EMBODIED COGNITION, ORGANIZATION AND INNOVATION

By Bart Nooteboom

April 2006

TILBURG ◆ UNIVERSITY

EMBODIED COGNITION, ORGANIZATION AND INNOVATION

Bart Nooteboom
Tilburg University
b.nooteboom@uvt.nl

Revised version, March 2006

Abstract

This chapter explains and employs a constructivist, interactionist theory of knowledge that has come to be known as the perspective of 'embodied cognition'. That view has roots in earlier developmental psychology, and in sociology, and more recently has received further substance from neural science. It yields a basis for a cognitive theory of the firm, with the notion of cognitive distance between people, the resulting view of organization as a cognitive focusing device, the need for external relations with other organizations to compensate for organizational myopia, and the notion of optimal cognitive distance between firms for innovation by interaction.

JEL code: D21, L22, M14, O31, O32

Key words: Theory of the firm, organizational cognition, learning, innovation.

Introduction

This chapter adopts a constructivist, interactionist perspective on knowledge that emerged from the developmental psychology of, in particular, Piaget and Vygotsky. According to this view, cognition is not only the basis of action but also a result from it, and 'intelligence is internalized action'. We perceive, interpret and evaluate the world on the basis of cognitive categories that we construct in interaction with that world, particularly in interaction with other people. These categories constitute our 'absorptive capacity' (Cohen & Levinthal 1990). As a result, people see the world differently to the extent that they have developed their cognition along different life trajectories, in different environments. In the literature on management and organization, this view has also been called the 'activity view' of knowledge (Blackler 1995), and it has been widely adopted by many scholars of organization (e.g. Weick 1979, 1995). This view also has roots in sociology, in particular in the 'symbolic interactionism' of G.H. Mead (1934). More recently it has received further substance from neural science, in what has come to be known as 'embodied cognition', which will be discussed in some detail in this chapter.

This perspective has far-reaching implications for economics and management, and enables improved understanding of the 'knowledge economy' and the 'network economy', or what has recently received the fashionable label of 'open innovation' (Chesbrough 2003). Clearly, if knowledge arises from interaction with others, in a

'knowledge economy' interaction between firms in networks becomes crucial. So, the claim here is that this perspective of cognition is important for a proper understanding of the 'knowledge' and the 'network' economy.

On a more fundamental level, with its view of the individual as mentally constituted in interaction with others, and hence socially, while preserving individual variety of cognition, this perspective enables us to transcend the 'methodological individualism' of economics as well as the 'methodological collectivism' of (some) sociology, in a new 'methodological interactionism', and thereby helps to make a novel combination of economics and sociology, in what may perhaps be seen as a newly emerging integrative behavioural science.

Also, this perspective has implications for the theory of the firm, including a theory of inter-organizational relations (IOR's). If people construct their cognition differently along different life paths, this yields 'cognitive distance', and this, in turn, yields the need for an organization to act as a 'focusing device', in order to sufficiently align cognition, by some 'organizational cognitive focus', to utilize opportunities for complementary capabilities. By definition, this yields some organizational myopia, and to compensate for this firms require outside relationships with other firms, at greater cognitive distance. This also has implications for the theory of innovation, particularly in innovation networks. The question there is to what extent the structure of a networks and a firm's position in it affect variety of cognition and abilities to absorb it.

The chapter consists of two parts. The first part introduces embodied cognition, and specifies its contrast with the traditional 'representational–computational' view of cognition. The second part analyzes the implications for economics and management.

THE NEW PERSPECTIVE OF EMBODIED COGN ITION[1]

The traditional view

The perspective of embodied cognition stands in opposition to the 'Representational-Computational' (RC) view that has been the dominant view in cognitive science. That view assumes that knowledge is constituted by symbolic mental representations and that cognitive activity consists of the manipulation of (the symbols in) these representations, called computations (Shanon 1988: 70). According to Shanon (1993), the representations according to the RC view are:

1. symbolic: in the use of signs there is a separation of a medium and the content conveyed in it
2. abstract: the medium is immaterial; its material realization (physiology) is of no relevance
3. canonical: there is a given, predetermined code which is complete, exhaustive and determinate
4. structured/decomposable: well-defined atomic constituents yield well-formed composites
5. static: mind is the totality of its representations, structure and process are well

---

[1] Much of this first part is taken, in an abbreviated form, from Nooteboom (2000, Chapter 6)

demarcated.

