

Der Open-Access-Publikationsserver der ZBW – Leibniz-Informationzentrum Wirtschaft
The Open Access Publication Server of the ZBW – Leibniz Information Centre for Economics

Herrmann-Pillath, Carsten

Working Paper

Neuroeconomics, naturalism and language

Working paper series // Frankfurt School of Finance & Management, No. 108

Provided in cooperation with:

Frankfurt School of Finance and Management

Suggested citation: Herrmann-Pillath, Carsten (2008) : Neuroeconomics, naturalism and language, Working paper series // Frankfurt School of Finance & Management, No. 108, urn:nbn:de:101:1-2008121084 , <http://hdl.handle.net/10419/27873>

Nutzungsbedingungen:

Die ZBW räumt Ihnen als Nutzerin/Nutzer das unentgeltliche, räumlich unbeschränkte und zeitlich auf die Dauer des Schutzrechts beschränkte einfache Recht ein, das ausgewählte Werk im Rahmen der unter

→ <http://www.econstor.eu/dspace/Nutzungsbedingungen> nachzulesenden vollständigen Nutzungsbedingungen zu vervielfältigen, mit denen die Nutzerin/der Nutzer sich durch die erste Nutzung einverstanden erklärt.

Terms of use:

The ZBW grants you, the user, the non-exclusive right to use the selected work free of charge, territorially unrestricted and within the time limit of the term of the property rights according to the terms specified at

→ <http://www.econstor.eu/dspace/Nutzungsbedingungen>
By the first use of the selected work the user agrees and declares to comply with these terms of use.

Frankfurt School – Working Paper Series

No. 108

**Neuroeconomics, Naturalism and
Language**

by Carsten Herrmann-Pillath

Dezember 2008



**Frankfurt School of
Finance & Management**
Bankakademie | HfB

Sonnemannstr. 9–11 60314 Frankfurt am Main, Germany
Phone: +49(0)69 1540080 Fax: +49(0)69 154008728
Internet: www.frankfurt-school.de

Abstract

Neuroeconomics stays in the center of the ongoing naturalistic turn in economics. It portrays the individual as a complex system of decision making mechanisms and modules. This results into a conceptual tension with the standard economic notion of the unity of the actor that is a systemic property of economic coordination. I propose to supplement neuroeconomics with a naturalistic theory of social coordination. Recent neurobiological and psychological research strongly supports claims made by some heterodox economists that the identity of actors emerges from social interaction, especially in the context of the use of language. Therefore, I argue that the completion of the neuroeconomic paradigm requires a naturalistic theory of language. I provide some sketches based on teleosemantics and memetics, and exemplify the argument by a naturalist account of money.

Key words: naturalism, neuroeconomics, individual identity, language and economics, naturalistic theory of social interaction

JEL classification: A12, B41, D87

ISSN: 14369753

Contact:

Prof. Dr. Carsten Herrmann-Pillath
Academic Director,
Sino-German School of Governance
Frankfurt School of Finance & Management
Sonnemannstr. 9-11
60314 Frankfurt am Main
c.herrmann-pillath@frankfurt-school.de

Content

1. A naturalistic turn in economics?	4
2. Whither the individual in neuroeconomics.....	7
3. The externalist solution to the problem of agent identity	10
4. Agent identity in economics	15
5. The naturalistic approach to language	17
6. A naturalistic account of money	22
7. Outlook: Towards a unified naturalistic paradigm of economics.....	25
8. References	27

(...) *information processing (strictly defined)*
in nervous systems arises primarily by
communication in a taxon.
Gary Edelman (1987: 320)

1. A naturalistic turn in economics?

In the past decade economics seems to switch from a unified neoclassical conception of the individual to a viewpoint that is multi-disciplinary, including psychology, sociology and the brain sciences. At least as far as recent Nobel award decisions appear to suggest, economics is moving towards a kind of ‘mainstream pluralism’ (Davis, 2006). In particular, neuroeconomics plus experimental economics emerges as a major conceptual alternative to traditional rational choice models. This goes hand in hand with the diffusion of new patterns of research practice in economics, in particular, with the ‘lab’ appearing as a standard part of economics departments. Economists’ contributions are being published in ‘Nature’ and ‘Science’, and there are many collaborative projects especially between biologists, anthropologists and economists.

These phenomena point toward a ‘naturalistic turn’ in economics. Naturalism is a term which is, in the philosophical debate, mostly related with the philosophy of mind (Searle, 2004), hence the mind-body problem, which makes the relevance to economics immediately evident, as the central notion of rationality refers to a mental phenomenon. There are two different uses of this term in philosophy, which can apply concurrently, ontological naturalism and methodological naturalism (for a survey, see Papineau 2007). The latter understanding supposes that all scientific endeavors eventually follow explanatory models and conceptual patterns of the natural sciences, including the social sciences and even the humanities. This means, basically, that scientific explanations build on a universal notion of causal processes and lawlike statements, and that the basic aims of all scientific endeavors is to understand the natural world, without considering other worlds apart, which means that understanding human beings is tantamount to explaining them. There is no epistemologically special approach to understand human thought and behavior, as it has been claimed for long by hermeneutical schools of thought. *Verstehen* is just another method to collect empirically relevant data. Scientific explanations can be in turn put into the framework of established models such as the hypothetico-deductive model, with possible limitations and alterations that result from the great complexity, historicity and openness of human social life (Bhaskar, 1989: 18ff.; Mantzavinos, 2006). In this sense, neuroeconomics, experimental game theory and similar fields of research certainly qualify as ‘naturalistic’.

However, a closer look at the history of economics reveals that this methodological naturalism approach was already implied in the behaviorist approach to preference theory which emerged in the Fifties, when ‘revealed preference theory’ claimed to be able to deduce standard utility theory exclusively from observational data. Indeed, since psychophysical ideas emerged in the second half of the 19th century, economics always strived at following methodological ideals and even conceptual models of the natural sciences. Mostly, this happened via the analogical or even only metaphorical use of physical theories (Mirowski, 1989), without, however, at the same time necessarily importing the corresponding standards of causal

explanations and empirical testing. For example, equilibrium theories have mostly lacked causal explanations of the generating mechanisms (Hausman, 2006: 10). Typically, natural scientists therefore criticize the vast distance between the claims of economics to be the most exact social science and the rather loose empirical standards that govern the formation of theories (e.g. Wilson, 1998: 216ff.; Roehner, 2002: Chapter 1). This has also repeatedly met with very sharp criticisms by leading economic methodologists, especially those adhering to Popperian philosophy of science, and who rejected the factual instrumentalism in most approaches to empirical testing in economics (for the classical survey on these debates, see Caldwell, 1994).

Given the widespread critique of instrumentalism in economic methodology, it seems that in the end ontological naturalism must be adopted by anyone who wishes to pursue methodological naturalism. The fundamental tenet of ontological naturalism is the notion of causal closure, i.e. the hypothesis that all phenomena in the world supervene on physical causation. Especially, the ontological naturalist rejects the notion of an ontologically separate mental causation, and, therefore, Cartesian dualism (Dennett 1991: 33ff.). For an ontological naturalist, the range of acceptable theories about human behavior is limited by the scope of supervenience (McLaughlin and Bennett, 2006). In the most flexible way, supervenience would allow to state that all mental phenomena correlate with physical phenomena, but that at the same time this relation may be multivalued. This leaves much leeway about possible theories about human behavior, including economic theories, but at the same time defines a clear constraint on what is an acceptable possible proposition at all. More exactly, the ontological naturalist:

- Does not accept any kind of theory that refers to an ontologically separate realm of the “mental”, or does not accept empirical evidence against some hypotheses which have been generated by theories that start out from “mentalism” as a methodological shortcut.
- Does not necessarily adopt a particular position in the internalism / externalism continuum, that is, does not necessarily believe that all mental phenomena are physical phenomena in the human brain. But in case of adopting an externalist position, the pertinent causal mechanisms are seen to supervene on physical mechanisms in the aforementioned broadest possible sense.

Against the background of these philosophical considerations, the current turn in economics towards an integrated approach to human behavior (aptly surveyed in Gintis, 2007) can be seen as a move from a fragmented methodological naturalism towards ontological naturalism. This is further supported by the warm reception of economic models in biology and biological anthropology, which is based on the formal homologies between mathematical models of population genetics and a number of fundamental economic categories, especially opportunity costs and optimization (Frank, 1995). Different from economics, however, biological applications of economics do not need to use the problematic concept of the rational agent, and can therefore do without the notorious “as if” of standard economics and its instrumentalist methodology. This results in successful empirical applications of economics far beyond the human species (for a representative collection of papers, see Noë et al., 2001). Thus, it seems that a naturalist synthesis is emerging. But in fact precisely in this convergence of theoretical ap-

proaches a daunting methodological issue raises its head, namely whether the core economic notion of rationality is to be understood in internalist or in externalist terms. In the biological uses, the rational agent is an emerging property of the evolutionary process, such that ‘rationality’ appears to be an externalist concept. In the standard economics approach, rationality is an internalist notion that is referring to properties of the individual exclusively. In fact, economics uncritically assumes that the unit to which the property of ‘being rational’ is assigned is identical with the human body, or, as neuroeconomics has it, the human brain (for an extensive discussion of these and related versions of internalism, see Wilson, 2004).

To be fair, precisely the classical Alchian / Friedman justification of the ‘as if’ approach to rationality represents an externalist approach, which would assign rationality to the status of an emergent property of the market process. However, that would immediately raise disturbing consequences regarding the universality of rationality as a feature of human beings, because evidently the kind of economic system that would give rise to rationality as a result of competitive pressures, is in fact a rare historical phenomenon, even under the conditions of contemporary capitalism (that is, we would introduce a Weberian notion of ‘rational capitalism’). That is, even though the formalism in biological and economic approaches to rationality appears to be the same, the underlying approaches to causal mechanisms are still worlds apart. This is most evident when we consider the most influential biological theory that was in turn imported into economics, namely evolutionary game theory. On the one hand, evolutionary game theory comes along with informal claims to be more realistic in projecting game theoretic models onto real world problems of social interaction (for an explicit approach, see Gintis, 2000). At the same time, however, its progress is still based on purely mathematical claims of equilibrium analysis, and a clear relation between formal structures and real-world causal mechanisms is still missing (being mostly substituted by simulation approaches). Sugden (2001) has presented a very compelling argument on this, showing in much detail that seemingly naturalistic approaches in evolutionary game theory such as Binmore (1994) and Young (1988) fail to present an empirical account of the presumed evolutionary mechanisms. For example, the notion of time remains an abstract concept of rounds of replication of rules, leaving entirely open, for example, whether the evolutionary emergence of certain rules can happen within empirically reasonable time spans. No wonder that leading game theorists even would like to eschew the standard terms of game theory, such as the term ‘strategy’, as they suggest misplaced relations with corresponding empirical phenomena (Rubinstein, 2000: 71ff.). This means, although evolutionary game theory might imply a move from an internalist to an externalist notion of rationality in economics, at the same time this version of methodological naturalism remains empirically hollow, because it is not supported by a corresponding move towards at least some minimum notions of ontological naturalism.

Even worse, the naturalistic turn in economics, as it stands, manifests a serious contradiction between two concurrent moves: On the one hand, the classical internalist position in economics is turned into an ontologically naturalist one, as economics begins to be integrated with the neurosciences and pursuing the aim to ground propositions about human behavior on empirically testable theories about neurophysiologically caused behavioral patterns. At the same time, theories about rationality increasingly adopt an externalist position in the sense of de-individualizing the notion of rationality in favor of an evolutionary reduction. This kind of externalism is lacking a naturalistic foundation, which in biology is provided by population and molecular genetics.

This paper presents an attempt to solve this contradiction. I follow the move towards ontological naturalism, but at the same time I agree that a fully-fledged theory of the human agent in economics requires an externalist foundation. This means that I need to construct a naturalist approach to the central problem of economics, i.e. coordination among agents. The bridge between the two aspects of the problem is the notion of agent identity. I show that neuroeconomics further accentuates the difficulties of economics to present a convincing account of agent identity, which, at the same time, is a pivotal notion in established economics. Agent identity cannot be explained as a result of economic coordination as commonly conceived, thus enters as a mere assumption, which is exploded by neuroeconomics. Thus, the only alternative seems to be a naturalistic approach to social coordination which directly hooks up with the identity issue. I propose that such a solution is at hand if neuroeconomics is enriched and supplemented with a naturalistic theory of language. These are the main steps of the argument in this paper, which concludes with an exemplary discussion of the central device in economic coordination, namely the naturalistic theory of money.

