guess and environment would provide us with new knowledge about the environment but would tell us nothing about the greater genius of the one man — he just happened to be standing where lightning struck. In such a case, however, we would ordinarily be tempted to look for a subtle and special talent on the part of

⁹ Basically the same processes of emotional selection have been described by Heath, Bell, and Sternberg (2001) to explain, which type of rumors stand the greatest likelihood of being diffused, while using memetic theory as explanatory framework (Saad, 2007, p. 167).

this lucky man. However, for the genuinely unanticipatable creative act, our ‘awe’ and ‘wonder’ should be directed outward, at the external world thus revealed, rather than directed toward the antecedents of the discovery.” (Campbell, 1960, p. 390).

Lorenz (1977) explained creativity as a trait as well as a process using evolutionary principles. Regarding the latter he referred to the term “Fulguration”¹⁰. He used this term to account for the emergence of new system characteristics, previously not contained in a creative setting (Lorenz, 1977, p. 47 f., 166). His explanation of creativity as a trait draws on the adaptiveness of a changed motivational system. By this change not only the final consummatory act but already the learning process itself had become reinforcing. This led to the emergence of curiosity as basis for exploratory and creative behavior (Lorenz, 1977, p. 191). This view is supported by findings on the special characteristics of neurons in the midbrain’s ‘Area A10’ within the Tegmentum mesencephali. These neurons are specifically sensitive to new and unexpected stimuli (Spitzer, 2003, p. 133 f.; Roth, 1997, p. 197, 230).

Csikszentmihaly (1996) also perceives creativity as an evolutionary adaptation, although he does not refer to the principles of random search and selective retention. He stresses an adaptation to novelty seeking and risk taking, which is now quite well documented by Zuckerman’s research on sensation seeking (Zuckerman & Kuhlmann, 2000).

¹⁰ Note that Bischof (1997, p. 86) rejects the term “Fulguration” as epistemological irrelevant. For him the emergence of new qualities which cannot be derived from gradual increase or summative interaction reflects only the confinedness of our perceptive apparatus.

1988 **Lumsden and Findlay** outline a causal model integrating biological and cultural influences on the creative process (see illustration 1). The model explains the context-dependency of creativity as an impact of culture on the expression of genes. It does not allow any direct influence of culture on the cognitive phenotype. As a result, direct context-effects cannot be explained with this model. Positively has to be remarked the differentiation between creative discoveries and their diffusion into culture: the latter is probably mediated by additional variables not included in the model, like communication skills, motivation and social status (Schuler & Görlich, 2007, p.25).

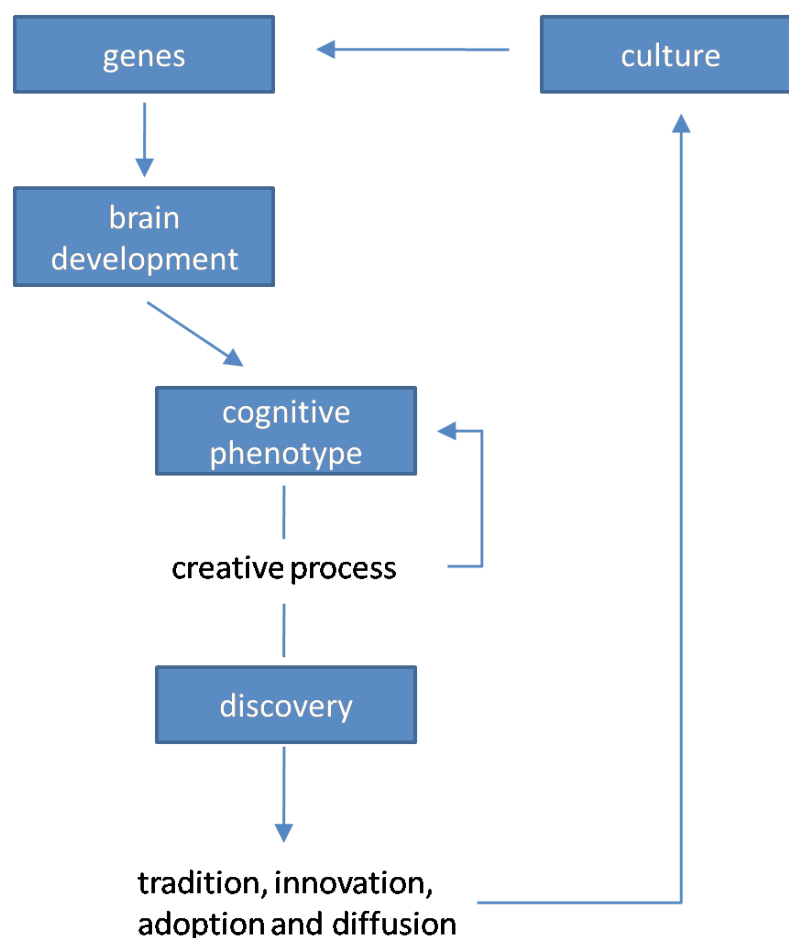


Illustration 1: The interaction of biological and cultural factors in the creative process according to Lumsden & Findlay (1988).

Eysenck (1993) traces back creativity to cognitive processes within hippocampus (see illustration 2). Changed levels of dopamine as well as serotonin affect these processes leading to a slightly decreased cognitive inhibition. Eysenck refers to this state as ‘psychoticism’ and places it between schizophrenia and depression (1995, p. 280). Eysenck’s notion of the importance of dopamine for creativity is supported by research results on dopamine as an attention stabilizing somatic marker for perceptual events (Donahoe & Palmer, 1993; Durstewitz, Kelc & Kunturkun, 1999; Schultz, 1999). Furthermore, dopamine is also closely related to ‘intrinsic motivation’ and ‘flow’ (Koepp et al., 1998). In summary, these aspects suggest that creativity at least partly bases on an enhanced attention controlling ability (Hesse & Koch, 1998, p. 428).

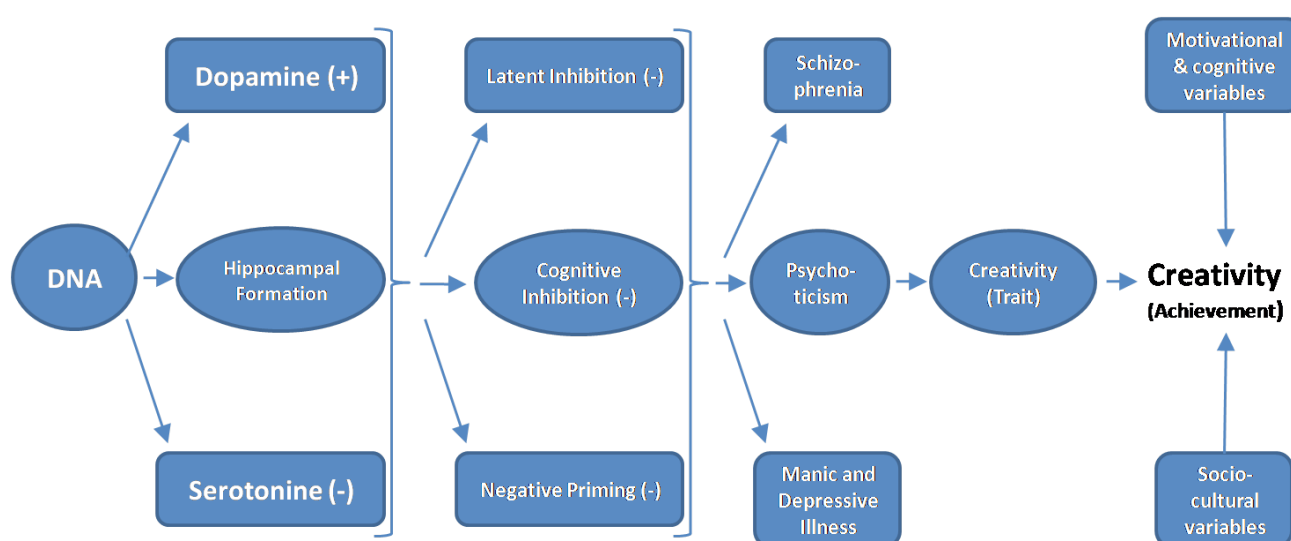


Illustration 2: Eysenck’s (1993) Model of Creativity.

The evolutionary model for inventions elaborated by **Hesse and Koch** (1998) can be considered of special relevance with regard to business innovation. They understand inventions as a cumulative variation-selection process, requiring three components: 1) mental basics such as abilities, motivations and goals, 2) an adequate mental state offering suitable and well-structured ideas, and 3) an idea evaluation selecting the highest valued ideas. For Hesse and Koch (1998) the key to inventions lies within the special character of the human perception system: It does not passively perceive environmental stimuli, it rather actively merges them with existing cognitive structures. Accordingly, Hesse and Koch (1998) are describing perception as an active construction process. Within this process several mental operations are used. Among these are sensation, inferences, as well as memory and

attribution. These operations are all applied under the ‘principle of cognitive creation’ (Hesse & Koch, 1998, p. 424). The creation process itself is ‘genuinely unpredictable’ as cognitive construction processes fluctuate in time. This fluctuation generates series of ontological entities of consciousness. The repetition of this process leads to the creation of new complex adaptive systems by ‘inheriting’ the single entities in case they proof valid in the above mentioned idea evaluation. This requires the retention of the results in a culturally appropriate form as well as a certain consistency of the selecting environment.