The basic intuition is that behaviour is based on beliefs, desires and goals, and representations are postulated as entities that specify them (Shanon 1993: 9). The reconstruction of variety as variable, combinatorial operations on fixed elements is an ancient ploy: the ploy of decomposition. In formal grammar it yields the 'standard principle of logic, ... hardly ever discussed there, and almost always adhered to' (Janssen 1997: 419), that the meaning of a compound expression is a function (provided by rules of syntax) of the meanings of its parts. It was adopted by Frege, in his later work (Frege 1892, Geach and Black 1977, Thiel 1965, Janssen 1997).

The motivation for this view is in a respectable scientific tradition to yield a parsimonious reconstruction, in terms of stable entities and procedures of composition of those entities into a variety of structures, to account for orderly and regular human behaviour across a large variety of contexts. It also explains how people can understand sentences they never heard before. A subsidiary motivation is that by interposing the cognitive as an intermediate, abstract level between psychological phenomenology and physiology we can circumvent the need for a full reconstruction in terms of physiology, and we can thereby evade reductionism. However, there are empirical and theoretical objections to such a symbolic, semantic, representational view (Shanon 1988, Hendriks-Jansen 1996).

If meanings of words were based on representations, it should be easy to retrieve them and give explicit definitions, but in empirical fact that is often very difficult. A second empirical point is that people are able to re-categorize observed objects or phenomena, so that representations vary, if they exist, and then they are no longer determinate. Words generally have more than one meaning, and meanings vary across contexts. Closed, i.e. exhaustive and universal definitions that capture all possible contexts are often either infeasible or extremely cumbersome. For most definitions one can find a counter-example that defeats it.

> *For example: what is the definition of 'chair'? Should it have legs? No, some chairs have a solid base. Not all chairs have armrests or back rests. Neither has a stool, but we distinguish it from a chair. A child's buggy seat on a bike has a backrest, but is not called a chair. At least in some languages, a seat in a car is called a chair. A chair is used for sitting, but so is a horse. A cow is not a chair, but years ago I saw a newspaper item 'watch him sitting in his cow', with a picture of someone who used a stuffed cow for a chair. If it were customary for people living along a beach to collect flotsam to use for chairs, it would make sense, when walking along a beach, to point to a piece of flotsam and say 'look what an attractive chair'. Not to speak of professorial chairs.*

Another empirical point of fact, recognized by many (e.g. Putnam 1975, Winograd 1980), is that meanings are unbounded, and open-ended with respect to context. Novel contexts do not only select from a given range of potential meanings, but also evoke novel meanings. Novelty is produced in contextual variation (Nooteboom 2000). Summing up, representations cannot be exhaustive, or determinate, or single-valued, or fixed. As Wittgenstein (1976) proposed in his 'Philosophical investigations', in his notion of

'meaning as use', words are like tools: their use is adapted to the context, in the way that a screwdriver might be used as a hammer.

One of the theoretical problems, recognized by Fodor (1975), who was a proponent of CR, is the following: if cognitive activity is executed by computation on mental representations, the initial state must also be specified in terms of those representations, so that all knowledge must be innate. That is preposterous, and certainly will not help to develop a theory of learning and innovation. Another theoretical objection is that if one admits that meaning is somehow context-dependent, as most cognitive scientists do, also if they are adherents of the RC view, then according to the RC view context should be brought into the realm of representations and computations. Shanon (1993: 159) characterizes this as the opening of a 'disastrous Pandora's box'. To bring in all relevant contexts would defeat the purpose of reducing the multiplicity of cognitive and verbal behaviour to a limited set of elements that generate variety in the operations performed on them. Furthermore, we would get stuck in an infinite regress: how would we settle the context dependence of representations of contexts? Note that contexts in their turn are not objectively given, somehow, but subject to interpretation. As Shanon (1993: 160) put it: 'If the representational characterization of single words is problematic, that of everything that encompasses them is hopeless'.

In recent developments in the logic of language, the notion has come up of 'discourse representation theory'. In the words of van Eijck and Kamp (1997: 181): 'Each new sentence S of a discourse is interpreted in the context provided by the sentences preceding it ...The result of this interpretation is that the context is updated with the contribution made by S.' The contribution from this theory is that it yields a dynamic perspective on semantics: truth conditions are defined in terms of context change. This theory can even be formalized so as to preserve compositionality (Janssen 1997). However, I propose that the dynamic of interpretation and context is more creatively destructive than is modelled in discourse representation theory: the interpretation of a novel sentence can re-arrange the perception of context and transform interpretations of past sentences.