2. Whither the individual in neuroeconomics

Neuroeconomics and behavioral economics (henceforth: NEBE) have generated substantial insights into human behavior in economic settings. Nobel laureate Vernon Smith (2003: 499) has summarized these insights in the following statement:

“Our brains conserve attentional, conceptual, and symbolic thought resources because they are scarce, and proceed to delegate most decision-making to automatic processes (including the emotions) that do not require conscious attention. Emergent arrangements, even if initially constructivist must have survival properties that incorporate opportunity costs and environmental challenges invisible to constructivist modeling. This leads to an alternative, ecological concept of rationality: an emergent order based on trial-and-error cultural and biological evolutionary processes.”

This statement highlights some essential ingredients of NEBE.

- Human decision making is based to a large extent on mechanisms that are optimized as a result of evolutionary processes, both in the sense of a phylogenetic legacy and of trial-and-error-learning. Optimization results from the fact that brain processes have to rely on scarce resources (time and energy).
- These mechanisms are partly independent from conscious decision-making, and may be even irretrievable to conscious reflection, and if so, cannot be changed unless being subject to intensive learning procedures.
- Learning is also conceived as an evolutionary process, implying that a part of the accumulated information also remains beyond consciousness. Different kinds of evolutionary processes converge in establishing coordination between behavior and environment, in the sense of adaptation.

Neuroeconomics is presented in two different approaches, which complement each other, but put economic theory in a different context. The first insight related above strongly vindicates an economic approach to the individual, because it supposes that the evolutionary formation of the neuro-architecture of the brain follows optimization principles. One of the leading proponents of this paradigm, Glimcher (2003), therefore applies Bayesian optimization of the analysis of behavioral patterns both in animals and humans, which follows up an earlier tradition of ‘animal economics’ in which strong empirical support was collected that even simple organisms manifest economic behavior which is accessible to standard microeconomics (for a classic, see Kagel et al., 1995).

However, at the same time these results do not necessarily support the idea that the entire set of individual behavioral patterns follows a unified system of rational choice in the sense of a coherent, encompassing and consistent set of one integral utility function. Indeed, although such a function can be shown to result from certain mathematical assumptions on an evolutionary process that is supposed to optimize over decision costs (Robson, 1996; 2001: 14ff.), it seems to be highly implausible empirically. The reason is that the connection between selective forces in the environment, indirect determinants of relative fitness (so-called ‘currencies’) and actual relative reproductive success is tenuous, as far as the concept of overall optimization is concerned. For example, there is a clear empirical link between observed patterns of (animal and human) foraging behavior and net energy harvested, which allows the conclusion that the optimization of single patterns of foraging result from selection, because energy is certainly a crucial determinant of relative reproductive success (Kramer, 2001). But these correlations remain uni-dimensional and become very complex if frequency-dependent selection enters the picture, for example and foremostly, sexual selection (resulting in the so-called ‘handicap principle’ for evolutionary optimization, i.e. the use of suboptimal designs for signaling, see Zahavi and Zahavi, 1997; compare the assessment by Dawkins, 1989: 309ff.).

Against this background, the picture of human behavior that emerges from evolutionary psychology seems to be more plausible than the standard unified economic approach: Human behavior is seen as being based on a set of decision modules that are task-specific, and that are not necessarily arranged into a unified and coherent decision system. That means, the proper background for neuroeconomics is the rejection of the fundamental notion of ‘general purpose rationality’ (Tooby and Cosmides, 2005; compare Camerer et al., 2005: 10f.). Interestingly, this conclusion can also be reached if one applies the conventional economic equilibrium framework on neuroeconomics. This is because the economic notion of the ‘rational agent’ is neutral to the ontological level of application, precisely in the Glimcher version. Thus, in the same way as it is possible to treat (super-individual) firms as economic agents, one can also treat lower-level units as ‘economic agents’ such as a single neurophysiological mechanism. Following this line of thinking, a real-world individual can be conceived as a collective of rational economic agents, i.e. a set of interacting and optimizing neuro-mechanisms. However, this inexorably implies that all results on the impossibility of collective utility functions and collective choice following from the Arrow impossibility theorem apply forcefully on the individual level (Ross, 2005: 352; for an early analysis in this vein, see Steedman and Krause, 1986).

Thus, we hit on the first hint how to resolve the methodological contradiction that surfaced in section one:

- Either the individual is interpreted along the lines of an empirically motivated evolutionary approach, thus sticking to the standard notion of methodological individualism in economics. Then, the empirical record strongly suggests that the human individual does not sum up to a unified and integrated rational agent, even if single modules of behavior might reflect the results of an optimizing process.
- Or the individual is interpreted according to the abstract formal notion of standard equilibrium theory, which is, however, neutral with reference to the ontological level of application. Then, all results of the impossibility of collective rationality apply for the human individual, because ‘rationality’ applies also for supra-individual mechanisms.

No wonder that neuroeconomics actually supports two different trends in economic methodology. Apart from the vindication of economic models in an evolutionary context, at the same time the economic theory of the individual is put into doubt. The latter conclusion seems to be firmly based on the current state of the brain sciences, which have clearly refuted the Cartesian idea of a central cognitive device in the brain, dubbed the ‘homunculus’ by the Darwinian philosopher Daniel Dennett (1991). This corresponds to the rejection of the ‘general purpose optimizer’ by evolutionary psychologists.

This approach can best be illustrated by an example. At the fringes of economics, the idea of ‘multiple selves’ has existed for long (for a survey of this older literature, see Elster, 1986). It has been moved into a more central position by psychologist Ainslie (1992), who analyzed empirical phenomena of human decision making with the help of hyperbolic time preferences. Over almost a decade, this approach was neglected by mainstream economics, until Laibson (1997) succeeded in applying the modified concept of quasi-hyperbolic time preferences to explain macroeconomic anomalies of savings behavior. Since then, the approach has received considerable attention. In a most recent contribution, a team of researchers including Laibson could demonstrate that the supposedly dual decision calculus underlying quasi-hyperbolic discount functions matches differential activation of brain areas, directly corresponding to the formula of the economic model (McClure et al., 2007). Thus, the multiple selves approach is supported by neuroeconomic research. This argument faces criticism from two sides. One comes from empirical research. For example, Kable and Glimcher (2007) claim to have shown that hyperbolic discounting actually seems to involve a broader set of brain areas, thus seemingly support a more holistic approach. The other is from theory, with contributions such as Gul and Pesendorfer (2001) who could show that hyperbolic discounting can be fit into standard economic model of optimization and dynamic control theory. Thus, the unity of the self or the economic agent is an open question both empirically and theoretically.

The Pesendorfer argument has been systematically extended on the methodological level by Gul and Pesendorfer (2005) and in a related manner by Ross (2007a). They make the fundamental point that economic theory is not about real individuals but about economic systems. This argument fits into the so-called ‘zero-intelligence’ models, for example, in complex adaptive system approaches which can show that the emergence of market equilibria can re-

sult from the interaction between agents that do not display any rationality at all, but simply follow rules of thumb. If this argument is put together with the classical justifications of the ‘as if’ argument proposed by Alchian and Friedman (i.e. the market selects ‘as if’ optimizers), there is a strong support for the idea that economics is all about systems, but not about real agents (just as Newtonian mechanics is about mass points, but not real apples). In other words, the agent is just a methodological construct that follows from the systems analysis, but it is by no means an empirical entity on which analysis is built. From that point of view, NEBE is simply irrelevant to economics. Clearly, the Gul and Pesendorfer argument straightforwardly confronts a purely externalist theory of rationality with NEBE, which so far is implicitly defined as a purely internalist approach.

The Gul and Pesendorfer argument, however, does not really resolve the problems posed by the issue of agent unity versus multiplicity. This is because the methodological pillar is the separation across domains. That is, the authors distinguish explicitly between economic research issues and the related phenomena and psychological, cognitive, social etc. research issues, and they claim that for economic research issues the question of the underlying agent motivations and structure is irrelevant, as economics also defines the set of data which are relevant for solving problems of economics. Neurophysiologic data are not the kind of data in which economic problems are defined, and vice versa. For example, risk aversion might be a general psychological issue, or a specifically economic term. The latter use only refers to monetary gambles, and if a problem is to be seen as an economic one, it should be presented in terms of data which correspond to monetary gambles. Once this is possible, the issue of agent motivations and internal structures is of no interest anymore, because only observable economic data need to be fed into economic models. Evidently, this argument raises the question how to separate across different domains, and how to explain why agent behavior may be different in different contexts, with only one corresponding to the economic. That is, we still face the formidable issue of proving agent identity across different domains. The economic agent may appear as an integrated agent in the context of economic theory, but this has no relevance whatsoever for the notion of real-world unity of agents.

I think that this discussion leaves us with the determination of the principal task: How to account for the identity of agents in a naturalistic approach to economics. I posit that this requires a clear stance towards the internalism / externalism polarity. There are strong reasons to assume that an alliance between NEBE and internalism does not allow for a solution of the problem of identity. We need an externalist approach to NEBE which can be confronted with the Gul and Pesendorfer argument.

3. The externalist solution to the problem of agent identity

As we have seen, NEBE does not necessarily support the notion of an individual at all, which might be regarded as a major flaw, because, after all, it’s we who think and act as individuals, also recognized by others. This question is related to the very complex philosophical notion of consciousness in the philosophy of mind, which makes even a tentative treatment highly difficult. However, it seems to be crucial for the establishment of a firm methodological base for NEBE in the context of economics.

Looking for corresponding notions in evolutionary psychology, there is the proposal that the unity of the fragmented system of evolved decision mechanisms is attained via the function of emotions. Emotions are a category which, on first sight, lies outside the reach of any economic theory which so far claims to be based on rationality (Elster, 1998). In evolutionary psychology, emotions have a twofold function. One is derived from the observation (systematicized, for example, in Damasio's, 1995 theory of 'somatic markers') that emotions are the foundation of valuations. The other, crucial in our context, is that emotions can be viewed as 'superordinate programs' that regulate the joint action of decision mechanism by linking their onset to certain classes of typical situations, such as fear resulting from certain classes of settings (Tooby and Cosmides, 2005). That means emotions exploit cognitive triggers in the environment to activate orchestrated action patterns. We can relate this idea to a central concept in NEBE that is framing. Emotions activate frames of perception and behavior. On the perception side, Gestalt effects work, because a main mechanism is to complement incomplete information flowing in from the environment. On the behavioral side, emotions produce coherent actions.

Now, there are strong reasons to assume that human emotions play a particularly important role in social interaction (for an early economic argument, see Frank, 1988). Indeed, evolutionary psychologists have produced much evidence about the fact that many human decision making mechanisms are geared towards 'social contract situations', that is, to the solution of problems of social coordination (surveyed by Cosmides and Tooby, 2005). This even affects fundamental mechanisms such as logical inference, in which test persons display stark differences in performance depending on the framing of the decision situation (Gigerenzer, 1996). These results vindicate theories that suppose that human intelligence is fore mostly 'social', given the fact that the complexity of social interactions is much higher than any interactions with the natural environment (Goody, 1995).

From this follows, that the unity of the agent in NEBE has to be based on some notion of identity that emerges from social interaction, such that the stable identity of the subject is not simply an a priori precondition for social interaction. This argument might be formally similar to the Gul and Pesendorfer argument, but turns it into a naturalistic proposition. So the similarity emerges because NEBE would move towards the externalist pole. The question is whether the identity of the NEBE individual emerges from a naturalistic account of social interaction, which might be broader than economic interaction as envisaged by economic theory. To be exact: The similarity boils down to the evolutionary-psychological point that there are classes of behavioral patterns that are domain-specific. On this Gul and Pesendorfer might concede a point. However, this also means that the question of "meta-identity" of the person as agent remains open, as it is in NEBE.

Why do we assume that there is an identity of an agent at all? It seems that this is related to a foundational, yet often implicit belief that the agent neatly corresponds to the body, i.e. that the boundaries of the body and the boundaries of the agent concur (Wilson, 2004). This is the internalist approach to identity. In NEBE, this is explicit in the approach to explain observed behavior by certain states of the brain, and by applying the corresponding individual-centered empirical techniques, such as brain imaging. Now, the modern conception of the brain conceives it as a highly dynamic and fluid system of interacting modules which is in turn emerging from an evolutionary process of neuronal variation, selection and retention (Edelman,

2006). Where does the unity of the agent come from? Why do we perceive ourselves as ‘individuals’?