Massey (1999) is focusing directly on creativity within new-product development. He is contrasting the Darwinian with the Lamarckian evolutionary view to examine the utility of each view as a metaphor within new-product development. He rejects the Darwinian in favor of the Lamarckian analogy, because he understands the development of new products to be driven by intentions, especially the intention to meet consumer needs. This argument already pronounced by Penrose (1952) stems from a misunderstanding of the character of randomness¹¹ in biological evolution and has been proven wrong in the fourth paragraph. Apart from that it has to be emphasized that the Lamarckian view has no empirical biological basis and therefore cannot serve as a plausible analogy. Hence, it is no surprise that Darwinian and not Lamarckian analogies are successfully applied within business contexts¹².

Similar to Campbell, **Simonton** (1999) is also regarding creativity as a fully Darwinian process of random generation and adaptive selection of ideas. Simonton describes these ideas as “chance permutations” (1988, pp. 6 ff.). Recently he has begun to explain creativity with combinatorial models that are capturing creativity as a “constrained stochastic process” (Simonton, 2004). From this completely random perspective, creativity can be held accountable for innovative leaps. Simonton also clearly differentiates between evolutionary explanations of creativity as a trait and evolutionary explanations of creative processes. He refers to these two different approaches as “primary and secondary” evolutionary theories of creativity (Simonton, 2005). In addition, Simonton assumes that evolutionary processes operate “at different levels of selection—ideas, products, individuals, and cultures— and by more than one selection process, including analogies to both natural and sexual selection” (Simonton, 1999).

¹¹ The misunderstanding is mainly based on a dichotomous understanding of randomness as being either random or not random (Simonton, 2005).

¹² One example is the application of Dawkins’ ‘memes’ for marketing and advertising (Saad, 2007, p. 167).

An approach not only to explain creativity but cultural products in general is applied by **Miller** (1999). From his point of view the generation of cultural products is serving as wasteful sexual signaling in the mating market, using honest cues according to the Zahavian handicap principle (Miller, 1999, 2000; Zahavi & Zahavi, 2000). According to his central idea many design features of art function as indicators of the artist's creativity and further important mental and physical traits (Miller, 2001, p. 21). Miller explains creativity resulting from an interaction of runaway sexual selection and an adaptive counter-measure to 'human mind reading', which he calls "protean behavior", following Humphries and Driver (1970).

One fact endorsing Miller's view seems to be the age-dependency of creativity: In several demanding domains¹³ creativity peaks around the age of 30 years. This is exactly the mean age of male marriage in industrialized countries¹⁴. Of course one can question this relation against the background of the domains mentioned above. Within demanding domains like science and technology it requires quite an extensive effort to bring forward the overall knowledge by contributing something truly novel and appropriate. Therefore, in our environment of evolutionary adaptedness our average mating age might have been significantly below the average mating age of today. Yet, there might still be an age coherence, for Ribaut (1912), Altschuller (1970), and Zlotin (1980) are assuming the creative peak of an individual during the lifespan to be already in the age of 14 (Herb, Herb & Kohnhauser, 2000, p. 14 f.).

Moreover, Griskevicius et al. (2006) recently provided empirical evidence for Miller's explanation of creativity. They conducted several experiments where they found positive effects on male creative behavior induced by mating cues. These experiments also accounted for the differences between male and female mating strategies and were able to elicit higher levels of creativity also in females by using special mating cues indicating trustworthiness and commitment in a potential mate. Although their findings were overall consistent with a sexual selection account of creativity, Griskevicius et al. admit that creativity might not be an exclusively sexually selected trait. Altogether, these experiments show that sexual selection plays some role in human creative displays, leaving open what might be their ultimate origin.

¹³ E.g. scientific achievements, technical inventions or new business ideas (Schuler & Görlich, 2007, p. 39 f.).

¹⁴ The average age of first marriage of men in 25 European countries in 2006 was 30.12 years, for women it was 27.61 years (Eurostat).

Based on Higgins' (1997) regulatory focus theory, **Friedman and Förster** (2001) present empirical evidence for basic cognitive mechanisms underlying creative thought. Like Higgins (1997) they assume the existence of two qualitatively distinct motivational orientations, a promotion focus, which entails motivation to attain nurturance and a prevention focus, which entails motivation to attain security. In several cueing experiments, Friedman and Förster (2001) provide evidence that the activation of the promotion focus enhances performance on creative tasks. They are explaining these findings by interpreting the activation of the promotion focus as signaling that the environment is prospectively benign, leading to the adoption of a "riskier," more explorative processing style which bolsters creativity. In addition they provide an evolutionary explanation for the existence of an automatic activation of these regulatory foci by cues that the environment offers nurturance or threatens security. From their perspective an automatic activation has clear survival value as it "would allow the individual to have the processing style 'appropriate' for responding to benign or dangerous situations activated before he or she consciously realizes that the current environment is indeed benign or threatening" (Friedman & Förster, 2001, p. 1003). Within their cognitive evolutionary approach they are also able to explain for individual differences of creativity by showing that an increased concern with promotion goals over time chronically renders the "risky," explorative processing style leading to permanently more creative behavior.

Finally, we will describe the evolutionary explanations of creativity focusing on social context. Here we can primarily refer to **Brothers** (1990a) who formulated the "social brain" hypothesis. Basing on her observational and neurological findings on primates (Brothers, 1990b) she assumed that 'theory of mind' (Premack & Woodruff, 1978), the ability to understand the mental states of others, has "developed progressively over the course of primate evolution" (Brothers, 1996, p. 2) in order to effectively predict the possible moves of others in an increasingly challenging social environment (Brothers, 1990b, p. 84).

Within this social context **van Schaik** (2007) is following Humphrey's (1976) view that social cohesion is fundamental to a context in which the transmission and learning of skills and knowledge can occur. He therefore provides a biological definition of culture as "socially transmitted innovations"¹⁵. Van Schaik points out, that "innovation is the ultimate source of all cultural change". This corresponds with our above mentioned finding of cultural relativity of creativity. Also, van Schaik distinguishes between social learning abilities and innovative

¹⁵ Regarding the "empathic" prerequisites of culture see McGrew (2003) and Wyman & Tomasello (2007).

abilities and suggests the latter to have ‘hitchhiked’ on the former as “selection on innovative abilities is only expected when social learning is common” (van Schaik, 2007, p. 111). He assumes that social learning automatically enhances innovative abilities.

This view receives fundamental quantitative empirical support from evidence brought forward on the correlation between social complexity and brain size in primates (Dunbar, 2003, p. 184 f.). **Dunbar** presents a plausible explanation for the importance of social learning. He refers to Joffe’s demonstration (1997) that the neocortex size in adult primates only correlates with the length of the juvenile period. Especially in humans the long juvenile period has been closely linked to the complexity of human sociality. In this context Richard Alexander coined the term “Better Adult Hypothesis”: The unique, big brain of the altricial human is probably part of his effort, to become a better adult, rather than to become an adult at all (Alexander, 1992, p. 160).

This social learning period has also been explicitly linked to creativity by **Winnicott** (1971). He emphasized that in this period the child creates his first “transitional objects” by creative play and symbol-making. Thereby it builds a bridge between his inner and outer world. These transitional objects later serve as prototype of all cultural activities (Hand, 1996). Winnicott does not consider cultural activity a simple adornment to be added to life, to him it appears to be “what life is about” (Hand, 1996). This rather psychoanalytical view of the relation between play and creativity also finds its evolutionary phrasing: Groos (1896) and Bateson (1955) describe the evolution of play behavior in mammals, where young animals playfully learn specific survival-relevant behavior, imitating the later context with ‘as-if-behavior’. Oerter (1999) emphasizes that play behavior increases in importance and variety with length of the developmental time of the specific animal. For humans of all cultures playing has importance at least until adolescence and reflects the social activities most central to the specific culture (Eibel-Eibesfeld, 1984).

The deeply rooted social notion of creative behavior is demonstrated by **Cross** (2007) for the field of music. He emphasizes the enculturative capacity of music¹⁶ as well as its ability to foster the cognitive development in children (Cross, 2007, p. 658). In this context he refers to Blacking (1967), who found sociality to be the primary driver for the development of

¹⁶ An impressive example for the enculturative capabilities of music has been established by the Venezuelan “Fundación del Estado para el Sistema Nacional de las Orquestas Juveniles e Infantiles de Venezuela” and his founder José Antonio Abreu (Vongries, 2005).

musicality in non-Western contexts as well. This social view on music finds support in the research of Ramus et al. (2000) who showed that newborns already have the ability to discriminate between different languages by drawing on the criterion of rhythm. This is consistent with the “missing link” hypothesis which is stressing the semiotic moment of music in the emergence of speech and culture (Cross, 2007, p. 664; Heisenberg, 1997, p. 182).