Summing up, compositionality is problematic due to context dependence plus the fact that contexts themselves are subject to interpretation and re-interpretation. Or, to put it differently: the meaning of the whole is not only determined by the meaning of the parts, but feeds back into shifts of meaning of the parts.

Situated action

I don't see how we can account for learning and innovation on the basis of representations that satisfy any, let alone all, of the assumptions of RC: separation of medium and content; a predetermined, complete, exhaustive and determinate code; well-defined and static constituents of composites. However, this does not mean that we need to throw out the notion of mental representations altogether. If we do not internalize experience by means of representations, and relegate it only to the outside world, how would cognition relate to that world? How can we conceptualize rational thought other than as some kind of tinkering with mental models, i.e. representations that we make of the world?

Despite his radical criticism of the RC view, even Shanon (1993: 162) recognized this: 'On the one hand, context cannot be accounted for in terms of internal, mental representations ....; on the other hand, context cannot be accounted for in terms of external

states of affairs out there in the world ....'. For a solution, he suggests (1993: 163) that 'Rather, context should be defined by means of a terminology that, by its very nature, is interactional. In other words, the basic terminology of context should be neither external nor internal, but rather one that pertains to the interface between the two and that brings them together'. Similar criticism and conclusions were offered by Hendriks-Jansen (1996), who concluded that we should take a view of 'interactive emergence', and Rose (1992), who proposed the view of 'activity dependent self-organization'. This leads to the 'situated action' perspective. This perspective entails that rather than being fully available and complete prior to action and outside of context, mental structures ('representations') and meanings are formed by context-specific action.

One could say that up to a point the situated action view goes back to early associationist theories of cognition, proposed, in various forms, by Berkeley, Hume, William James and the later behaviourist school of thought (Dellarosa 1988: 28, Jorna 1990). However, a crucial difference with behaviourism (notably the work of Skinner and his followers) is that here there is explicit concern with internal representation and mental processing, even though that does not satisfy the axioms of the RC view.

Nevertheless, in some important respects the 'situated action' view seems opposite to the RC view. It proposes that action is not so much based on cognitive structure as the other way around: cognitive structure is based on action. However, the cognitive structuring that arises as a function of action provides the basis for further action. Thus both are true: action yields cognitive structuring, which provides a new basis for action. Rather than taking one or the other position I take both, in a cycle of development. Knowledge and meaning constitute repertoires from which we select combinations in specific contexts, which yield novel combinations that may shift repertoires of knowledge and meaning. Such shifts of knowledge and meaning occur in interaction with the physical world, in technological tinkering, and in social interaction, on the basis of discourse (cf. Habermas' 1982, 1984 notion of 'communicative action').

Situated action entails that knowledge and meaning are embedded in specific contexts of action, which yield background knowledge, as part of absorptive capacity, which cannot be fully articulated, and always retain a 'tacit dimension' (Polanyi 1962). This view is also adopted, in particular, in the literature on 'Communities of practice' (COP, Brown & Duguid 1991, 1996, Lave & Wenger 1991, Wenger & Snyder 2000). This is related to the notion of 'background' from Searle (1992). Interpretation of texts or pictures is based, to some extent, on unspecified, and incompletely specifiable, assumptions triggered in situated action. When in a restaurant one asks for a steak, it is taken for granted that it will not be delivered at home and will not be stuffed into one's pockets or ears. As a result, Canonical rules, i.e. complete, all-encompassing and codified rules, for prescribing and executing work are an illusion, since they can never cover the richness and variability of situated practice, which require improvisation and workarounds that have a large tacit component that cannot be included in codification of rules, as recognized in the literature on COP (Brown & Duguid 1991). The proof of this lies in the fact that 'work to rule' is a form of sabotage.

Internalized action

According to developmental psychologists Piaget and Vygotsky intelligence is internalized action. By interaction with the physical and social environment, the epistemological subject constructs mental entities that form the basis for virtual, internalized action and speech, which somehow form the basis for further action in the world. This internalized action is embodied in neural structures that can be seen as representations, in some sense, but not necessarily in the symbolic, canonical, decomposable, static sense of mainstream cognitive science. In contrast with Piaget, Vygotsky (1962) recognized not only the objective, physical world as a platform for cognitive construction, but also the social world with its affective loading. While according to Piaget a child moves outward from his cognitive constructs to recognition of the social other, according to Vygotsky the social other is the source of the acquisition of knowledge and language. Vygotsky proposed the notion of ZOPED: the zone of proximal development. This refers to the opportunity for educators to draw children out beyond their zone of current competence into a further stage of development. In language acquisition by children, a phenomenon on which Piaget and Vygotsky agreed was that at some point children engage in ego-centric speech, oriented towards the self rather than social others, and that this subsequently declines. Piaget interpreted this as an outward movement <u>from</u> the self to the social other; a 'decentration' from the self. Vygotsky ascribed it to a continued movement <u>into</u> the self, in an ongoing process of formation and identification of the self and development of independent thought. The reason that egocentric speech declines is that overt speech is partly replaced by 'inner speech'. Before that stage, however, speech is preceded by and based on sensori-motor actions of looking, gesturing, pointing, aimed at satisfying a want.