One of the main designers of Darwinian psychoneural monism, Gary Edelman, already pointed out in his first systematic exposition of this theory (Edelman, 1987: 308ff.) that the stability of cognitive structures in Darwinian brains can only result from communication between brains. In the simplest case, cognitive stabilization requires signaling processes in which recurrent patterns of neuronal action are reinforced by impulses that are generated in response to organismic action that is produced internally. The reason why communication plays a special role beyond mere organism-environment interactions is that communication entails a mutual confirmation of species-specific cognitive patterns. Because of the highly idiosyncratic nature of neuronal evolution, a convergence of more complex cognitive patterns across different individuals requires the exchange of information via signaling, such as, for example, imitation, observation and teaching (for a detailed corresponding view in the current literature, based on so-called ‘shared circuits’, see Hurley 2007). Edelman calls this “communicated learning”. Today, there are strong reasons to believe that this kind of collective cognitive processes even take place on the simplest level of organismic evolution, i.e. the bacteria (see e.g. Ben-Jacob et al. 2006; compare Skyrms, 2004).

In humans, this kind of communicated learning seems to play a central role in the emergence of a particularly human phenomenon which presumably underlies the notion of an identity, that is, the ‘theory of mind’. In their systematic summary of the pertinent results from cognitive science and brain research, Tomasello et al. (2004; cf. Tomasello and Carpenter, 2007) argue that human cognition is essentially cultural because it is based on a species-specific form of shared intentionality which is unique to humans. Whereas intentionality is found in many other species, and could even be seen as a necessary feature of all information-processing systems resulting from natural selection (Maynard Smith, 2000), shared intentionality is based on a continuous communication between individuals. Human infants clearly undergo a developmental trajectory which builds up three essentially human capabilities in a coordinated fashion, namely understanding the intentions of others, having a theory of one’s own and the other’s mind, and language (compare a related approach by Carpendale and Lewis, 2004). The critical activity during this trajectory is what might be called cognitive cooperation, which in the end is the basis for the core feature of human intelligence, that is, ‘anticipatory interactive planning’ (Goody, 1995).

Tellingly, this kind of cooperation starts very early in adult-infant interactions which have the exchange of emotions as an object. That is, the way to language moves through stages of a holistic joint establishment of frames of interaction, in which the single elements of meaning only emerge after a long process of developing mutual understanding and coordination of actions. This is important because it reveals the failure of analytic-algorithmic views of language, which have emerged in ex post scientific approaches to syntax and semantics, mainly based on the analysis of written language. In fact, language builds on larger-scale units of utterances which have functions in social interaction, and where meaning emerges from the replication of utterances in communities of language-users (Millikan, 2005: Chapter 10; for an evolutionary account of speech and language, see Locke and Bogin, 2006). Language presupposes the capability to reverse imitation, which implies the capacity to reconstruct the intentions of others and to use utterances to express similar intentions of one’s own (Arbib, 2007).

Thus, the ‘theory of mind’ is not simply a genetically endowed capacity of humans, but is essentially dependent on the formation of ‘dialogic cognitive representations’. Different levels of complexity of this ToM emerge through linguistic development of the child. The ToM clearly has a neurophysiological foundation in brain architecture, both in terms of macrostructures and in terms of basic neuronal units, such as the so-called ‘mirror neurons’ (e.g. Firth and Firth, 2003; Gazzola et al., 2006). That is, ontogenesis in a setting of continuous social exchange activates the development of hard-wired neuronal structures which are somehow related to genetic programming.

To be precise, the specific role of language in relation to other cognitive processes is under dispute in the discourse that I have barely sketched in the previous paragraph. However, this partly depends on where the different researchers actually draw the line between language and culture as the more general symbolic system, and, of course, language and thought. This is not the place to delve into the intricacies of these issues. Following Searle (2006), I would say that one has to neatly distinguish between language and prelinguistic cognition, which already involves many functions that are also critical for language, but which are not constitutive as a distinctive feature of language, such as essential aspects of intentionality, i.e. beliefs, representations of the external world etc. Yet, these functions are also relevant for the Edelman mechanism, i.e. founding neurophysiological ‘equilibria’ in communication between brains.

Ross (2007b) presents an approach to language which is congenial to our problem, in particular, as we shall see in the next section, with reference to the treatment of identity in economics. This argument continues with an earlier treatment, where Ross (2005: 351ff.) proposes to conceive of economic agents as individuals on which the ongoing concern of economic and social interactions imposes some kinds of disciplines that ultimately lead to the emergence of behavioral patterns that can be condensed into the stylized facts theorized in economic models. Ross (2005: 285ff.) introduces a critical role for language, building on the neurophilosophical approach heralded by Dennett, in which the unity of the individual results as a foundational problem, given the fluid, even chaotic nature of the brain. For Ross, then, individual selves are “narrated systems of behavioral dispositions that extend across nontrivial numbers of schematic boundaries (i.e. that imply networks of expectations in multiple types of situations)”.

Ross (2007b) follows those positions in the literature which assign language a pivotal role in externalist accounts of human cognition. Language has evolved as a device for decoupled representations of the world, and as a system of cues in which adaptively relevant information has been stored and can be utilized in a community of users of a language. Decoupling is the main precondition for the human capability to represent counterfactuals, and hence the unique human capability to lie. Once this capability had emerged, a cognitive arms race started which rapidly increased the complexity of social interaction among humans (a special version of the Red Queen effect, see Robson, 2005). That is, language emerged both as a problem and as a solution: Decoupling by language triggers an explosion of complexity, and at the same time linguistic cues obtain the crucial role in solving problems of complexity. As Searle (2006) has it (compare Searle, 1995, and with reference to economics Searle, 2005), this solution capacity of language emerges from the deontic powers activated by language. That is, language involves commitments of agents, which stabilize mutual expectations.

This viewpoint is tantamount to an externalist version of ontological naturalism with reference to human beings, with a special focus on social interaction. Cognitive externalism in general refers to the human capability to store and activate adaptively relevant information in the environment through the construction of artifacts (Sterelny, 2004). However, this might just be regarded as a special case of the general evolutionary phenomenon of the co-evolution between the genetic information and the environment (e.g. Odlin-Smee, 1988). As Ross (2007b) argues, the specialty of the human case rests on the role of language as an externalized carrier of information which is both decoupled from the genetic information and the natural environment as given in the immediate situation of action. One crucial consequence of this is that the representation of others in strategic interactions obtains a central role in providing the conditions for success in coordination. For this, two functions of language are essential. One is that language operates as a system of contingent meanings which mutually support and constrain each other in making sense of events and observations, such that agents are able to recognize situations of interaction. Second, based on this function, language supports the emergence of stable patterns through time, in particular by imposing constraints on the intertemporal consistency of narratives. In other words, the deontic powers of language emerge from the conditions of proper functioning, because otherwise language would just result into ‘babbling’, i.e. cheap talk. Mere babbling would not be evolutionary stable, because it is a waste of organismic energy, attention and time.

Now, Ross argues that agent identity emerges as a result of linguistically mediated coordination among agents. That is, the agent does not simply appear ‘as such’ in social interaction, but as a construction through narratives. This implies an externalist approach to agent identity. This is a crucial insight for the naturalistic approach, because it immediately makes clear why a naturalistic theory of the individual cannot simply equate the agent with the brain or the body, in general. As far as social interaction is concerned, the agent is an emergent property of the systems level. This also means, following the notion of supervenience, that there is no necessary and direct connection between certain linguistic states and neurophysiological states. As we shall see later in some more detail, language operates as a constraint on these states, but not as a direct causal determinant of single states. That is, same semantic notions might correlate with different neurophysiological states of different brains. In this sense, language becomes an ontologically autonomous fact (more specifically, an ‘observer-dependent fact’ in Searle’s 1995 parlance).

Thus, we can safely say that the very notion of the ‘individual’ is inextricably related to cognitive collaboration mediated via signals and, on later stages, via language. This is a specific form of the original Edelman hypothesis. The implications for NEBE follow on the spot: NEBE has to be supplemented by a naturalistic theory of language in order to be able to formulate a theory of individual identity. It is important to demonstrate that this argument has a close parallel in the economics discourse about identity, which would finally resolve the Gul and Pesendorfer issue.

4. Agent identity in economics

John Davis (2003) has shown that the problem of agent identity can be reduced to two essential criteria: Re-identification and individuation. Individuation means that any notion of identity should allow for a unique and unequivocal separation of the agent from other agents or, generally speaking, entities. Re-identification means that the same notion should give standards for recognizing the sameness of agents through time. Clearly, these two aspects of identity are of central importance for economic theory and human life in general. For example, imagine somebody who would in fact claim to consist of different persons inside her chest, so that there might be shifting responsibilities for action, and no assignment of responsibility to the single individual agent, or imagine that somebody would claim to be different persons through time, so that earlier commitments would be totally irrelevant for later action. The two criteria correspond to what Ross has fixed as the necessary conditions for successful social interaction emerging in human evolution. Interestingly, my examples already reveal a close relation between identity and language, as the phenomenon of identity appears to be one of representing one's self to others, and, in a reflexive relation, also to oneself. Once language enters the picture, however, a new problem emerges, namely that there can be fake identities, precisely because representations and reality become decoupled. This is the foundation of the unique human capability to lie.

Normally, economics takes identity for granted. Plainly speaking, an economic notion of identity does not exist, but is an implicit condition in the standard approach to rationality, insofar as stable preferences are assumed, supported by the presumption, presumably, that the individual has full information about her preferences. This assumption also underlies more complex theories such as Gary Becker's (1996) approach, in which ideas are included such as the derived preferences for inputs that are needed to produce the final consumption items or the dependence of preferences on stocks of human and social capital. These conceptual supplements serve to explain observed changes in preferences while maintaining the notion of a stable identity of the individual.

The most advanced economic theory of identity, as far as the mainstream approach is concerned, seems to be the Akerlof and Kranton (2000; 2005) framework, in which identity is just an additional determinant of individual utility. This concept of identity, however, already moves far beyond the simple notion of a stability of the preference function across time, because there is an explicit reference to complex social determinants of group ascriptions and social norms governing those ascriptions. As a result, individual identity is mainly understood as social identity, and hence manifests a manifold of externalities between individual actions. However, there is no explanation whatsoever how identity emerges from social interaction. Thus, simply treating identity as an object of a standard utility function raises the specter of a circular argument, because the perception of utility depends on preferences, and at the same time preferences are constitutive for individual identity. In his analysis of the Akerlof and Kranton approach, Davis (2006) argues that it remains incomplete as far as personal identity is concerned. That means, the individual appears as an amalgam of different social identities, reflecting the manifold of group ascriptions (e.g. being a husband, a worker, a soccer fan etc.), which generate utility, but there is still no account of the unity of the individual that stays behind the utility function that integrates those different social identities. Therefore, Davis proposes to expand the Akerlof and Kranton utility function into an explicit function of personal

identity. This function is interpreted in a similar fashion as Becker's functions, namely as a production function, i.e. the individual actually employs a set of social identities to generate a certain state that confirms a separate and stable personal identity. Thus, the social identities are reflected upon. I would add the crucial point that this is the very place where language enters the scene.

Indeed, Davis does not claim that this is a complete account of personal identity. In particular, he rejects the notion that personal identity emerges out of a rational optimization, which, after all, would only reproduce the same problems as with the standard approach on a higher level of aggregation and abstraction. In his own independent approach to identity, Davis (2003) shows that the concept of identity has to be based on a notion of collective intentionality with reflexivity. In a nutshell, this means that identity is always based on a derivation of the criteria for identity from a history of interactions between the individual and a social group, and at the same time human individuals have the unique capacity to take a partial distance from this history by means of reflecting upon their relation to the group. This results in a notion of contingent, socially embedded individual autonomy. A simple linguistic expression of this fact is the pivotal role of the 'we' in human action (Tuomela, 1995). Therefore, it seems to me that Davis theory ultimately also relies on a foundational role of language. This refers to two fundamental processes in the formation of identity. One is the process of social categorization, which has to rely on a system of semantic markers which guide perceptions and assignments of group characteristics as related to individual characteristics. The other is the very act of reflection, which turns individual states into objects, in the sense of reification through linguistic means. In this sense, social identity emerges as a surface phenomenon of the more fundamental process of representing one's self, which necessarily has to rely on linguistically mediated classifications.

This extension of the Davis argument is further supported if we realize that deontology builds the conceptual bridge between his notion of identity and Searle's theory of language (in particular, Searle 2006). Davis (2003: 167ff.) establishes a direct connection between identity and social deontology, i.e. relates identity to normative issues. Practically speaking, this means two things. One is that identity also imposes obligations (which is the foundation of what Ross means when he talks about the mutual stabilization of expectations), the other is that collective intentionality is by no means neutral in power terms (Tuomela 1995 includes almost dictatorially imposed 'we' notions in his conception, for example), which means that identities may be imposed or even coercive. This immediately raises ethical and normative concerns. If we relate this with Searle's view of language, this conception can be grounded in more foundational categories of language. As Searle has the formula, only language allows to make statements of the kind "X counts as Y in C", which also applies for social identity, with X as the individual, Y as the social role, and C as the pertinent context. This is the foundation of the deontic power of identity.