Although being all evolutionary approaches, the above presented theories vary significantly in their understanding of creativity. Therefore, it will be our task in the following paragraph to develop one overall consistent and adequate research approach on the basis of the theories presented above. Furthermore, we will find an adequate context and develop a suitable methodology allowing us to test and verify hypotheses derived from our theoretical approach.

6. Research Approach and Methodology

For the development of an adequate research approach and a suitable methodology we start off from our research problem, the formulation of a consistent integrated evolutionary theory of creativity, providing new insights in business innovation processes. Therefore we will pursue in three steps: (1) Firstly, we will define an adequate approach for an integrated evolutionary theory of creativity. (2) Secondly, we will specify an appropriate business innovation context for applying the evolutionary theory of creativity. (3) Finally, we will identify a suitable methodology for verifying the theory within the specified context.

6.1 Defining an adequate approach for a an evolutionary theory of creativity

With respect to our research problem as well as to the existing research on creativity we can specify detailed requirements for an integrated evolutionary theory of creativity. An adequate approach to an integrated theory of creativity has to meet the following six key requirements:

- (1) The approach must account for **inter-cultural differences** of creativity
- (2) The approach must account for **inter-temporal differences** of creativity
- (3) The approach must provide an **integrative explanation** of creative behavior
- (4) The approach must specify the **social conditions** required for creative behavior
- (5) The approach must be able to **explain the emergence** of creativity
- (6) The approach must be **extendable to a group level perspective** of creativity

Due to their noncompliance to these requirements we can rule out most of the theoretical approaches mentioned in the previous paragraph. This leaves us necessarily with the strongest

of the theories presented, the finally outlined evolutionary approach drawing on social context. This holds true for its compliance with all six of our requirements. Ensuing we will demonstrate this compliance for each specified requirement:

6.1.1 Theory's aptitude to account for inter-cultural differences

By defining creativity as a trait emerging from our social evolutionary environment, this approach can easily explain inter-cultural differences, even a complete change of perspective. This can be illustrated by the difference between our Western and the Chinese perspective on creativity. While we are focusing more on the individual being creative by originating something new and appropriate in a specific domain, Chinese people “focus more on the social influence of creative individuals, such as being inspirational, and contributing to the progress of society” (Niu, 2006, p. 387)¹⁷. Although being unfamiliar to our Western point of view, the Chinese perspective of creativity is actually very close to our social evolutionary approach of creativity¹⁸.

6.1.2 Theory's aptitude to account for inter-temporal differences

The social evolutionary approach also meets our second requirement, the possibility to account for chronological change of creativity. Here, the approach benefits from a functional rather than contextual concept of creativity or as van Schaik (2007, p. 110) phrased: “innovation is the source of all culture”. From this point of view creativity holds a genuine enculturating social function. Given this function, the behavior of an individual always has to take into consideration the cultural ‘status quo’ to be called creative¹⁹.

¹⁷ In the context of the upcoming Chinese economy it will be interesting to see if Chinese researchers will adopt our individualistic view on creativity. Exactly this seems to happen currently in Taiwan (Niu, 2006, p. 390).

¹⁸ A more in depth view on the traditional Taoist Chinese perspective on creativity is provided by Chang (1963) and Hall (1978).

¹⁹ For example, although it has been a creative masterpiece of Leonardo da Vinci to invent a helicopter, today the same idea would not be valued creative (Laurenza, 2006).

6.1.3 Theory's aptitude to provide an integrative explanation for creative behavior

Having demonstrated the compliance with the first two requirements we now have to prove the capability of the approach to provide an integrative explanation for creative behavior. We have shown in the fourth paragraph that the creative process can be aptly explained in evolutionary terms. In the previous fifth paragraph we have provided a strong theoretical basis for understanding creativity as a social-evolutionarily adaptive trait. Ensuing we will integrate these different theoretical aspects of creativity in one unifying framework.

Considering creativity to be a social evolutionary adaptation, our approach can easily explain creativity as a trait: Accordingly, humans are creative due to the adaptive, group-benefitting character of creativity. Creative individuals provided cunning new techniques that led to group-benefitting innovations in procuring and defending food (van Schaik, 2007, p. 111). The fact that learning is self-rewarding reflects the adaptive character of creativity (Spitzer, 2003, p. 142). Learning is pleasurable²⁰, so humans are actively searching their environment for situations with new stimuli. The arising key question is: How did this happen? How did humans become so curious?

To answer this question we have to take a deeper look into the environment explored by humans. This environment is and always has been socially mediated (Dunbar, 2003 & 2007; Flinn, 2007; Gintis et al., 2007; Ploog, 1997; van Schaik, 2007; Wilson, 2007). This fact is extremely important for an integration of the trait- and process-character of creativity. The nexus between the social environment and the individual creatively contributing to it can be located within the social learning abilities of humans (van Schaik, 2007, p. 110). The essential basis for the development of these learning abilities is located within the social character of humans (Chiappe & MacDonald, 2005). In the following we will analyze in depth this “social nexus” between creativity as a group-benefitting trait and the creative behavior of the individual. In doing so we will also answer the question why the individual shows creative behavior despite its time-consuming and risky character (van Schaik, 2007, p. 109).

²⁰ This strongly supports our view of creativity as an evolutionary adaptation as pleasure is an “evolutionary hallmark” of psychological adaptation (Miller, 2001, p. 20).

For this purpose we will start off from our findings on creativity in child's play. Afterwards we will associate these findings with results from research on the evolution of cooperation. Finally, we will integrate all of our findings in one comprehensive evolutionary approach unifying the individual and the collective level of creativity.

From the findings of Winnicott (1971) we know that children start creating their own world using "transitional objects", which are the first manifestation of both creative play and symbol making. According to Winnicott (1971) these objects possess subjective valence and are replacing the mother in the first periods of separation, for example while going to bed. The essential meaning of these objects has been recently emphasized by Trevarthen and Aitken (2001) who argue that the child's sense of "self" and individual consciousness arises from a primary shared intersubjectivity between mother and infant. This means that at some point of time in its development the child – just like our ancestors during the course of evolution – starts actively constructing its own subjective representation by its interaction with the (social) environment²¹. However, the representation of the first objects of the outside world within the child's mind represents a not solvable lasting paradox. Winnicott (1971) described this paradox with regard to the transitional objects being both 'subjective' and 'objective', both 'created' and 'found'. He emphasized that these objects are forming a "third area" between inner and outer world (Hand, 1996). Winnicott (1971) also refers to this "third area" as "potential space" in which he locates the origins of all later creative activities. He therefore stresses that we "must always struggle to redefine our own sense of the relationship between inner and outer, perception and apperception" (Hand, 1996).

Winnicott's understanding of the importance of the "potential space" for the emergence of creativity becomes clear as he describes the construction of higher level representation of the outside world within the child. As we saw, the first level of representation contains the above mentioned transitional objects and possesses only subjective valence. This implies that these objects are relevant only for the child itself. On the second level things are gaining objective valence. This results from the first social interactions, in which the child is realizing that an

²¹ Thus this experience within the development of the child can be considered an ontogenetic replication of a phylogenetic incident, in which one of our ancestors for the first time realized his own apprehending hand and the apprehended object to be both things from the outside world and in addition understood the interaction between these. This has been the moment, when his conception of the action of apprehending became his "comprehension", his knowledge of the main characteristics of the apprehended object became his "apperception" of this object (Lorenz, 1977, p. 194).

object is meaningful to others as well. The child then creates a shared meaning of the object, which – at this level – still must not coincide with the customary meaning of an object²². The last step then implies abstract valence which refers to multiple roles and generalizations building the basis for social constructs like work, money, and justice (Plotkin, 2007, p. 12). At these higher levels of representation the “potential space” becomes “the location of cultural experience” (Winnicott, 1971, pp. 102 f.) which at the same time separates from and joins us with our social environment.

To sum up, the creativity of play according to Winnicott (1971) provides a basic understanding of creative processes as active cognitive constructions during the mental development of the child. Yet, this does not limit the relevance of these findings in the general context of creativity. Due to our human neoteny we keep our general curiosity enabling us to be creative in adulthood. However, as we have seen in the preceding paragraph, creativity peaks in early age (Schuler & Görlich, 2007, p. 39 ff.; Herb, Herb, & Kohnhauser, p.14). This might be on the one hand due to the risky character of explorative behavior (van Schaik, 2007, p. 109): Blood testosterone concentration as proxy-variable for risk-prone behavior also peaks considerably before the age of 30 (Daly & Wilson, 1985, p. 60 f.). On the other hand there is also a plausible cognitive explanation for this phenomenon. Piaget (1974) describes the mental development as a strictly genetic process in which everything, the own subject included, results from an active construction process basing on three principles: assimilation, accommodation and equilibration. Assimilation can be understood as adaptation of perceptions to cognitive schemata, whereas accommodation is the opposite. These two principles account for the development of actual intelligent, means-end-oriented behavior and thus deserve to be called ‘engine of mental development’ (Piaget, 1974, p. 16, 35). During maturation, however, the third principle gains more and more influence. This principle of equilibration causes an increasing conciliation of contradicting cognitive structures²³. Within this conciliation cognitive structures become increasingly formalized, which is serving as a basis for the later development of abilities for logic and mathematics (Piaget, 1974, p. 18 ff.).