This interpretation would result into a neat convergence between the economic and the NEBE treatment of the problem of agent identity. Accordingly, the Davis approach also emerges as an externalist theory of identity (Davis, 2003: 169f.). From this follows, that a possible integration between the two does not imply a reductionist approach to identity in the sense that the Davis approach would be 'naturalized' as a theory about brain or body states. Precisely because the NEBE approach ultimately results into an externalist approach, language can

serve as a methodological bridge between superficially unrelated approaches. To clarify this point further, we need to elaborate on the naturalistic conception of language.

5. The naturalistic approach to language

The argument that I presented so far suggests a simple solution to the Gul and Pesendorfer problem of NEBE as related to economics, especially with regard to so-called anomalies: They might simply reflect the fact that human individuals simultaneously interact in different social spheres with overlapping domains and a domain-specific logic. Thus, in specific situations of interaction defined by experimental economics, domain-specific behavior might be activated, which does not fully correspond to the economic systems logic, such as fairness notions. As a result, neuroeconomic research can be integrated with standard economics if it is complemented by a theory of social learning (Cohen, 2005). That means individuals might learn to behave like economic agents, depending on the institutionalized setting of their interactions (for an early interpretation in this vein, see Frey and Eichenberger, 1989). Indeed, economists recently have turned to the idea that consumer rationality might require public action in terms of educational initiatives or institutionalized constraints on “irrationality” (McFadden, 2006). In Searle’s conception of language, that would be tantamount as to state domain-specific deontologies. That is, something essential is missing between the NEBE approach and observed human behavior, which is the fact that human behavior depends on deontologies which are constitutive for agent identity, and which are inextricably involved with human language.

In my argument developed so far, this would mean that economics is just about a specific subset of human language, i.e. the language of economic interaction as opposed to, say, the languages of love and war. Gul and Pesendorfer argue that the empirical fact of the frame dependence of actions might be accommodated in the economic approach by treating frames as constraints, however, this still leaves open the questions how frames actually emerge and assume causal power as constraints, after all. In fact, this causal power is deontic power. Thus, I think that the question of language is foundational for solutions to all these different problems.

NEBE could be possibly expanded to include language as an analytical category. In a sense, this is a straightforward problem: How can brains cross the gulf that separates them from other brains? How can we imagine that particular linguistic symbols impact on the brain? Well, in a paper on economic methodology it would seem to be an outright case of intellectual hubris to propose a solution to complicated issues such as mental causation (see Robb and Heil, 2005), so again, I confine myself on an even narrower argument, that is, I present one possible solution that has been developed by Aunger (2002) in his theory of memes.

To make the relevance of the problem for economics clear, it is important to note that language is so far a category only invoked in the context of hermeneutical approaches and a number of heterodox theories on the social conditioning of individuals. Closer to the mainstream, language is rarely treated analytically, and if so, mostly in the context of signaling. As in the social sciences in general, language appears to be a category which almost automatically leads towards ideas of postmodern creativity and even arbitrariness of meanings, which

coalesce into interpretive frames that ultimately determine individual actions. This also holds true for economics as an epistemic activity (McCloskey, 1994).

There is an entirely different approach to language which is based on the naturalistic view of mind, understood ontologically, that is, along the lines of psychoneural monism. This view has recently organized itself in the perspective of teleosemantics. Teleosemantics proposes a naturalistic approach to meaning in reducing meaning to function (for surveys, see Neander, 2004; Macdonald and Papineau, 2006). This works via the naturalistic reduction of the category which is fundamental to meaning, i.e. the notion of mental content. It can best be understood when adopting a neat differentiation between meaning and information, which has been elaborated in much detail by Dretske (1981).

Dretske has shown that the transfer of information is essentially different from the transfer of meaning, because information is extracted from a message independent from the meaning of the message that is intended by the sender. Information is useful for the receiver if it is supportive of its systems processes (cf. Millikan, 1989). One way to conceptualize this usefulness is to explain the emergence of information by natural selection. This requires that sender and receiver are embedded into a coevolutionary process. That means, on the one hand the information that is sent by the sender is useful to the receiver, and at the same time the resulting actions by the receiver need to somehow support the proper systemic functioning of the sender, including the reinforcement of the capacity of the sender to send the signals that carry the information which is useful to the receiver. This approach fits well into evolutionary game-theoretic approaches to the emergence of meaning which followed up to Lewis' analysis of signaling systems (Skyrms, 1996: 80ff.; 2004: 45ff.). The difference is mainly terminological, but crucial: The game-theoretic approach confuses the terms of meaning and function, because what actually emerges is a coordinating device, which is independent from any 'intention' in the sense of a correlated mental content beyond the mere disposition to send the signal.

One way to further conceptualize this connection is Aunger's theory of the meme. The concept of the meme has been sometimes favorably received in economics (e.g. Binmore, 1994: 20, 66) as it is one way to naturalize the game-theoretic notions of common knowledge and strategy. Though being a highly controversial topic (see e.g. the different contributions in Aunger 2000), it is seen as a central term in a naturalist theory of mind by influential authors such as Dennett (1995). Originally, the meme was conceived by Dawkins (1989) as a kind of new replicator aside of the gene, thus reducing the mind to a sort of interface between gene and meme evolution. In our context, this broader setting is not directly relevant, as we can limit ourselves to the question how we can define language as a bridging device between brains in a naturalistic way. That is, for the moment we can set aside the complex issues involved in the Darwinian treatment of memes (for example, whether memes are a new kind of replicator beyond genes and so forth). For this it is sufficient to subsume that what we normally understand as 'mental content' is supervening on recurrent structures of neuronal activity, an idea which is more fundamental than the specific evolutionary theory of memes, and which is the established view of modern brain science (Calvin, 1996; Edelman, 2006).

Against this background, a 'meme' is what Aunger (2002: 197) specifies as 'neuromeme', i.e. "A configuration in one node of a neuronal network that is able to induce the replication of its

state in other modes”. To be precise, that means that memes only encompass a part of brain activity. Their functioning can be briefly summarized in the following few statements:

- Firstly, memes are physical entities in the sense that they are neuronal structures, and in the sense that any transfer between brains must be based on a causal mechanism described in physical terms. A meme is not an idea, as it is often portrayed in the literature, such as a tune, a design shape, or a political value.
- Secondly, memes carry information in the sense of transferring structural constraints on other processes causally related with them (Aunger 2002: 148ff.).
- Third, similar memes that are related via a replication process follow the ‘same influence rule’ i.e. they exert the same influence on the surrounding system, if the context is similar.

Following this definition, the concept of a meme exactly fits into the teleosemantic approach because it makes no sense to assign a meaning to a meme (Aunger 2002: 221ff.). A meme is exclusively defined via the physical stability and similarity of its causal effects in similar contexts that means its function in a given system. Thus, the causal processes that reproduce memes across different brains are also independent from the category of meaning. Aunger (2002: 240ff.) therefore argues that signals are ‘instigators’ of meme replication. This role is embedded into an evolutionary process of signal dissemination, i.e. the perspective of standard communication theory is somewhat misleading that concentrates on dyads of senders and receivers (Aunger 2002: 262ff.). Instead, the functioning of signals emerges out of chains of communication events that are related to groups of senders and receivers. These groups are, first of all, defined through a common phylogenetic heritage that provides the convergence points for meme replication. At the same time, however, this does not mean that meme replication just follows gene replication, in the sense of genetic reductionism. In contrast, we have a coevolution of genetically determined biological features and memetic functionings, corresponding to the current understanding of coevolution of human biology and culture. Memetic reproduction, in turn, is connected with, but also independent from the reproduction of meanings on the level of signals (which is misunderstood in the common criticism of the meme concept in coevolutionary theories, which equate memes with meaningful units, see e.g. Jablonka and Lamb, 2005: 206ff.; Richerson and Boyd, 2005: 80ff.). This is precisely the teleosemantic notion of the distinction between meaning and information, with the latter being related to biological functionings.

Thus, for a proper understanding of brain interaction it is crucial to conceive of both memes and signals as population phenomena, yet different ones (this makes an essential difference to conventional memetics, as in Blackmore, 2000). There is no direct bijective physical relation between a signal and a meme whatsoever, in this sense, the sign is arbitrary, as it is fundamental for language. Thus, the causal link between signals and neuronal states can only emerge via the mutual stabilization and the constraints that emerge from the simultaneous operation of a larger number of signals and their memetic counterparts. This offers a solution to the problem that in a highly fluid system of neuronal brain action, fix points such as the economist’s ‘preferences’ and ‘constraints’ may just be submerged in a hotpot of randomly firing neurons (Park and Zak, 2007: 51). A meme is a stable subset of neuronal structures, that

is connected with external communication in the sense of Edelman, and which works as an emergent order parameter. This picture neatly fits to the recent turn in cognitive science, programmatically announced by Fauconnier and Turner (2002), which eschews the standard AI separation between syntax and semantics, and which treats concepts as fuzzy categories which are built via metaphorical transfers of meanings across domains. This implies that a signal can change its function via the evocation of contexts and frames, thus becoming recurrently related with newly emerging neuronal structures. Thus, the Aunger approach gives a clear account of both the necessary correspondence between signals and physical phenomena in the brain, and the arbitrariness of this relation, which implies that there is no unequivocal reduction of signs to neuromemes. This is precisely the necessary condition for language operating as an external complement to brain action.

Putting all this back into the context of NEBE, there is a direct connection with the widespread acceptance of the view that human decision making is an integrated whole of two different systems, i.e. a cognitive one and an affective one, which in turn manifests controlled and automatic processes (Kahnemann, 2003; Camerer et al., 2005). What is conventionally treated as ‘rational decision making’ is just a subset of controlled cognitive processes, which is the tip of the iceberg of a massively parallel system of neuronal dynamics. From the memetic perspective, ‘rational decision making’ is a mere construct that emerges from a population level signaling system, and thus cannot be assigned any separate existence at all. The aspectual splitting of decision making into the systems is misleading, because it downplays the fundamental role of what is subsumed under the ‘affective system’. Remembering the evolutionary psychology point of view in this context, ‘emotions’ appear to be the basic coordinating mechanisms in the brain that orchestrate the more fragmented neuronal input-output loops. ‘Emotions’ can be viewed as subsystems of brain action that are steered by memes in Aunger’s sense, i.e. neuronal structures that spread across the brain via replication, and which are instigated across brains by signals.

Language, thus, emerges as a set of constraints on an otherwise chaotic flow of neurophysiologic events in the brain. Millikan (2005: 166ff.) speaks of “pushmepullyu” representations as a root function also of language, a position which seems to be confirmed by Searle’s viewpoint that the declarative function of language is one of the essential differences between human linguistic capacities and pre-human modes of representation. A pushmepullyu-representation merges variations in the environment with variations in behavior, thus establishing the functional prerequisites for a proper working of intentions. Behavior, in turn, is coordinated among individuals via signals. That means, for example, a pushmepullyu representation at the same time involves a proposition that there is food and the related move towards the food, which can also be observed by other individuals, leading towards coordinated action. On the level of language, and in the parlance of speech act theory, this is a performative in the sense that the information about the environment and the performance of an action are one unit. Now, the essential difference between pre-human pushmepullyu-representations and human language is that human language allows declaring something to be real which is not yet an external given, that is, it is ontologically creative. If I say “I go out to buy some food” this states an intention and declares the action which is simultaneously taken. If I say for the first time “I am your friend” I change the reality of the social relation between two people in a substantial way. There are obvious and hidden instances of this ontologically creative role of language. For example, most human institutions are created by linguistically me-

diated declarations, such as “this is a legal tender”. Even if we were only to focus on these obvious cases, we would already realize that this is pervasive in human life, and, as Searle (1995) has it, constitutive for human society. But the hidden instances add to these phenomena, such as when I enter the kitchen and state “I feel hungry”. This means a lot of things, depending on context, and many are declarative, such as “I will approach the fridge to fetch some food”, or, “you have no right to prevent me from approaching the fridge” and so on.

Against this background, we can see how language emerges as an essential determinant of stabilizing the fluidity of brain action. Language hooks up brain action with contingent, yet deontological structures of reality that emerge from social interaction. These deontologies make up the identity of human biological agents, such that the agent becomes a phenomenon that can only be properly understood in externalist terms.

There is a game-theoretic argument presented by Ross (2005: 291ff.) that makes this point in a technical terminology which is more familiar to the economist. Picking up the thread of a naturalistic theory of strategic interaction that has been laid by Binmore (1994), we can distinguish between two levels of games, one, G' , encompassing the biological aspect of interaction, and the other, G , the specific strategic context of actual interactions among individuals. The latter is normally analyzed in game theory. Biological reductionism would claim that the results of this game are ultimately determined by natural selection, as in sociobiology. This is the level of ‘functionings’ that involves memetic structures, in the sense that biological games result in locking up functionings between physically separate organisms, such as signaling between prey and predator. Ross argues that this picture leaves another level out of sight which stand in between these two, and which only is possible once language is there, I would add. This is a series of recurrent and interrelated games G' in which the agents mutually coordinate their selves. That is, the results of the games of type G will depend crucially on the results of the games G' in which it is determined which identity the players in G games will assume. This argument is closely related to the analysis of Skyrms (2004) which shows how signaling makes pre-coordination in games G possible by sorting populations of players into subsets of a similar kind, hence similar identity, thus changing the games G into games with correlated equilibriums. Interestingly, Skyrms also argues that after the emergence of equilibrating behavior, the signals that actually supported its emergence lose any informational content, so that the observer *ex post* would indeed believe that identity does not matter in the actual strategic situation.

Evidently, we can say that these games G' represent the level of language, with the signals enabling the agents to pre-coordinate their actions. The naturalistic account of language relates these games to the more fundamental ‘game of life’ G . This link can be envisaged according to Aunger’s conception of memes, which completes the naturalistic turn in economics. Thus, the emergent view is not that of a simple reduction, but the more sophisticated one of supervenience. This implies that a naturalist approach is able to integrate specific methodologies for the different levels of games, such that a naturalistic approach, for example, allows assigning a separate ontological status to consciousness and related phenomena (Searle, 2004). Language analysis still requires specific hermeneutic techniques to unravel the meanings of signs, even if those are ultimately related to more fundamental biological functions. Holding function and meaning constant, standard concepts of economics remain powerful to analyze specific situations of social interaction, including their systemic effects.

To summarize, the teleosemantic and memetic view on social interaction understands recurrent patterns of behavioral coordination among individuals as emergent phenomena of the synchronization and coordination of functionings by means of stable neuronal structures, whose reproduction is mediated via language or, more general, signal processing between individuals. The resulting fixation of structures in the human brain converges to what the agents themselves perceive as the identity of individuals. Perhaps an example is useful to make this approach clear. I choose money, the archetypical institutional feature of modern economic systems.

6. A naturalistic account of money

All experimental tests of neuroeconomics presume that certain signals are interpreted in the same way by the test persons. From the perspective developed so far, this is an unwarranted assumption because signals which may carry a stable meaning from the viewpoint of the experimenter may activate different memes on part of the test persons, which seem to be directly observable from the fact that culturally distinct groups show a significantly different performance in games as simple and as clearly structured as ultimatum games (Henrich, 2000; Bowles, 2004: 114ff.). The common explanation so far offered by economists neatly fits into the ‘emotions in command’ picture, because normally fairness norms are invoked which are seen as ultimately based in certain emotional responses that put rational calculus out of action.

How can we know that a certain signal may be linked with specific memes? An interesting case in point is the neuroeconomic result that money seems to be a direct reinforcer, i.e. may carry independent utility in the economist’s sense, which would result into a direct contradiction with established notions of economics (Camerer et al., 2005: 35f.). This is a foundational issue, because money is the central medium for social coordination in the economic system, which is also clearly language-based (in the sense of Searle’s 1995; 2005 approach to institutions). Money is created by declaration. So it is an ideal testing ground for a naturalist theory of interaction.

Is money a meme, or, more exactly, a meme instigator? I think, yes. There is one important aspect of the cultural history of money that is not treated in economic theories about the emergence of money, that is, firstly, money is a signal, and secondly, money seems to be correlated with different emotional loadings through the course of economic and cultural history. To summarize a complex story, as has been demonstrated by Hutter (1994), the historical emergence of money in the Eastern Mediterranean came hand in hand with a semantic oscillation between ‘metal sign’ and ‘signed metal’ especially at the boundaries between different social and political systems. Early coins were just pieces of metal that bore punchmarks resulting from physical testing of the quality. These marks could serve to recognize the origin, so that a semantic ambiguity emerged. This turned the pieces into a medium of exchange in original trading communities, and their use could spread in the moment when the pieces were deliberately coined, i.e. additionally stamped with images of sacred animals, which allowed recognition beyond community borders. From that time onwards, the early history of money was inextricably linked with the merger of the value carrying functions of money and the imbued authority of the political powers which later even defined and exploited the right to issue money. Finally, and most interestingly in our context, the transition to modern money in the

context of emerging large-scale market systems goes hand in hand with an historical stage of the demonization of money. It is this stage by which money qualifies as a meme, in the sense of particular monies in particular societies that operate as a sign that instigates particular neuronal responses. Money appeared to be related to specific emotional complexes, related to the broader semantic field of the cardinal sins. This is the major reason why the transition to capitalism was most easily achieved in societies with a specific religious setting, because the emotional coding of money was different. In Europe the accumulation of money obtained the role of an indicator of religious rightness in Calvinist settings, whereas in Catholic Spain the demonization of money prevailed for a longer time. Interestingly, this demonization of money was also observed in China during the Song dynasty, replicating the European views that the diffusion of money signified the transition from the moral economy to a new way of life, full of uncertainties and new dependencies from anonymous powers.

Thus, the emerging role of money as a crucial device of economic coordination was directly related to its functioning as a signal in relation to emotional frames. Modern markets normally put money into a seemingly neutral framework, which is, in fact, only one aspect in particular frames of action. As has been elucidated in Lea's and Webley's (2005) survey of the pertinent literature on money in contemporary social systems, money cannot be fully interpreted as a 'tool' but seems to come close to a 'drug' in the biosocial sense. More exactly, they identify money as a perceptual drug, i.e. a perceptual stimulus that elicits some positive organismic responses without actually producing the ultimate benefits, comparable to other runaway signaling systems in nature. For example, gaming can work as a drug; insofar it activates human motivators such as curiosity, without the action directly contributing to fitness. A drug parasites on other motivational systems, which is a clear sign of meme activity, i.e. a meme hijacking a genetically preformed organismic mechanism. As money can be shown to be a direct motivator in stimulating parts of the brain that are related with immediate rewards, this seems to be the main reason why money plays a very special and central role in many human societies. Lea and Webley propose that money especially piggybacks on an essentially human instinct, the instinct to trade. This is also the basis for the merging of the tool and drug aspect in existing uses of money.

As has been argued by Ofek (2001), trade and social exchange in general are constitutive traits of the human species and presumably developed out of the specific setting of utilizing so-called 'contrived commodities' collectively. This refers to the collective consumption of large game, or the sharing of fire, which have the common property of being excludable, but at the same time being non-rivalrous (large game could not be stored at those times, so additional consumers did not reduce the consumption of the successful hunter). That means, trading goes back on reciprocal altruism, which emerged out of a system of ongoing exchange with possible punishments. This seems to be one possible adaptationist explanation for the fact that the cognitive system of humans is not guided by a general purpose rationality even in the case of exchange relations, but by special decision modules that focus on the detection of cheating and the maintenance and control of implicit social contracts (Cosmides and Tooby, 2005). These can be shown to match activation patterns in the brain that correspond to the 'theory of mind' pattern (Ermer et al., 2006).

Considering these phylogenetic and neuropsychological aspects of the use of money can explain why simple games such as the ultimatum game elicit different responses in different

societies. If the use of money has complex emotional underpinnings, it is no wonder that simple games involving the sharing of money do not only activate ‘rational’ calculations, but mainly emotional reactions, which in the viewpoint of the observer coalesce into fairness notions and related interpretations (Bolton and Ockenfels, 2000). Money is especially related to emotional complexes that enable humans to engage in social exchange, and in that context, to build and use trust. In fact, in the original situation described by Ofek, trust into delayed reciprocity plays a critical role in the emergence of trading behavior, thus a primordial form of credit. In that context, it seems remarkable that trust has remained a category in economic behavior which up to now defies purely rationalist reconstructions (Nooteboom, 2002). Hollis (1998) has demonstrated that trust can only be understood as a category related to forms of collective intentionality in groups (‘teams’). These arguments close the circle with our general considerations about the foundation of human behavior in social interaction.

Thus, the naturalist interpretation of one of the central coordinating devices in economics, money, seems feasible. Money would be seen as a signal that instigates underlying memetic structures in the human brain, which can be empirically identified by now standard NEBE methods. This implies that the standard account of money in economic theory is partly wrong, as it provides a wrong picture of the functioning of money. This has far-reaching implications also for the systemic analysis in economics, such as, for example, the role that money plays in coordinating the labor market and the employment relation: For example, in Akerlof’s (1982; 2007) theory of the employment relation as ‘gift exchange’ the pecuniary dimension of the employer-employee relation is by no means perceived as a mere instrumental relation, even though the ultimate result of the interaction may also be to improve worker performance. The money exchange is governed by normative concerns, which substantially contributes to the formation of trust among the two sides.

To close the circle of my argument, money is finally an important ingredient of defining the identity of agents. An intriguing observation both in psychology and sociology as well as in everyday life is that money directly affects the way how identities of agents are mutually perceived. The reason is that once an interaction is defined as based on pecuniary terms, a fundamental shift of frames takes place. This is a shift from intrinsic to extrinsic motivation, in most general terms (Frey, 2002). There are many examples of this, beginning with the Titmuss paradox that blood donations are reduced once people are paid for it, the fact that if parents are fined for coming late to pick up their kids at the kindergarten, the number of latecomers actually increases, or the fact that in selling sex, prostitutes are able to be emotionally detached precisely because money stands in between the relation with the patrons. This list of examples can be easily expanded. In all these cases, identity issues are involved. The prostitute is not a lover because she is paid for the service. The parent becomes a customer buying the right to be late, because he pays. The donor becomes a seller, with the effect of activating a reservation price. In all these cases, there is a direct causal connection between emotional patterns, pairings of frames and agent identities, and the use of money.

Thus, a naturalistic account of the role of money in the economy seems feasible, which would bridge the two essential functionings related to its use, namely one to be a linguistic sign with deontic powers, and the other to be causally correlated with a memetic structure that can be observed via standard NEBE procedures. Finally, this is important for a reassessment of the Gul and Pesendorfer argument. This argument relates the notion of a rational economic

agent to a particular notion of the systemic functioning of the economy, thus developing an externalist account of rationality in economics. As a consequence, the way how we perceive the system becomes a central issue. The example of money shows that an externalist approach to NEBE would entail another view also of the systems functioning, which feeds back on the notion of the agent. We have now a direct correspondence between an externalist standard economics approach and an externalist NEBE approach which builds on a naturalistic conception of language. This has immediate implications also for economic modeling on the systemic level, even macroeconomics (compare Akerlof, 2007).

7. Outlook: Towards a unified naturalistic paradigm of economics

I have tried to show that NEBE remains incomplete if it is based on experimental approaches to isolated individuals, as it is practically done in the context of brain imaging techniques. This is because it is impossible to define an individual identity only by taking neuronal processes of the isolated brain into consideration. Thus, neuroeconomics needs to be enriched by a theory of communication between brains, as it had been proposed originally by Edelman. This is possible in the context of a teleosemantic approach to meaning, which could be synthesized with Aunger's theory of memes. The result is an externalist approach to NEBE, whereas the standard approach is uncritically internalist, i.e. just takes the boundaries of the body and brain as being the boundaries of what has to be conceived theoretically as an agent.

Interestingly, this approach fits into a strand of economic research which is so far isolated from neuroeconomics. This is the reinstatement of the category of culture in economics, following as diverse contributions such as Greif's (1994), North's (2005), Aoki's (2001) or Bowle's (2004). What they all have in common is that all economic action is based on a reduction of behavioral possibilities by certain mental models which determine the interpretation of the actual situation. These models are seen to be shared within communities of agents. What is missing here is that culture is founded in language, at least in my view. The medium of coordinating mental models is language. Switching from culture to language implies that an incredibly rich and well developed theoretical tool case can be introduced into economics, namely the philosophy of language and general linguistics. Indeed, so far the uses of culture in economics suffer from a lack of conceptual detail and analytical clarity.