This elimination of conflicting signals also seems to be the basic function of our consciousness. The main adaptive advantage of our consciousness obviously consists of its

²² For example playing kids can declare a desk to be a house, under which they crawl to ‘live in’.

²³ This principle has been verified by findings of brain sciences on the ‘convergence’ of our perceptual system to an unambiguous cognition (Singer, 1997, p. 63) and the conflict solving character of “reentry” communication between neural populations (Edelman, 1997, p. 199).

power to integrate a vast number of different sensory information to one informative basis of our behavior (Pöppel, 1997, p. 75; Edelman, 1997, p. 224). This integration of conflicting signals to one coherent, meaningful perceived experience does imply information losses. Roth (1997, p. 220) refers to this fact as ‘narrowness of consciousness’. Unfortunately, the reasonable advantage of a logical, highly consistent brain structure at the same time diminishes the ability for creative behavior, especially when this consistency becomes an increasingly stable state at older age. This logic becomes clear as we remember that the first step of a creative process consists in the finding of the problem (Wallas, 1926; Basadur, 1994; Herb, Herb & Kohnhauser, 2000, p. 17). This insight has already been stressed by Souriau who phrased the following (1881, p. 17 f.):

“In the case just analysed we supposed that we had to solve a problem already stated for us. But how was the problem statement itself found? It is said that a question well posed is half answered. If so, then true invention consists in the posing of questions. There is something mechanical, so to speak, in the art of finding solutions. The truly original mind is that which discovers problems.”

In this context we can apply the metaphor of a “detector for inconsistencies” for the cognitive structure of a creative brain. A highly formalized, rigorously-structured “hygienic” brain does not work well detecting inconsistencies²⁴. This reminds us of the importance of personality traits like independence and absence of conformity for creativity, especially with respect to the findings on cognitive dissonance (Festinger, 1957; Amabile, 1983, p. 365).

In conclusion, Winnicott’s (1971) findings on creativity serve as a plausible basis of an integrative theory of creativity. This holds especially true if we match it with Piaget’s (1974) insights on the mental development. As most important result we must seize on the active, cognitively constructing character of creativity (Hesse & Koch, 1998, p. 423). Also, we have to hold on to continuing change of perspective between inner representation and outer environment, where environment explicitly includes our social environment. The importance of this aspect can be described best in Winnicott’s (1971, pp. 102 f.) own words:

“I have tried to draw attention to the importance both in theory and practice of the third area, that of play, which expands in creative living and into whole cultural life of man. The third area has been contrasted with inner or personal psychic reality and with the actual world in

²⁴ The reason therefore is the absence of inconsistencies within the brain structure. Mathematical evidence for the validity of this metaphor provides Gödel’s incompleteness theorem (Vollmer, 1994, p.12; Gödel, 1931).

which the individual lives, which can be objectively perceived. I have located this important area of experience in the potential space between the individual and the environment, that which initially joins and separates the baby and the mother when the mother's love displayed or made manifest as human reliability, does in fact give the baby a sense of trust or confidence in the environmental factor."

Although these findings have a rather descriptive than explanatory character, they prepare the ground for a deeper evolutionary analysis of this social nexus between individual and collective aspects of creativity. Winnicott's (1971) description of the child's creation of shared meaning of an object directly leads us to Wyman and Tomasello's (2007) research on "shared intentionality" as a basis of cooperation. According to Wyman and Tomasello (2007, p. 228) the emergence of shared intentionality depends on the phenomenon of "joint attention". This joint attention constitutes an interpersonal frame in which children can share their experience with others. Although other social mammals are able to share their attention as well, humans stand out in this comparison by their special cooperative form of intentionality. This seems to constitute the basis of "shared goals" which children can achieve through the adoption and reversal of designated roles. Wyman and Tomasello (2007) also provide experimental evidence for this cooperative character of human joint attention by playing cooperative and competitive hide-and-find games with children and chimpanzees. Interestingly, unlike 14 month old infants, chimpanzees could not use helping cues in the cooperative situation, but were able to understand prohibitive cues in the competitive situation (Wyman & Tomasello, 2007, p. 232). This indicates the appearance of a fundamental shift in the emotional orientation of humans, providing the basis of trust in social interactions. Hare & Tomasello (2005) assume that this shift appeared as a result of selection on emotional systems balancing fear and aggression. They are basing their hypothesis on experimental findings on selectively bred fearless and non-aggressive foxes, which were able to find hidden food using a human's cue as competently as domestic dogs (Wyman & Tomasello, 2007, p. 234).

As a consequence, they suggest a model of reduced emotional reactivity, mediated by reduced stress levels. This allowed a closer social proximity and gave rise to the emergence of a cooperative joint attention which led to a rise in foraging efficiency.

However, this model seems to contradict with the high social sensitivity of our stress system (Flinn, 2007, p. 274). To resolve this conflict and improve our understanding of the relation between the rise of cooperation and this shift in our emotional system we will draw on additional research on our stress system.

A vast number of studies confirms the crucial impact of social challenges on our neuroendocrine stress regulation (Cummins, 2000; Caspi et al., 2003; Dickerson & Kemeny, 2004). Stress regulation is functionally provided by the limbic hypothalamic-anterior pituitary-adrenal cortex system (HPA). The HPA system, amongst others, regulates cortisol, a key hormone produced in response to psychosocial stressors. Cortisol accounts for the control of important somatic functions like energy release, immune activity, growth, reproductive function, mental activity and neural modification. These complex, multiple effects can be summarized as flexible regulation of the body's response to changing environmental conditions by preparing for and recovering from specific short-term demands (Flinn, 2007, p. 279). Unfortunately, this complex balancing mechanism is highly vulnerable to maladjustments linked to increased risk for several mental disorders including depression and schizophrenia (McEwen, 1999; Caspi et al, 2003). If we assume humans to have always been a genuinely social animal there must be an over-compensatory positive effect of the social reactivity of our stress system explaining these negative effects of long term psychosocial stress. Following Huether (1998) the psychosocial stress response could be promoting adaptive neuronal modification necessary for coping with the demands of an unpredictable and dynamic social environment. From this perspective the effect of cortisol could be an adaptation to extensive learning demands or as Huether (1998, p. 297) describes:

“...destabilization of previously established synaptic connections and neuronal pathways in cortical and limbic structures is a prerequisite for the acquisition of novel patterns of appraisal and coping and for the reorganization of the neuronal connectivity in the developing brain.”

This stress-induced plasticity could contribute to the unique human ability to produce creative novelties of cultural change (Flinn, 2007, p. 277). One example for this highly creative ability connected with an active process of neuronal destruction is the human acquisition of language skills (Jacobs & Schuman, 1992; Hannon, 2003; Spitzer, 2003, p. 89 f.). From this perspective the negative effects of chronic psychosocial stress would have to be appraised as opportunity costs of an enhanced social learning disposition.

An even more revealing picture of the adaptive character of our stress regulation system appears if we differentiate between potentially beneficial short term effects of enhanced plasticity and apparently negative long term effects of stress. Negative effects of long term social stress especially can be observed within early stages of development (Flinn, 2007, p. 275, 279, 285; Bardi, 2005). According to Belsky (2007) these permanent alterations of the

stress system could be an adaptive reproductive strategy²⁵. A stressful developmental context then would result in the child's adoption of a quantity-oriented reproductive strategy. In such a context the psychosocial stress reflects an emotional cue of general social uncertainty for the child (Flinn, 2007, p. 279). If this state of uncertainty persists for a substantial period of time the child's stress system adapts by permanently changing its threshold for emotional cues. Apart from serious physical consequences²⁶ this results in a general mistrustful outlook on the world and a rather opportunistic than mutually beneficial orientation towards others (Belsky, 2007, p. 243). This differentiation between short and long term stress mechanisms receives support from neuro-scientific findings on the effects of stress on hippocampal plasticity (McEwen, 1999).

Summarizing this paragraph we could point out the social character of our stress regulation system. The high sensitivity of our stress system to social challenges directly reflects the importance of sociality for us humans. Hormonally mediated social stress reactions almost automatically bind us as individuals to social contexts and are forcing us to adapt our brain structure according to social conditions. This "social nexus" between individual creativity and its group-benefitting character at the same time connects the biological and cultural nature of humans. Therefore, we can agree with the statement that "mankind's natural place is culture, and culture is a part of human biology" (Plotkin, 2007).