The naturalistic theory of language is not reductionist in the narrow sense, but assumes that language supervenes on brain mechanisms. This allows for developing an externalist theory of identity, and hence, the economic agent. The main flaw of NEBE is to take the correspondence between the agent and the individual as defined by the boundaries of the body just for granted. This is the position of methodological individualism, as it is normally stated. To be precise, externalism does not preclude methodological individualism, but it entails the rejection of the uncritical equation between body and agent. Following externalist approaches in biology (Sterelny 2004) we can talk of an 'extended agent' which is still different from super- and subindividual levels of the economic system.

Finally, externalist approach to the individual opens new vistas on the position of economics in the sciences, in particular between the *Naturwissenschaften* and the *Geisteswissenschaften* (sciences and the humanities). The analysis of language is mostly assigned to the latter. A

naturalistic approach to language seems to trigger a shift to the sciences. However, supervenience does not imply that a full scale reduction of language on the neurosciences would be feasible. Whether people perceive money as a device for organizing economic transactions efficiently or as a demonic thing that lures them into sinful activities, might be described by means of neurosciences. But one cannot explain why this is the case. This depends on the analysis of worldviews and values, their change through history, and their complex interrelations. The case for interpretive social science remains strong, precisely because the naturalistic approach to language shows how meanings assume causal powers. Thus, it seems to me that naturalism can work both as a unifying paradigm of economics and as a framework for the consilience of the different human sciences.

8. References

- Ainslie, George (1992): *Picoeconomics. The Strategic Interaction of Successive Motivational States within the Person*. Cambridge et al.: Cambridge University Press.
- Akerlof, George A.: Labor Contracts as Partial Gift Exchange, in: *Quarterly Journal of Economics*, 97: 543 – 569.
- Akerlof, George (2007): The Missing Motivation in Macroeconomics, *American Economic Review*, 97(1): 5-36.
- Akerlof, George A. and Kranton, Rachel E. (2000): Economics and Identity, *Quarterly Journal of Economics* CXV(3): 715-753.
- Akerlof, George A. and Kranton, Rachel E. (2005): Identity and the Economics of Organizations, *Journal of Economic Perspectives* 19(1): 9-32.
- Aoki, Masahiko (2001): *Toward a Comparative Institutional Analysis*, Stanford: Stanford University Press.
- Arbib, Michael (2007): The Mirror System Hypothesis. Linking Language to Theory of Mind, <http://www.interdisciplines.org/coevolution/papers/11>
- Aunger, Robert (2002): *The Electric Meme. A New Theory of How We Think*. New York et al.: Free Press.
- Aunger, Robert, ed. (2000): *Darwinizing Culture: The Status of Memetics as a Science*, Oxford: Oxford University Press.
- Baltes, Paul B. / Staudinger, Ursula M., eds. (1996): *Interactive Minds. Life-span Perspectives on the Social Foundation of Cognition*. Cambridge et al.: Cambridge University Press.
- Becker, Gary S. (1996): *Accounting for Tastes*, Cambridge: Harvard University Press.
- Ben Jacob, Eshel / Shapira, Yoash / Tauber, Alfred I (2006): Seeking the Foundations of Cognition in Bacteria: From Schrödinger's Negative Entropy to Latent Information, in: *Physica A* 359: 495-524.
- Bhaskar, Roy (1989): *The Possibility of Naturalism. A Philosophical Critique of the Contemporary Human Sciences*, New York et al.: Harvester Wheatsheaf.
- Binmore, Ken (1994): *Game Theory and the Social Contract Volume I: Playing Fair*, Cambridge / London: MIT Press.
- Blackmore, Susan (2000): The memes' eye view, in: Aunger (2000): 25-42.
- Bolton, Gary E. and Ockenfels, Axel (2000): ERC: A Theory of Equity, Reciprocity, and Competition, *American Economic Review* 90(1): 166-193, 2000.
- Bowles, Samuel (2004): *Microeconomics. Behavior, Institutions, and Evolution*. New York, Princeton and Oxford: Russell Sage and Princeton University Press.
- Buss, David M., ed. (2005): *The Handbook of Evolutionary Psychology*, Hoboken: Wiley.

- Caldwell, Bruce J. (1994): *Beyond Positivism. Economic Methodology in the Twentieth Century*. Revised Edition, London and New York: Routledge.
- Calvin, William H. (1996): *The Cerebral Code. Thinking a Thought in the Mosaic of Mind*, Cambridge/London: MIT Press.
- Camerer, Colin (2007): Neuroeconomics: Using Neuroscience to Make Economic Predictions, *Economic Journal* 117(519): C26-C42.
- Camerer, Colin / Loewenstein, George / Prelec Drazen (2005): Neuroeconomics: How Neuroscience Can Inform Economics, in: *Journal of Economic Literature* Vol. XLIII: 9-64.
- Carpendale, Jeremy I.M. / Lewis, Charlie (2004): Constructing an understanding of mind: The development of children's understanding of mind within social interaction *Behavioral and Brain Sciences*, 27, 79-150.
- Cohen, Jonathan D. (2005): The Vulcanization of the Human Brain: A Neural Perspective on Inter-actions between Cognition and Emotion, in: *Journal of Economic Perspectives* 19(4): 3-24.
- Cosmides, Leda / Tooby, James (2005): Neurocognitive Adaptations Designed for Social Exchange, in: *Buss* (2005): 584-628.
- Damasio, Antonio R. (1995): *Descartes' Error. Emotion, Reason and the Human Brain*. New York: G.B. Putnam's Son.
- Davis, John B. (2003): *The Theory of the Individual in Economics. Identity and Value*. London and New York: Routledge.
- Davis, John B. (2006): The Turn in Economics: Neoclassical Dominance to Mainstream Pluralism? *Journal of Institutional Economics* 2(1): 1-20.
- Dawkins, Richard (1989): *The Selfish Gene*. New edition. Oxford/New York: Oxford University Press.
- Dennett, Daniel C. (1991): *Consciousness Explained*, Boston et al.: Little, Brown and Company.
- Dennett, Daniel C. (1995): *Darwin's Dangerous Idea. Evolution and the Meanings of Life*, New York: Simon & Schuster.
- Dretske, Fred (1981/1999): *Knowledge and the Flow of Information*, Reprint, Stanford: CSLI Publications.
- Dretske, Fred (1995): *Naturalizing the Mind*, Cambridge and London: MIT Press.
- Edelman, Gerald M. (1987): *Neural Darwinism. The Theory of Neuronal Group Selection*. New York: Basic Books.
- Edelman, Gerald M. (2006): *Second Nature. Brain Science and Human Knowledge*. New Haven and London: Yale University Press.
- Elster, Jon (1998): Emotions and Economic Theory, in: *Journal of Economic Literature*, Vol. XXXVI, S. 47-74.
- Elster, Jon, ed. (1986): *The Multiple Self*, Cambridge et al.: Cambridge University Press.

- Ermer, Elsa / Guerin, Scott A. / Cosmides, Leda / Tooby, John / Miller, Michael B. (2006): Theory of Mind Broad and Narrow: Reasoning About Social Exchange Engages ToM Areas, Precautionary Reasoning Does Not, *Social Neuroscience* 1(3-4): 196-219.
- Fauconnier, Gilles & Turner, Mark (2002): *The Way We Think. Conceptual Blending and the Mind's Hidden Complexities*. New York: Basic Books.
- Fox, Ch. W./Roff, D. A./Fairbairn, D. J., eds. (2001): *Evolutionary Ecology: Concepts and Case Studies*, Oxford et al.: Oxford University Press.
- Frank, Steven A. (1995): *Foundations of Social Evolution*, Princeton: Princeton University Press.
- Frank, Robert H. (1988): *Passions Within Reason. The Strategic Role of Emotions*, New York/London: Norton.
- Frey, Bruno S. / Eichenberger, Rainer (1989): Anomalies and Institutions, *Journal of Institutional and Theoretical Economics* 145: 423-437.
- Frey, Bruno S. (2002): *Inspiring Economics: Human Motivation in Political Economy*, Edward Elgar.
- Gazzola, Valeria / Aziz-Adeh, Lisa / Keysers, Christian (2006): Empathy and the Somatotopic Auditory Mirror System in Humans, *Current Biology* 16: 1824-1829.
- Gigerenzer, Gerd (1996): Rationality: Why Social Context Matters, in: Baltes / Staudinger (1996): 319-346.
- Gintis, Herbert (2000): *Game Theory Evolving. A Problem-Centered Introduction to Modeling Strategic Interaction*, Princeton: Princeton University Press.
- Gintis, Herbert (2007): A Framework for the Unification of the Behavioral Sciences, *Behavioral and Brain Sciences* 30: 1-16.
- Glimcher, Paul W. (2003): *Decisions, Uncertainty, and the Brain. The Science of Neuroeconomics*. Cambridge and London: MIT Press.
- Goody, Esther (1995): *Social Intelligence and Interaction. Expressions and Implications of the Social Bias in Human Intelligence*. Cambridge: Cambridge University Press.
- Greif, Avner (1994): Cultural Beliefs and the Organization of Society: A Historical and Theoretical Reflection on Collectivist and Individualist Societies, in: *Journal of Political Economy*, Vol. 102, No. 5, 912-950.
- Gul, Faruk / Pesendorfer, Wolfgang (2001): Temptation and Self-Control, *Econometrica* 69: 1403-1436.
- Gul, Faruk / Pesendorfer, Wolfgang (2005): *The Case for Mindless Economics*, <http://www.princeton.edu/~pesendor/mindless.pdf>
- Hausman, Daniel M. (2006): *Philosophy of Economics*, *The Stanford Encyclopedia of Philosophy* (Summer 2006 Edition), Edward N. Zalta (ed.), URL = <<http://plato.stanford.edu/archives/sum2006/entries/economics/>>.

- Henrich, Joseph (2000): Does Culture Matter in Economic Behavior? Ultimatum Game Bargaining Among the Machigienga of the Peruvian Amazon. *The American Economic Review* 90(4): 973-979.
- Hollis, Martin (1998): *Trust Within Reason*, Cambridge et al.: Cambridge University Press.
- Hurley, Susan (2007): *The Shared Circuits Model: How Control, Mirroring and Simulation Can Enable Imitation, Deliberation, and Mindreading*, forthcoming in *Behavioral and the Brain Sciences*.
- Hutter, Michael (1994): Communication in Economic Evolution: The Case of Money Changing the Primary Distinction: From Observer to Observation, in: England, Richard W. (ed.), *Evolutionary Concepts in Contemporary Economics*, Ann Arbor: University of Michigan Press, 111-138.
- Jablonka, Eva / Lamb, Marion J. (2006): *Evolution in Four Dimensions. Genetic, Epigenetic, Behavioral and Symbolic Variation in the History of Life*, Cambridge and London: MIT Press.
- Kable, Joseph W. / Glimcher, Paul W. (2007): *Matching Mental and Neural Representation of Value During Intertemporal Choice*, <http://www.cns.nyu.edu/events/neuroecon/KableGlimcher.pdf>
- Kagel, John H. / Battalio, Raymond C. / Green, Leonard (1995): *Economic Choice Theory: An Experimental Model of Animal Behavior*, Cambridge et al.: Cambridge University Press.
- Kahnemann, Daniel (2003): Maps of Bounded Rationality: Psychology for Behavioral Economics, *American Economic Review* 93(5): 1449-1475.
- Konow, James (2003): Who Is the Fairest of All? A Positive Analysis of Justice Theories, *Journal of Economic Literature* XLI(4): 1188-1239.
- Kramer, Donald L.(2001): Foraging Behavior, in: Fox et al. (2001): 232-246.
- Laibson, David (1997): Golden Eggs and Hyperbolic Discounting, *Quarterly Journal of Economics*, May 1997: 443-477.
- Lea, Stephen G. / Webley, Paul (2005): Money As Tool, Money As Drug: The Biological Psychology of a Strong Incentive, *Behavioral and the Brain Sciences* 29: 161-209.
- Locke, J. L. and Bogin, B. (2006): Language and life history: A new perspective on the development and evolution of human language. *Behavioral and Brain Sciences*, 29: 259-280.
- Lycan, William G. (1999): *Philosophy of Language. An Introductory Text*. London & New York: Routledge.
- Macdonald, Graham / Papineau, David, eds. (2006): *Teleosemantics. New Philosophical Essays*, Oxford / New York: Oxford University Press.
- Mantzavinos, Chrysostomos (2005): *Naturalistic Hermeneutics*, Cambridge et al.: Cambridge University Press.
- Maynard Smith, John (2000): The Concept of Information in Biology, *Philosophy of Science* 67(2): 177-194.