6.1.4 Theory's aptitude to specify the social conditions required for creative behavior

The social evolutionary approach can also describe the social conditions permitting creative behavior. According to our findings in the preceding section social contexts themselves are imposing adaptation pressure on the individual. This autonomous adaptation process is what creativity is all about. Of course this adaptation is not autonomous and thus not creative, if the

²⁵ Liu et al. (1997) suggested an adaptive character of the same early developmental "programming" of the HPA system for the Norway rat.

²⁶ Chapin (1921, p. 214) provided evidence for several serious physical consequences of permanent social stress in early childhood development on the basis of data from children raised in orphanages in early 20th century America. These children showed significantly increased rates of morbidity and mortality simply due to the lack of normal intimacy and social contact.

adaptation criteria are already fully given by the sociality. On the other hand adaptation to total uncertainty is not possible either. Therefore, social conditions must offer a minimum of predictability for the individual. This minimum must reflect the shared social values as a “shared goal” (Wyman & Tomasello, 2007, p. 228). Creativity then arises from the competition of the individuals for the best sharable adaptation to those values. If social conditions lack any predictability individuals are at risk of developing stress-induced mental disorders. The stressful character of creativity also requires times without adaptation pressure. Moreover, the general time-consuming character of creativity due to its underlying restructuring process of living tissue brain cells has to be emphasized. Experimental data from rats suggest that reversible atrophy of hippocampal dendrites takes between 3 to 4 weeks (McEwen, 1999, p. 107 f.). In addition, the meaning of early developmental social conditions must be stressed. Only if these conditions are socially supportive the individual can develop a sufficiently trustful internal working model (Belsky, 2007, p. 243) to be able to “invest” in explorative behavior (van Schaik, 2007, p. 109). Because of the social character of the creative effort it will ultimately be strongly dependant on the available basic “trust” within the social environment. Trustful environments therefore will elicit more creative behavior than mistrustful environments would. Social tolerance and cooperation can be regarded as key factors within this context (van Schaik, 2007, 111).

6.1.5 Theory’s aptitude to explain the emergence of creativity

By describing its evolutionary environment the approach is able to explain the emergence of creativity. However, with respect to the general scarcity of evidence²⁷ we can only tentatively describe the evolutionary environment giving rise to the emergence of creativity. It must have been similar to the cultural environment of the great apes. The unique human form of culture probably rose during the occupation of the open savanna habitat while changing on exclusive bipedality for long-distance walking along with stronger reliance on meat (van Schaik, p. 111). These complex foraging changes must have put pressure on our emotional reactivity

²⁷ Mameli (2007, p. 28) refers to this scarcity as “problem of the problem”. He points out that our “ignorance of Pleistocene phenotypes and of how exactly the hominin physical and cognitive niche changed during those 1.8 million years makes it difficult for us to identify with enough detail the specific adaptive problems faced by our Pleistocene ancestors.”

allowing for closer proximity and first forms of cooperation, basing on joint attention (Wyman & Tomasello, 2007, p. 234).

6.1.6 Theory's aptitude to explain group level creativity

The approach is also extendable to a group level perspective of creativity. Therefore, we can refer to the requirement of "joint attention" to be cooperatively creative. Herein, we quickly reach a quantitative limit of joint attention resulting from the limited cognitive capacities of our social brain. This limit is suggested to be close to 150 individuals (Dunbar, 2003, p. 187). Due to the higher order intentionality necessary to establish group creativity the limiting number will probably be significantly below 150 persons and creative groups will generally have diminishing marginal utility with rising number of participants. This view gets support from the requirement of shared goals and designated roles as a framework for creative groups (Wyman & Tomasello, 2007, p. 228). Also hierarchically higher level groups should be less creative due to the increasing difficulty of higher order intentionality (Dunbar, 2007, p. 188). Therefore we can conclude that there should be no task-irrelevant hierarchy within the group. This view finds support from Cummins (2000, p. 11), who emphasizes the social stress related to hierarchy. As a result we can state the requirement that groups should "own the problem" (Burow & Hinz, 2005, p. 39) and should be able to constitute a cooperative form of intentionality, a creative "groupmind" (Sawyer, 2006, p. 254). Arising problems therefore should be solved in free group interaction, converging to a joint solution as a group (Singer, 1997, p. 63).

6.1.7 Conclusion and Integration

Finally we can sum up and integrate our findings in one consistent framework of creativity:

Creativity can only be fully understood in a social perspective of human activities. Creativity is not only an integrated part of the child's social development. Rather does its meaning reach far beyond childhood learning processes. Corresponding with general human neoteny creativity has become part of human adult behavior. This fact has changed human beings into genuinely cultural animals. Underlying adjustments of our basic emotional reactivity towards

a general cooperative intentionality have provided the basis of social learning and cooperation. High social sensitivity of our stress system reflects the extraordinary importance of the social dimension of our existence. Just as the innate human ability to learn any language (Spitzer, 2003, p. 77), there also exists an innate module for social adaptation: our neurochemically controlled stress regulation system. Starting off in our childhood this system forms and adjusts our overall life strategy by modulating our emotional reactivity. The adjustment itself is triggered by social emotions, which are functioning as emotional cues for essential social values²⁸ and social contingencies. These social values and contingencies are basically what the child's higher learning is all about and can be understood as the nucleus of every social system²⁹. Evidence of this fact is provided by the crucial importance of social support and parental warmth in early childhood³⁰ (Chappin, 1922; Belsky, 1997; Davidson et al., 2001; Meaney, 2001; O'Connor, 2003; Bardi, 2005). The delay of human reproduction until an age of almost 20 years (Flinn, 2007, p. 275) has to be interpreted against this background as well. It is not so much the learning of single techniques or skills which is requiring this long learning period. It is rather the learning of sociality itself which takes so much time. In this context the individual has to calibrate its emotional reactivity in interaction with its social environment. If this calibration fails, the individual can be socially handicapped for the rest of its life. Complex social learning via social cooperation is only possible if the individual is able to adjust its emotional system by attuning to the commonly shared social values. This process is essentially basing on empathy and can be considered an intuitive awareness rather than an intellectual process (Hoffman, 1975).

This adjustment process of the emotional system is driven by neurochemical mechanisms of our stress system. These mechanisms involve substantial neuronal restructuring processes (McEwen, 1999; Duman et al., 1999). Due to the delicate character of the neurochemical balance of our stress system these processes are not without risk. Uncontrolled stress can lead to serious physical and mental impairments like depression and schizophrenia (Mc Ewen, 1999, p. 116; Flinn, 2007, p. 279).

²⁸ Of course these social values are always closely related to biologically important aspects of human life. This is why Griskevicius et al. (2006) was able to enhance creative behavior with mating cues and why Friedman & Förster (2001) could do the same with promotion cues.

²⁹ Mead described this process of identifying the social core values as construction of the "generalized other" (Mead, 1934, p. 158).

³⁰ Clinical studies of O'Connor et al. (2003) demonstrate that children growing up with social deprivation exhibit autistic-like behavior and enduring deficits in attachment. Furthermore, social deprivation can result in serious physical impairments (see footnote 23).

Why does nature expose us to these risks? These risks are highly over-compensated by substantial social advantages resulting from a byproduct of our social stress sensitivity: culture. From this point of view creativity can be described as an autonomous, complex process of adaptation to society's underlying essential values. However, we have to distinguish this adaptation from a simple process of conforming to existing rules and behavior. A simple process of adaptation to existing behavior would not contribute to culture as a whole. Culture depends on innovation (van Schaik, 2007, p. 100). The adaptation process of humans is designed as an actualizing re-construction of the perceived social values rather than a simple conformation to the existing behavior³⁰. According to Schumpeter (1939) this makes the creative entrepreneur a truly value-creating individual in the context of business innovation (Andersen, 1997, p. 116).

This view of creativity as a complex process of social adaptation and integration finds support in numerous facts:

Firstly, we can refer to the social intentionality already emerging in early childhood. Wyman and Tomasello (2007, p. 232) carried out an experiment that showed the innate need of children to understand and influence social processes.

Secondly, results of long-term studies on primates demonstrated that infants of timid and fearful mothers showed the signs of depression commonly observed in maternally separated infants, even though the infants were in contact with their mothers. As adolescents, these infants were more fearful and submissive and showed less social play behavior.

Thirdly, we can refer to the age effects of creativity. These age effects also exist in the prevalence of stress related mental disorders (Demyttenaere, 2004, p. 25; Alonso & Lépine, 2007, p. 7). We also find these age effects within entrepreneurial activities (Bosma & Harding, 2007, p. 20).