- McCloskey, Donald N. (1994): *Knowledge and Persuasion in Economics*, Cambridge et al.: Cambridge University Press.
- McClure, S.M. / Ericson, K.M. / Laibson, D.I. / Loewenstein, G. / Cohen, J.D. (2007): Time Discounting for Primary Rewards, *The Journal of Neuroscience* 27(21): 5796-5804.
- McFadden, Daniel (2006): Free Markets and Fettered Consumers, *American Economic Review* 96(1): 5-29.
- McLaughlin, Brian and Karen Bennett, "Supervenience", *The Stanford Encyclopedia of Philosophy* (Fall 2006 Edition), Edward N. Zalta (ed.),
URL = <<http://plato.stanford.edu/archives/fall2006/entries/supervenience/>>.
- Millikan, Ruth (1989): Biosemantics, *Journal of Philosophy* 86: 281-297.
- Millikan, Ruth (2005): *Language: A Biological Model*, Oxford: Clarendon.
- Mirowski, Philip (1989): *More Heat Than Light: Economics as Social Physics, Physics as Nature's Economics*. By.. Cambridge: Cambridge University Press.
- Neander, Karen (2004): Teleological Theories of Mental Content, *The Stanford Encyclopedia of Philosophy* (Summer 2004 Edition), Edward N. Zalta (ed.),
URL = <<http://plato.stanford.edu/archives/sum2004/entries/content-teleological/>>.
- Noë, Ronald / van Hooff, Jan A.R.A.M. / Hammerstein, Peter, eds. (2001): *Economics in Nature. Social Dilemmas, Mate Choice and Biological Markets*, Cambridge et al.: Cambridge University Press.
- Nooteboom, Bart (2002). *Trust. Forms, foundations, functions, failures and figures*. Cheltenham / Northampton: Edward Elgar.
- North, Douglass C. (2005): *Understanding the Process of Economic Change*, Princeton and Oxford: Princeton University Press.
- Odlin-Smee, F.J. (1988): Niche-Constructing Phenotypes, in: Plotkin, H.C., ed. (1988): *The Role of Behavior in Evolution*. Cambridge/London: MIT Press, 73-132.
- Ofek, Haim (2001): *Second Nature. Economic Origins of Human Evolution*, Cambridge: Cambridge University Press.
- Papineau, David (2007): Naturalism, *The Stanford Encyclopedia of Philosophy* (Spring 2007 Edition), Edward N. Zalta (ed.),
URL = <<http://plato.stanford.edu/archives/spr2007/entries/naturalism/>>.
- Park, Jang Woo / Zak, Paul J. (2007): Neuroeconomic Studies, *Analyse & Kritik* 29: 47-59.
- Richerson, Peter J. and Boyd, Robert (2005): *Not By Genes Alone. How Culture Transformed Human Evolution*. Chicago: University of Chicago Press.
- Robb, David and John Heil (2005): Mental Causation, *The Stanford Encyclopedia of Philosophy* (Spring 2005 Edition), Edward N. Zalta (ed.),
URL = <<http://plato.stanford.edu/archives/spr2005/entries/mental-causation/>>.
- Robson, Arthur (1996): A Biological Basis for Expected and Non-expected Utility, *Journal of Economic Theory* 68:397-424.

- Robson, Arthur J. (2005): Complex Evolutionary Systems and the Red Queen, *Economic Journal* 115: F211-F224.
- Roehner, Bertrand (2002): *Patterns of Speculation. A Study in Observational Econophysics*, Cambridge et al.: Cambridge University Press.
- Ross, Don (2005): *Economic Theory and Cognitive Science: Microexplanations*, Cambridge and London: MIT Press.
- Ross, Don (2007a): *The Economic Agent: Not Human, But Important*, <http://www.uab.edu/philosophy/faculty/ross/The-economic-agent-Not-human-but-important.htm>
- Ross, Don (2007b): H. sapiens as Ecologically Special: What Does Language Contribute? *Language Studies* 29: 710-731.
- Rubinstein, Ariel (2000): *Economics and Language. Five Essays*, Cambridge et al.: Cambridge University Press.
- Thaler, Richard H. (1994): *Quasi-Rational Economics*, New York: Russell Sage.
- Searle, John R. (1995): *The Construction of Social Reality*, New York: Free Press.
- Searle, John R. (2004): *Biological Naturalism*, <http://socrates.berkeley.edu/~jsearle/articles.html>
- Searle, John R. (2005): What Is an Institution?, in: *Journal of Institutional Economics* 1(1): 1-22.
- Skyrms, Brian (1996): *Evolution of the Social Contract*, Cambridge et al.: Cambridge University Press.
- Skyrms, Brian (2004): *The Stag Hunt and the Evolution of Social Structure*, Cambridge et al.: Cambridge University Press.
- Smith, Vernon L. (2003): Constructivist and Ecological Rationality in Economics, *The American Economic Review* 93(3): 465-508.
- Steedman, Ian / Krause, Ulrich (1986): Goethe's Faust, Arrow's Possibility Theorem and the Individual Decision-Taker, in: *Elster* (1986): 197-231.
- Sterelny, Kim (2004): Externalism, Epistemic Artefacts and The Extended Mind, in: *Schantz* (2004): 239-254.
- Sugden, Robert (2001): The Evolutionary Turn in Game Theory, *Journal of Economic Methodology* 8(1): 113-130.
- Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005a): Understanding and sharing intentions: the origin of cultural cognition, *Behavioral and Brain Sciences*, 28, 675-735.
- Tomasello, Michael / Carpenter, Malinda (2007): Shared Intentionality, *Developmental Science* 10(1): 121-125.
- Tooby, John / Cosmides, Leda (2005): Conceptual Foundations of Evolutionary Psychology, in: *Buss* (2005): 5-67.

- Tuomela, Raimo (1995): *The Importance of Us. A Philosophical Study of Basic Social Notions*. Stanford: Stanford University Press.
- Wilson, Edward O. (1998): *Consilience. The Unity of Knowledge*, London: Abacus.
- Wilson, Robert A. (2004): *Boundaries of the Mind. The Individual in the Fragile Sciences: Cognition*, Cambridge et al.: Cambridge University Press.
- Wilson, Robert A. (2007): *The Biological Notion of Individual*, *The Stanford Encyclopedia of Philosophy* (Fall 2007 Edition), Edward N. Zalta (ed.), forthcoming
URL = <<http://plato.stanford.edu/archives/fall2007/entries/biology-individual/>>.
- Young, H. Peyton (1998): *Individual Strategy and Social Structure*, Princeton: Princeton University Press.
- Zahavi, Amotz / Zahavi, Avishag (1997): *The Handicap Principle. A Missing Piece of Darwin's Puzzle*, New York / Oxford: Oxford University Press.

FRANKFURT SCHOOL / HFB – WORKING PAPER SERIES

No.	Author/Title	Year
107.	Schalast, Christoph / Benita, Barten Private Equity und Familienunternehmen – eine Untersuchung unter besonderer Berücksichtigung deutscher Maschinen- und Anlagenbauunternehmen	2008
106.	Bannier, Christina E. / Grote, Michael H. Equity Gap? – Which Equity Gap? On the Financing Structure of Germany's Mittelstand	2008
105.	Herrmann-Pillath, Carsten The Naturalistic Turn in Economics: Implications for the Theory of Finance	2008
104.	Schalast, Christoph (Hrsg.) / Schanz, Kay-Michael / Scholl, Wolfgang Aktionärschutz in der AG falsch verstanden? Die Leica-Entscheidung des LG Frankfurt am Main	2008
103.	Bannier, Christina / Müsch, Stefan Die Auswirkungen der Subprime-Krise auf den deutschen LBO-Markt für Small- und MidCaps	2008
102.	Cremers, Heinz / Vetter, Michael Das IRB-Modell des Kreditrisikos im Vergleich zum Modell einer logarithmisch normalverteilten Verlustfunktion	2008
101.	Heidorn, Thomas / Pleißner, Mathias Determinanten Europäischer CMBS Spreads. Ein empirisches Modell zur Bestimmung der Risikoaufschläge von Commercial Mortgage-Backed Securities (CMBS)	2008
100.	Schalast, Christoph (Hrsg.) / Schanz, Kay-Michael Schaeffler KG/Continental AG im Lichte der CSX Corp.-Entscheidung des US District Court for the Southern District of New York	2008
99.	Hölscher, Luise / Haug, Michael / Schweinberger, Andreas Analyse von Steueramnestiedaten	2008
98.	Heimer, Thomas / Arend, Sebastian The Genesis of the Black-Scholes Option Pricing Formula	2008
97.	Heimer, Thomas / Hölscher, Luise / Werner, Matthias Ralf Access to Finance and Venture Capital for Industrial SMEs	2008
96.	Böttger, Marc / Guthoff, Anja / Heidorn, Thomas Loss Given Default Modelle zur Schätzung von Recovery Rates	2008
95.	Almer, Thomas / Heidorn, Thomas / Schmaltz, Christian The Dynamics of Short- and Long-Term CDS-spreads of Banks	2008
94.	Barthel, Erich / Wollersheim, Jutta Kulturunterschiede bei Mergers & Acquisitions: Entwicklung eines Konzeptes zur Durchführung einer Cultural Due Diligence	2008
93.	Heidorn, Thomas / Kunze, Wolfgang / Schmaltz, Christian Liquiditätsmodellierung von Kreditzusagen (Term Facilities and Revolver)	2008
92.	Burger, Andreas Produktivität und Effizienz in Banken – Terminologie, Methoden und Status quo	2008
91.	Löchel, Horst / Pecher, Florian The Strategic Value of Investments in Chinese Banks by Foreign Financial Institutions	2008
90.	Schalast, Christoph / Morgenschweis, Bernd / Sprengel, Hans Otto / Ockens, Klaas / Stachuletz, Rainer / Safran, Robert Der deutsche NPL Markt 2007: Aktuelle Entwicklungen, Verkauf und Bewertung – Berichte und Referate des NPL Forums 2007	2008
89.	Schalast, Christoph / Stralkowski, Ingo 10 Jahre deutsche Buyouts	2008
88.	Bannier, Christina / Hirsch, Christian The Economics of Rating Watchlists: Evidence from Rating Changes	2007
87.	Demidova-Menzel, Nadeshda / Heidorn, Thomas Gold in the Investment Portfolio	2007
86.	Hölscher, Luise / Rosenthal, Johannes Leistungsmessung der Internen Revision	2007
85.	Bannier, Christina / Hänsel, Dennis Determinants of banks' engagement in loan securitization	2007

84.	Bannier, Christina "Smoothing" versus "Timeliness" - Wann sind stabile Ratings optimal und welche Anforderungen sind an optimale Berichtsregeln zu stellen?	2007
83.	Bannier, Christina Heterogeneous Multiple Bank Financing: Does it Reduce Inefficient Credit-Renegotiation Incidences?	2007
82.	Cremers, Heinz / Löhr, Andreas Deskription und Bewertung strukturierter Produkte unter besonderer Berücksichtigung verschiedener Marktszenarien	2007
81.	Demidova-Menzel, Nadeshda / Heidorn, Thomas Commodities in Asset Management	2007
80.	Cremers, Heinz / Walzner, Jens Risikosteuerung mit Kreditderivaten unter besonderer Berücksichtigung von Credit Default Swaps	2007
79.	Cremers, Heinz / Traugber, Patrick Handlungsalternativen einer Genossenschaftsbank im Investmentprozess unter Berücksichtigung der Risikotragfähigkeit	2007
78.	Gerdemesmer, Dieter / Roffia, Barbara Monetary Analysis: A VAR Perspective	2007
77.	Heidorn, Thomas / Kaiser, Dieter G. / Muschiol, Andrea Portfoliooptimierung mit Hedgefonds unter Berücksichtigung höherer Momente der Verteilung	2007
76.	Jobe, Clemens J. / Ockens, Klaas / Safran, Robert / Schalast, Christoph Work-Out und Servicing von notleidenden Krediten – Berichte und Referate des HfB-NPL Servicing Forums 2006	2006
75.	Abrar, Kamyar / Schalast, Christoph Fusionskontrolle in dynamischen Netzsektoren am Beispiel des Breitbandkabelsektors	2006
74.	Schalast, Christoph / Schanz, Kay-Michael Wertpapierprospekte: Markteinführungspublizität nach EU-Prospektverordnung und Wertpapierprospektgesetz 2005	– 2006
73.	Dickler, Robert A. / Schalast, Christoph Distressed Debt in Germany: What's Next? Possible Innovative Exit Strategies	2006
72.	Belke, Ansgar / Polleit, Thorsten How the ECB and the US Fed set interest rates	2006
71.	Heidorn, Thomas / Hoppe, Christian / Kaiser, Dieter G. Heterogenität von Hedgefondsindizes	2006
70.	Baumann, Stefan / Löchel, Horst The Endogeneity Approach of the Theory of Optimum Currency Areas - What does it mean for ASEAN + 3?	2006
69.	Heidorn, Thomas / Trautmann, Alexandra Niederschlagsderivate	2005
68.	Heidorn, Thomas / Hoppe, Christian / Kaiser, Dieter G. Möglichkeiten der Strukturierung von Hedgefondsportfolios	2005
67.	Belke, Ansgar / Polleit, Thorsten (How) Do Stock Market Returns React to Monetary Policy ? An ARDL Cointegration Analysis for Germany	2005
66.	Daynes, Christian / Schalast, Christoph Aktuelle Rechtsfragen des Bank- und Kapitalmarktsrechts II: Distressed Debt - Investing in Deutschland	2005
65.	Gerdemesmer, Dieter / Polleit, Thorsten Measures of excess liquidity	2005
64.	Becker, Gernot M. / Harding, Perham / Hölscher, Luise Financing the Embedded Value of Life Insurance Portfolios	2005
63.	Schalast, Christoph Modernisierung der Wasserwirtschaft im Spannungsfeld von Umweltschutz und Wettbewerb – Braucht Deutschland eine Rechtsgrundlage für die Vergabe von Wasserversorgungskonzessionen? –	2005
62.	Bayer, Marcus / Cremers, Heinz / Kluß, Norbert Wertsicherungsstrategien für das Asset Management	2005
61.	Löchel, Horst / Polleit, Thorsten A case for money in the ECB monetary policy strategy	2005
60.	Richard, Jörg / Schalast, Christoph / Schanz, Kay-Michael Unternehmen im Prime Standard - „Staying Public“ oder „Going Private“? - Nutzenanalyse der Börsennotiz -	2004
59.	Heun, Michael / Schlink, Torsten Early Warning Systems of Financial Crises - Implementation of a currency crisis model for Uganda	2004