Fourthly, these age effects also coincide with gender effects, for most of the global entrepreneurs are men. However, in contrast to Miller (1999) we do not read these age and gender effects primarily in terms of mating differences with respect to reproduction. We

³⁰ Interestingly, law requires only the external conformity and leaves everything else, including the belief in values contradicting to those of the society, to the individual.

rather interpret these effects in a global context of social integration³¹. In consequence, we do not impose categories of male sexual signaling on female creativity but concede female creativity its own right and need in the context of cultural and social integration³². Nevertheless, with respect to gender differences in our stress system we would expect (quantitatively) more creative behavior from men than from women (Campbell, 2007, p. 368). This can be traced back to the counter-regulating effects of the female release of oxytocin and oestrogen, resulting in more calming and social bonding effects under stress. Regarding the almost doubled prevalence of stress-related mental disorders in females (Demyttenaere, 2004, p. 24; Alonso & Lépine, 2007, p. 6) we can speak of a biological distribution of roles: Males generally play a direct part within creative social integration, females play a rather indirect part, establishing the social bonding for the society. Additionally, they procure the social values to children as prerequisite for the succeeding of their creative adaptation process.

Fifthly, this apprehension of creativity as a complex social adaptation is also supported by findings on risk taking. Here we find strong age and gender effects, corresponding with our findings on the biologically and psychologically risky character of creativity (Daly & Wilson, 1983; Campbell, 2007, p. 370; van Schaik, 2007, p. 109; Marade et al., 2007). Winterhalder (2007, p. 435) could demonstrate a sigmoid utility function of risk taking, suggesting that risk-prone behavior should be more profitable for young individuals – who still have to „earn their spur’s”.

Sixthly, neuro-scientific research emphasizes the importance of synaptic plasticity for learning and memory, but at the same time stresses that the currently assumed level of plasticity cannot offer an overall sufficient explanation (Martin, Grimwood, & Morris, 2000).

Seventhly, our model can explain why creative behavior cannot be displayed continuously as it involves stress-induced neuronal restructuring processes that require time for growth or atrophy of living brain tissue (McEwen, 1999, p.108, 115). Long-term stress can lead to nonreversible atrophies of prefrontal cortex, amygdala, and hippocampus (McEwen, 2001, p. S14).

³¹ Thus we can say that in most countries the economic task of social integration is predominantly a male one.

³² This holds especially true for female entrepreneurial activities, which are more pronounced in middle than in high income countries (Bosma & Harding, 2007, p. 20). An explanation of limited access of women to labor markets in middle income countries, prompting them to start their own businesses instead, fits our view of creativity as complex social adaptation.

Eighthly, the model's focus on the human stress system and its crucial impact on the general life orientation as either optimistic or pessimistic (Belsky, 2007, p. 242 f.) is supported by the basic claims of attachment theory. According to Bowlby (1979), attachment is regulated by a motivational system that develops in infancy. In his theory the secure attachment serves as a safe base which enables the individual to explore and play in its social environment (Josephs & Ribbert, 2003, p. 155).

Ninthly, our understanding of empathy as basis of the ability to learn about the social values underlying any creative act is shared by the traditional Chinese view on creativity (Chang, 1963, p. 19 ff.).

Finally, macroeconomic context seems to influence creative business behavior as seen by the u-shaped relation between GDP and entrepreneurial activity (Bosma & Harding, 2007, p. 11) or by the actual worldwide declining trend of innovation per capita (Huebner, 2005).

To sum up, we can define creativity as a complex adaptation process to social values (see illustration 3). Within this process new and appropriate benefits are created which are actualizing these values and thereby contributing to society as a whole. In this way creative behavior becomes a truly value creating process. We can notice that creativity relies on a competition of creative ideas "rather than on [economic] size, speed or strength" (van Schaik, 2007, p. 111). This form of competition has to be seen as tolerance for new ideas and reflects the character of cooperation and freedom rather than of a conflicting competition. In this way the conflict between competition and cooperation can be resolved. Only the reliance on tolerance and cooperation opened up the way to the development of creativity.

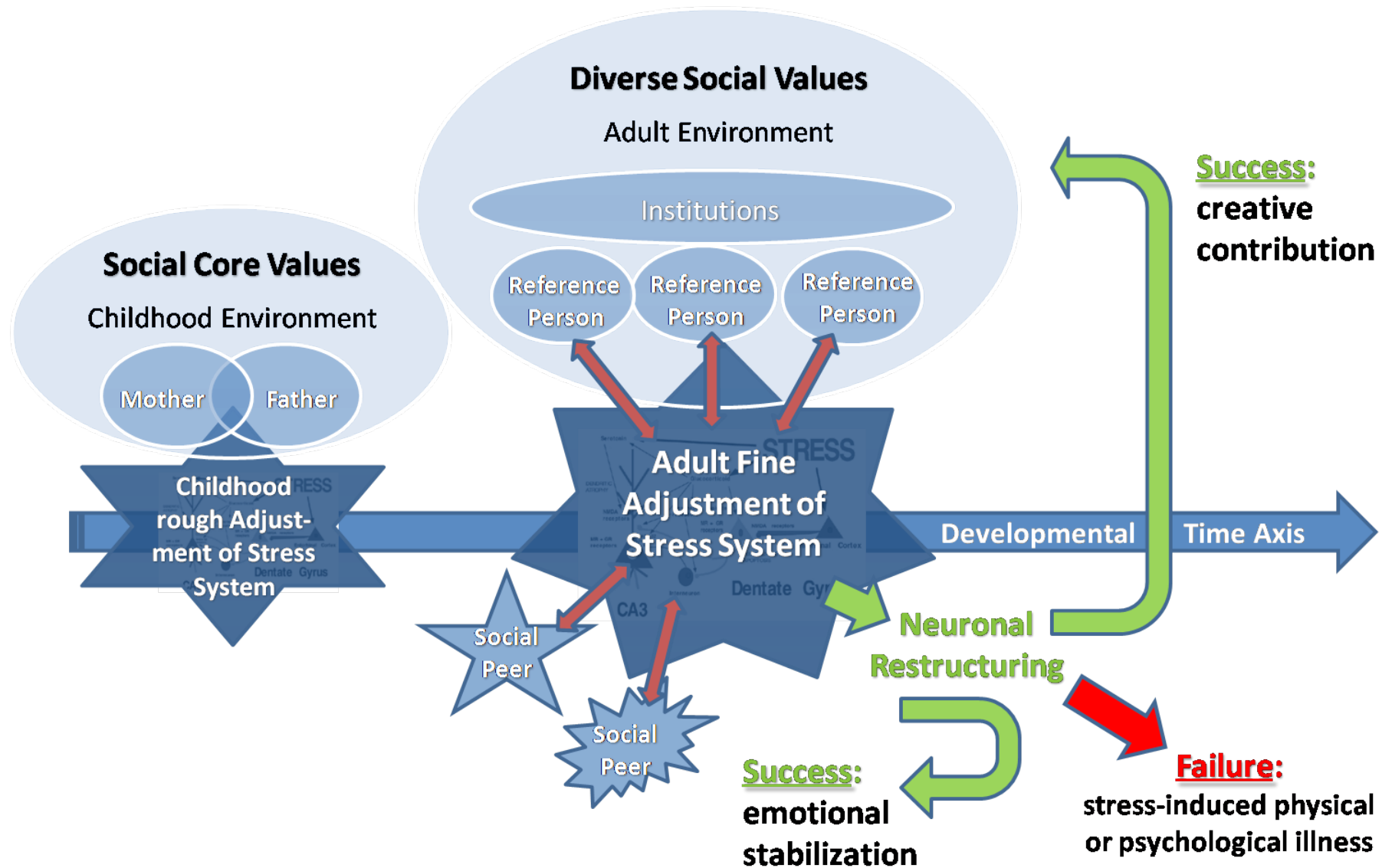


Illustration 3: Social-Evolutionary Developmental Model of Creativity. At as early age as six month (Ungerer, 1990, p. 105) first stable patterns of long term adjustment of the HPA-regulated stress system are documented. This long-term “calibration” of stress reactivity can be interpreted as an adaptive life strategy, anticipating a more favorable or more adverse environment (Meaney, 2001, p. 1181; Belsky, 2007, p. 243).

Current research suggests that the main predictor for a “negatively” calibrated life strategy is early childhood uncertainty (Meaney, 2001, p. 1180; Flinn, 2007, p. 279). A normal stress response aims at providing full alertness to overcome complex, uncertain situations (Flinn, 2007, p. 279). Permanent uncertainty, however, cannot be responded with a permanent alertness, as this will exhaust the individual’s resources. Rather, the stress system learns that “there is nothing to learn” (Petersen, Maier, & Seligman, 1995). Chronically stressed children therefore may show subnormal cortisol levels and may appear socially ‘tough’ (Flinn, 2007, p. 285).

The same stress-related mechanism is assumed to play a major role in the creative process of adults. The reason is seen mainly in the dependency of creativity on social context (Amabile, 1982). Furthermore, the stress mechanism provides a socially triggered source of extended neuroplasticity, which probably accounts for the degree of fluid intelligence necessary for creativity (Chiappe & MacDonald, 2005; Krill et al., 2007, p.234, 236 f.). The neuronal restructuring process involved in adult humans experiencing social stress has to take into account the early childhood calibration of the stress system. This is assumed to at least partly explain individual differences in creativity as an individual trait. Only individuals with low or moderate stress reactivity are assumed to be capable of highly creative behavior. More detailed, neuropsychological explanations for this assumption are given along with illustration 4.

From this perspective, the basis of the creative quality is perceived as an actualization of basic social values underlying the specific social context. To be able to identify these (partly changing) social values the individual has to be able to recognize an adequate social environment and appropriate reference persons. In this context a creative individual is then capable of a high level of sympathetic distress (Hoffman, 1975), recognizing and reacting to the motives and feelings not only of individuals but of an entire class or group of people as a „generalized other“ (Mead, 1934, p. 158).

As these motives of groups of people can be heterogeneous and complex, creative solutions responding to them often require a completely novel approach. Such an approach can only find an individual who can – for a time long enough to get acquainted with all facts involved – sustain this sympathetic distress. In this model we assume, that for these quite stress-resistant individuals the self-imposed sympathetic distress fosters the finding of a creative solution by inducing neuronal restructuring, mainly in the hippocampus.

However, less stress-resistant individuals cannot go this way and at some point of time have to cease from the problem, often induced by additional stress imposed by (competing) social peers. They simply re-arrange their social field and choose new reference person, so they can stabilize their emotional relationship with their peers.

For not so few unlucky individuals, this is also not an option. They eventually will break under the partly self-imposed pressure of distress and will suffer from physical or psychological illness (Simonton, 1999, p. 96).

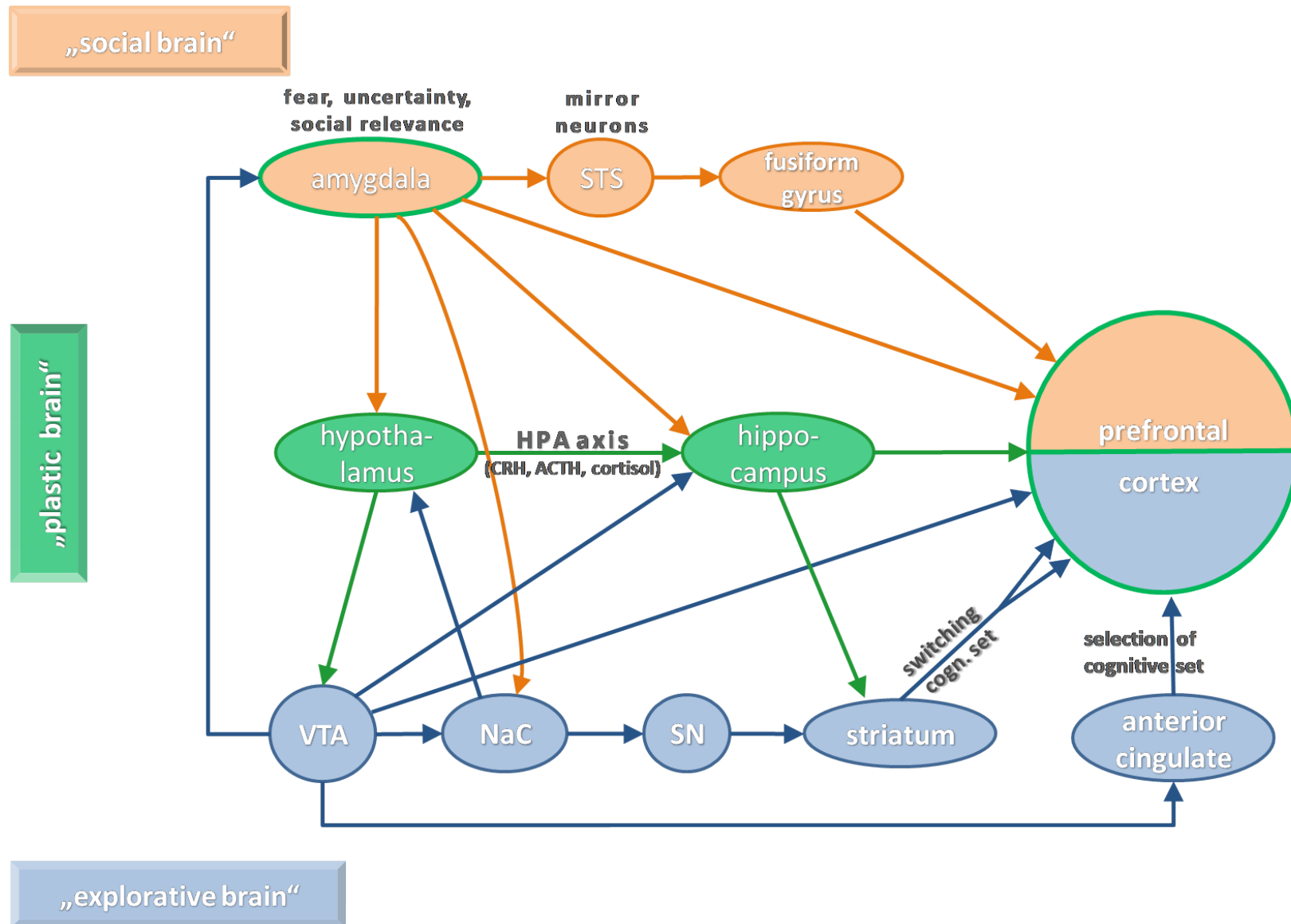


Illustration 4: Neuropsychological Evolutionary Model of Creativity. An interaction of three brain systems within creativity is assumed: **(1)** The “social brain”, comprising of the amygdala, the superior temporal sulcus (STS) containing mirror neurons (Rizzolatti & Craighero, 2004, p. 171), the fusiform gyrus, and the prefrontal cortex (Martin & Weisberg, 2003, p. 7; Insel & Fernald, 2004, p. 741). **(2)** The “explorative brain”, consisting of the ventral tegmental area (VTA), the nucleus accumbens (NaC), the substantia nigra (SN), the striatum, the anterior cingulate, as well as the prefrontal cortex (Ashby, Turken, & Isen, 1999, p. 533; Spitzer, 2003, p. 133). **(3)** The parts of the brain distinguished by a high level of plasticity, namely

the hypothalamus as major component within the hypothalamic-pituitary-adrenal axis (HPA-axis), the hippocampus as most important target showing plasticity under the influence of cortisol, as well as to a lesser degree the amygdala and the prefrontal cortex (McEwen & Magarinos, 2001, p. S.14). With this model we can explain the puzzling undermining effects of reward on creativity, also more generally referred to as “motivational crowding effect” (Amabile, 1986; Meier, 2007, p. 67). The still common, but often as unsatisfying described (Schiefele, 1996; Rheinberg, 1997) explanation for this “corruption effect” refers to the self-determination theory of Deci and Ryan (1985) and its misleading differentiation between “intrinsic” and “extrinsic” motivation. Considering the role of the amygdala in the interaction of the brain components described in the model we can offer two equally plausible explanations for this effect:

The first explanation draws on the difference of intensity and duration of the stimuli affecting the amygdala in the context of crowding effects. While an individual is looking for a creative solution it is – from the presented point of view– imposing sympathetic distress on itself by considering the plights and motives of others. Although these considered motives are only “imaginary” they are socially relevant and thus stimulate the amygdala which in turn can lead to long-term increased dopamine release in nucleus accumbens, representing an enduring motivational state (Floresco et. al., 1998). A directly offered reward in this context represents a stronger – because actually present and not only imaginary –stimulus to the nucleus accumbens. Stimulation by the amygdala then is overridden by the self-activation of the nucleus accumbens. In addition, a cognitive switching in the striatum takes place. However, crucially important to note is that the actual presented stimulus of reward is stronger, yet of shorter duration. It is only a onetime reward offered compared to the otherwise long lasting effect of the sympathetic distress.

The second explanation refers to the multimodal responsiveness of amygdala, reacting to both socially relevant facts as to uncertainty. In the context of an individual looking for a creative solution this would imply an initial social activation of the amygdala with the above mentioned long-term motivating effect via the nucleus accumbens. The certainly assured reward would then lead to an evaluation of the degree of uncertainty of the persisting social activation of sympathetic distress. While this social activation - like any social task - contains uncertainty (Camerer, Bhatt, & Hsu, 2007, p. 143), the amygdala would then signal a preference of the (safer) reward over the generally uncertain social task of sympathetic distress. This would hold especially true for those individuals with a due to early childhood negative calibrating with respect to stress and uncertainty over-sensitized amygdala (Flinn, 2007, p. 281). In case this second explanation is true, stress-resistant individuals should be less or none susceptible to undermining “crowding effects”.