58.	Heimer, Thomas / Köhler, Thomas Auswirkungen des Basel II Akkords auf österreichische KMU	2004
57.	Heidorn, Thomas / Meyer, Bernd / Pietrowiak, Alexander Performanceeffekte nach Directors Dealings in Deutschland, Italien und den Niederlanden	2004
56.	Gerdemesier, Dieter / Roffia, Barbara The Relevance of real-time data in estimating reaction functions for the euro area	2004
55.	Barthel, Erich / Gierig, Rauno / Kühn, Ilmhart-Wolfram Unterschiedliche Ansätze zur Messung des Humankapitals	2004
54.	Anders, Dietmar / Binder, Andreas / Hesdahl, Ralf / Schalast, Christoph / Thöne, Thomas Aktuelle Rechtsfragen des Bank- und Kapitalmarktrechts I : Non-Performing-Loans / Faule Kredite - Handel, Work-Out, Outsourcing und Securitisation	2004
53.	Polleit, Thorsten The Slowdown in German Bank Lending – Revisited	2004
52.	Heidorn, Thomas / Siragusano, Tindaro Die Anwendbarkeit der Behavioral Finance im Devisenmarkt	2004
51.	Schütze, Daniel / Schalast, Christoph (Hrsg.) Wider die Verschleuderung von Unternehmen durch Pfandversteigerung	2004
50.	Gerhold, Mirko / Heidorn, Thomas Investitionen und Emissionen von Convertible Bonds (Wandelanleihen)	2004
49.	Chevalier, Pierre / Heidorn, Thomas / Krieger, Christian Temperaturderivate zur strategischen Absicherung von Beschaffungs- und Absatzrisiken	2003
48.	Becker, Gernot M. / Seeger, Norbert Internationale Cash Flow-Rechnungen aus Eigner- und Gläubigersicht	2003
47.	Boenkost, Wolfram / Schmidt, Wolfgang M. Notes on convexity and quanto adjustments for interest rates and related options	2003
46.	Hess, Dieter Determinants of the relative price impact of unanticipated Information in U.S. macroeconomic releases	2003
45.	Cremers, Heinz / Kluß, Norbert / König, Markus Incentive Fees. Erfolgsabhängige Vergütungsmodelle deutscher Publikumsfonds	2003
44.	Heidorn, Thomas / König, Lars Investitionen in Collateralized Debt Obligations	2003
43.	Kahlert, Holger / Seeger, Norbert Bilanzierung von Unternehmenszusammenschlüssen nach US-GAAP	2003
42.	Beiträge von Studierenden des Studiengangs BBA 012 unter Begleitung von Prof. Dr. Norbert Seeger Rechnungslegung im Umbruch - HGB-Bilanzierung im Wettbewerb mit den internationalen Standards nach IAS und US-GAAP	2003
41.	Overbeck, Ludger / Schmidt, Wolfgang Modeling Default Dependence with Threshold Models	2003
40.	Balthasar, Daniel / Cremers, Heinz / Schmidt, Michael Portfoliooptimierung mit Hedge Fonds unter besonderer Berücksichtigung der Risikokomponente	2002
39.	Heidorn, Thomas / Kantwill, Jens Eine empirische Analyse der Spreadunterschiede von Festsatzanleihen zu Floatern im Euroraum und deren Zusammenhang zum Preis eines Credit Default Swaps	2002
38.	Böttcher, Henner / Seeger, Norbert Bilanzierung von Finanzderivaten nach HGB, EstG, IAS und US-GAAP	2003
37.	Moormann, Jürgen Terminologie und Glossar der Bankinformatik	2002
36.	Heidorn, Thomas Bewertung von Kreditprodukten und Credit Default Swaps	2001
35.	Heidorn, Thomas / Weier, Sven Einführung in die fundamentale Aktienanalyse	2001
34.	Seeger, Norbert International Accounting Standards (IAS)	2001
33.	Moormann, Jürgen / Stehling, Frank Strategic Positioning of E-Commerce Business Models in the Portfolio of Corporate Banking	2001

32.	Sokolovsky, Zbynek / Strohhecker, Jürgen Fit für den Euro, Simulationsbasierte Euro-Maßnahmenplanung für Dresdner-Bank-Geschäftsstellen	2001
31.	Roßbach, Peter Behavioral Finance - Eine Alternative zur vorherrschenden Kapitalmarkttheorie?	2001
30.	Heidorn, Thomas / Jaster, Oliver / Willeitner, Ulrich Event Risk Covenants	2001
29.	Biswas, Rita / Löchel, Horst Recent Trends in U.S. and German Banking: Convergence or Divergence?	2001
28.	Eberle, Günter Georg / Löchel, Horst Die Auswirkungen des Übergangs zum Kapitaldeckungsverfahren in der Rentenversicherung auf die Kapitalmärkte	2001
27.	Heidorn, Thomas / Klein, Hans-Dieter / Siebrecht, Frank Economic Value Added zur Prognose der Performance europäischer Aktien	2000
26.	Cremers, Heinz Konvergenz der binomialen Optionspreismodelle gegen das Modell von Black/Scholes/Merton	2000
25.	Löchel, Horst Die ökonomischen Dimensionen der ‚New Economy‘	2000
24.	Frank, Axel / Moormann, Jürgen Grenzen des Outsourcing: Eine Exploration am Beispiel von Direktbanken	2000
23.	Heidorn, Thomas / Schmidt, Peter / Seiler, Stefan Neue Möglichkeiten durch die Namensaktie	2000
22.	Böger, Andreas / Heidorn, Thomas / Graf Waldstein, Philipp Hybrides Kernkapital für Kreditinstitute	2000
21.	Heidorn, Thomas Entscheidungsorientierte Mindestmargenkalkulation	2000
20.	Wolf, Birgit Die Eigenmittelkonzeption des § 10 KWG	2000
19.	Cremers, Heinz / Robé, Sophie / Thiele, Dirk Beta als Risikomaß - Eine Untersuchung am europäischen Aktienmarkt	2000
18.	Cremers, Heinz Optionspreisbestimmung	1999
17.	Cremers, Heinz Value at Risk-Konzepte für Marktrisiken	1999
16.	Chevalier, Pierre / Heidorn, Thomas / Rütze, Merle Gründung einer deutschen Strombörse für Elektrizitätsderivate	1999
15.	Deister, Daniel / Ehrlicher, Sven / Heidorn, Thomas CatBonds	1999
14.	Jochum, Eduard Hoshin Kanri / Management by Policy (MBP)	1999
13.	Heidorn, Thomas Kreditderivate	1999
12.	Heidorn, Thomas Kreditrisiko (CreditMetrics)	1999
11.	Moormann, Jürgen Terminologie und Glossar der Bankinformatik	1999
10.	Löchel, Horst The EMU and the Theory of Optimum Currency Areas	1998
09.	Löchel, Horst Die Geldpolitik im Währungsraum des Euro	1998
08.	Heidorn, Thomas / Hund, Jürgen Die Umstellung auf die Stückaktie für deutsche Aktiengesellschaften	1998
07.	Moormann, Jürgen Stand und Perspektiven der Informationsverarbeitung in Banken	1998
06.	Heidorn, Thomas / Schmidt, Wolfgang LIBOR in Arrears	1998
05.	Jahresbericht 1997	1998

04.	Ecker, Thomas / Moormann, Jürgen Die Bank als Betreiberin einer elektronischen Shopping-Mall	1997
03.	Jahresbericht 1996	1997
02.	Cremers, Heinz / Schwarz, Willi Interpolation of Discount Factors	1996
01.	Moormann, Jürgen Lean Reporting und Führungsinformationssysteme bei deutschen Finanzdienstleistern	1995

FRANKFURT SCHOOL / HFB – WORKING PAPER SERIES
CENTRE FOR PRACTICAL QUANTITATIVE FINANCE

No.	Author/Title	Year
16.	Veiga, Carlos / Wystup, Uwe Closed Formula for Options with Discrete Dividends and its Derivatives	2008
15.	Packham, Natalie / Schmidt, Wolfgang Latin hypercube sampling with dependence and applications in finance	2008
14.	Hakala, Jürgen / Wystup, Uwe FX Basket Options	2008
13.	Weber, Andreas / Wystup, Uwe Vergleich von Anlagestrategien bei Riesterrenten ohne Berücksichtigung von Gebühren. Eine Simulationsstudie zur Verteilung der Renditen	2008
12.	Weber, Andreas / Wystup, Uwe Riesterrente im Vergleich. Eine Simulationsstudie zur Verteilung der Renditen	2008
11.	Wystup, Uwe Vanna-Volga Pricing	2008
10.	Wystup, Uwe Foreign Exchange Quanto Options	2008
09.	Wystup, Uwe Foreign Exchange Symmetries	2008
08.	Becker, Christoph / Wystup, Uwe Was kostet eine Garantie? Ein statistischer Vergleich der Rendite von langfristigen Anlagen	2008
07.	Schmidt, Wolfgang Default Swaps and Hedging Credit Baskets	2007
06.	Kilin, Fiodor Accelerating the Calibration of Stochastic Volatility Models	2007
05.	Griebisch, Susanne/ Kühn, Christoph / Wystup, Uwe Instalment Options: A Closed-Form Solution and the Limiting Case	2007
04.	Boenkost, Wolfram / Schmidt, Wolfgang M. Interest Rate Convexity and the Volatility Smile	2006
03.	Becker, Christoph/ Wystup, Uwe On the Cost of Delayed Currency Fixing	2005
02.	Boenkost, Wolfram / Schmidt, Wolfgang M. Cross currency swap valuation	2004
01.	Wallner, Christian / Wystup, Uwe Efficient Computation of Option Price Sensitivities for Options of American Style	2004

HFB – SONDERARBEITSBERICHTE DER HFB - BUSINESS SCHOOL OF FINANCE & MANAGEMENT

No.	Author/Title	Year
01.	Nicole Kahmer / Jürgen Moormann Studie zur Ausrichtung von Banken an Kundenprozessen am Beispiel des Internet (Preis: € 120,-)	2003

Printed edition: € 25.00 + € 2.50 shipping

Download:

Working Paper: http://www.frankfurt-school.de/content/de/research/Publications/list_of_publication0.html

CPQF: http://www.frankfurt-school.de/content/de/research/quantitative_Finance/research_publications.html

Order address / contact

Frankfurt School of Finance & Management

Sonnemannstr. 9–11 ▪ D–60314 Frankfurt/M. ▪ Germany

Phone: +49 (0) 69 154 008–734 ▪ Fax: +49 (0) 69 154 008–728

eMail: m.biemer@frankfurt-school.de

Further information about Frankfurt School of Finance & Management
may be obtained at: <http://www.frankfurt-school.de>