Furthermore, the above presented model is also able to explain the age-effects of declining creativity over the course of the life time. Two of the three components of our model, namely the “plastic brain” and the “explorative brain” show these aging effects. The aging effects of the latter can be traced back to its dopaminergic character (Ashby, Turken, & Isen, 1999, p. 533). Several studies have shown that, during the course of normal aging, dopamine levels in the human brain decrease by 7% or 8% each life decade (e.g., van Domburg & ten Donkelaar, 1991; Gabrieli, 1995). As a consequence, Ashby, Turken, & Isen (1999, p. 543) particularly attribute that the age-related decrease in cognitive flexibility and creative problem-solving ability to the decrease of dopamine level over the course of the life time. However, also the “plastic brain” is displaying strong aging-effects. An age-related decline in neurogenesis within the dentate gyrus, a hippocampal subfield, has been reported for rodents (Kempermann et al., 1998) and rhesus monkey (Fallah et al., 1998). Findings of a reversed decline in neurogenesis after an adrenalectomy (Cameron and McKay, 1998), suggest that the decline is the result of age-related increases in HPA activity (Landfield and Eldridge, 1994). Further, we also have to remember the stress-induced early childhood plasticity of the hippocampus (Meaney, 2001, p. 1182).

Taken together we can describe the brain’s neuroplasticity as highly affected by normal and – at the worst – premature ageing effects. The connection to a decreasing creativity becomes especially visible in findings that already mild hippocampal atrophy impaired generalization involving novel recombinations of familiar stimuli in elderly humans (Myers et al, 2001). This supports the assumption that neural plasticity accounts at least in part for the fluid intelligence involved in creative problem solving as well more general in producing novelties of cultural change (Chiappe & MacDonald, 2005; Bjorklund and Rosenberg, 2005; Flinn, 2007, p. 277).

6.2 Specifying an appropriate business innovation context for applying the theory

An adequate business innovation context for the application and verification of this integrated evolutionary theory of creativity must be able to test the theory within all six requirements postulated in the preceding paragraph (6.1). Therefore, the context must be able to challenge the theory for its predictive value with regard to

- (1) **inter-cultural differences** of creativity. To be able to test for predictions of inter-cultural differences we will rely on business innovation contexts which can be compared internationally.
- (2) **inter-temporal differences** of creativity. To test for predicted inter-temporal differences we will draw on business innovation contexts offering similar, recurrent creative tasks that can be quickly repeated and subsequently compared.
- (3) an **integrative explanation for creative behavior**. Our business innovation context should allow for controlling of the adaptive pressures and the imposed stress from sociality on the creative individual to be able to test our integrative approach.
- (4) the **social conditions** required for creative behavior. In combination with our first requirement we will use a business innovation context allowing to test for different social conditions in different markets and its effect on the creative outcome of the same task.
- (5) a **general explanation** of the emergence of creativity. In order to test the predictions related to the emergence of creativity we will rely on business innovation contexts with the possibility to change the extent of cooperation.
- (6) the **extendability to group level perspective**. To be able to verify predictions derived from our theory regarding group creativity we will use business innovation contexts that are scalable in the number of participants. The context should also allow for different forms of group cooperation with regard to hierarchy and goals.

With regard to the above stated requirements it seems appropriate to rely on a quick, repeatable and scalable form of business innovation context. Therefore we will draw on the recently developed technique of using information markets for creating and evaluating business innovation ideas (Soukhoroukova, 2007). Information markets are a new Internet-based method to connect a large network of participants who interact by trading information and expectations. The creative ideas of participants can be efficiently elicited and aggregated using the underlying market mechanism (Soukhoroukova, 2007, p. 75). An additional advantage of this method is the possibility to let the market participants assess the creative outcome themselves. This valuation of the creative outcome can be interpreted as a quantifiable application of the technique of consensual assessment of creativity (Amabile, 1982). The general practicality of such a quantifiable application of the consensual assessment technique has been proved by Taylor & Greve (2006). By the application of this internet-based information and communication technique our approach also intends to overcome main arguments against the classical use of the consensual assessment technique including time-demand, impracticality and lack of appropriateness for individual differences (Horn & Salvendy, 2006).

6.3 Identifying a suitable methodology for verifying the theory

Today, information markets are mainly used for the forecasting of events like elections and business outcomes, and have demonstrated a very good predictive validity in this context (Forsythe et al. 1999, Spann & Skiera 2003). However, recently, the general practicability of information markets as a method to create and evaluate new product ideas has been demonstrated (Soukhoroukova, 2007, p. 117). These “idea markets” are designed as virtual markets, where all participants are able to suggest new product ideas and collectively evaluate those ideas using the underlying market mechanism. Idea markets use idea stocks to represent new product ideas, which can be traded by participants on a virtual market place. The efficiency of markets and the resulting stock prices thereafter are used as an indicator for the possible success of the new product ideas. This technique offers several advantages with regard to our research question:

Firstly, we can assess the relation between product creativity and product success. Assuming that we can consider the emerging price of the idea stocks to be a valid indicator of their chance of success (Soukhoroukova, 2007, p. 154) we could directly correlate these prices with an additionally conducted rating of the creative level of the ideas. We thereby could also screen the method of Taylor & Greve (2006), who took the price valuation of products as a direct measure of creativity in form of a quantifiable use of the consensual assessment technique (Amabile, 1982). According to our theory, creativity has to be viewed as a genuine value creation mechanism. Therefore we will expect a close correlation of an assessment of creativity and the idea stock prices.

Secondly, idea markets offer the possibility to test our cooperative concept of creative processes. In this context evidence has been presented for the creativity enhancing character of the interaction of idea creators. The exposure to unusual ideas might be able to elicit individual creativity and increase the overall quality of ideas (Goldenberg et al. 1999; Garfield et al. 2001). Open, market-like idea competition seems to provide the transparency that allows participants to use the traded ideas and their evaluation as cues³³ for underlying social values. This leads to learning effects (Nunamaker et al., 1997; Toubia 2006; Maciejovsky & Budescu, 2007). In this context we could test our assumption that creativity implies insight into social values by measuring creative outcome in relation to the degree of participation³⁴.

Thirdly, idea markets would allow us to test the basic conditions of group creativity effects by varying the collaboration degree of participants while creating new idea stocks.

Fourthly, idea markets have the advantage to be fast and scalable, so we could test for intercultural and inter-temporal differences of creative outcome.

³³ Of course it will be necessary to identify in which way these cues are mainly used to generate creativity. According to our approach these cues are used to identify social values. Market dynamics, however, often show that prices can also be used as “competitive” cues (Wyman & Tomasello, 2007, p. 230). This would reflect a more profit-oriented view of creativity, not coinciding with our model. Probably it will also be possible to identify to what degree traders will behave as “advantage-taking” short term dealers vs. “value-creating” long term dealers. This view finds support in the differentiation between promotion and prevention cues of Friedman and Förster (2001). However, we assume that the same stimulus can either be interpreted in a promoting or in a preventing way, depending on the underlying motivation of the individual.

³⁴ E.g. measured in duration of trading and trading behavior.

Fifthly, we could additionally test our cooperative model of creativity by varying between cooperation and competition of market participants. This could be realized by applying different incentive structures.

Summarizing, we can note that the idea market approach to creativity seems to be a very promising methodology of generating and evaluating creativity to test our evolutionary model of creativity.

7. Potential Outcome and Importance

Our theoretical integration of process and trait aspects will provide a deeper understanding of creativity as well as extended possibilities for its application. Testing the theory within the framework of idea markets will offer new insights on the creative potential of markets as well as on the motivation of its participants. We will derive consistent and interrelated hypotheses that reflect the model as a whole, so we can test the complete model rather than individual hypotheses. Our notion therefore will be that either all or none of our predictions will prove true. With regard to individual as well as group level creativity we suggest to test the following ten hypotheses as representative for our whole model:

1. **Cooperation:** The possibility to cooperate and collaborate in idea finding should significantly increase the quality of creative outcome.
2. **Incentives:** Incentives not related to the idea (e.g. money for participation in the idea market) should not have any positive effect on the creative outcome³⁵). However, incentives related to the idea should foster creativity, if they are generated consensually.
3. **Social values:** Those participants acquainted with the social values of the trading group should generate higher quality³⁶ creative ideas.
4. **Groups:** Groups already existing before the idea market should generate significantly higher quality creative ideas due to their deeper understanding of their shared values³⁷.
5. **Group size:** Group size should have marginal utility to overall creativity of participants. Beyond 150 participants additional participants should contribute significantly less relative to overall creativity.

³⁵ With respect to Amabile (1986) they should rather have detrimental effects for the creative outcome.

³⁶ The quality of the creative idea is measured by the valuation of the participants themselves.

³⁷ This links directly to the usage of „Internet Communities“ for finding participants in idea markets.

6. **Shared goals:** Shared goals should foster overall creative outcome of idea market participants.
7. **Group values:** Creativity should directly reflect cultural group values. This should be significant in cross-cultural comparison of idea markets with the same task.
8. **Stress:** Stress-resistant participants with lower cortisol-levels should generate more and higher quality creative ideas.
9. **Gender and age:** Male participants should be more active and thus develop more creative ideas than female participants. At the same time males should show more short-term (advantage-taking) trading than females and thus show less quality of creativity than women. Creativity in business context should be highest with participants at or around the age of 30 years.
10. **Trading:** Overall trading frequency should correlate with overall creative outcome of all idea market participants. Short-term (advantage-taking) traders should have lower quality creative ideas than long-term (value-creating) traders.

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