> *Werner and Kaplan (1963) demonstrated 'that reference is an outgrowth of motor - gestural behaviour. Reaching evolves into pointing, and calling-for into denoting'. They note that 'it is in the course of being shared with other people that symbols gain the denotative function'.*

Both Shanon and Hendriks-Jansen use the notion of the 'scaffolding' that the context yields. It is reminiscent of Vygotsky's notion of ZOPED. Literally, a scaffold is used in the building of an arch: stones are aligned along a wooden scaffold until they support each other and the scaffold can be removed. The paradigmatic case in cognitive development of children is the support provided to the infant by its mother. According to the account given by Hendriks-Jansen (1996), infants do not have an innate language capability as claimed by Chomsky.

> *They have innate repertoires of activity sequences, such as facial 'expressions', eye movements and myopic focusing, kicking movements, randomly intermittent bursts of sucking when feeding, random gropings. At the beginning these movements do not signify anything nor do they seek to achieve anything, and they certainly do not express any internal representations of anything. The mother, however, instinctively assigns meanings and intentions where there are none, and this sets a dynamic of interaction going in which meanings and intentions get assigned to action sequences selected from existing repertoires on the occasion of specific contexts of interaction. Thus the random pauses in sucking are falsely picked up by the mother as indications of a need to jiggle the baby back into feeding action. In fact it is not the jiggling but*

on the contrary the stopping of it that prods the baby to resume the action. The taking turns in stops and jiggles does not serve any purpose of feeding, as the mother falsely thinks, but a quite different purpose, for which evolution has 'highjacked' what was thrown up by previous evolution. It is 'used' to ready the child for the 'turn taking' that is basic for communication: in communication one speaks and then stops to let the other speak. Here, the child acts, stops, and triggers the mother to action, who jiggles and then stops and thereby triggers the baby to action.
At first, the infant can focus vision only myopically, which serves to concentrate on the mother and her scaffolding, not to be swamped by impressions from afar. Later, the scope of focusing vision enlarges, and the infant randomly fixes its gaze on objects around it. The mother falsely interprets this as interest and hands the object to the infant, and thereby generates interest. The child is then prone to prod the mother's hand into picking up objects, first without and later with looking at the mother.

Groping and prodding develop into pointing, which forms the basis for reference that is the basis for meaning and language. While the child points and utters sounds, the mother responds with the correct words, and so language develops. In egocentric speech the child starts to provide his own scaffolding, which further contributes to the development of his own identity. Along these lines, meaning and intentionality do not form the basis for action but arise from it, with the aid of scaffolds from the context.

As indicated, according to Vygotsky overt speech is next internalized, to yield virtual speech, and cognitive constructs serve as a basis for virtual action: to explore potential actions mentally, by the construction of mental models, deduction, mental experiments. While cognition is not necessarily in terms of language, and can to some extent develop without it, its development is tremendously enhanced by language, in the development of internal speech.

The notion of scaffolding lends further depth to the debate, in the COP literature, on the role of specific actions contexts, in specifying and elaborating the meaning of words, and in generating new meanings.

Connectionism and neural Darwinism

As indicated, the situated action view contests the idea of *semantic* representations as a necessary and universal basis for all knowledge, but it allows for representations in some sense as the basis for at least some behaviour. For example, it might be consistent with connectionism: the view that cognition is based on neural nets, which can generate systematic regularity without the explicit specification of generative rules in underlying representations. Such nets are representations in some sense, generated, by some mechanism, from experience in the world (cf. Smolensky 1988).

In parallel distributed processing (PDP, cf. Rumelhart and McClelland 1987) two radical steps are taken. One is to no longer accept the computer metaphor of sequential processing according to some algorithm, but to approach knowledge and learning in terms of parallel processes that interact with each other. The second is that knowledge is not stored in units, to be retrieved from there, but in patterns of activation in connections between units. Knowledge is implicit in this pattern of connections rather than in the units themselves

(Rumelhart, Hinton and McClelland 1987: 75). What is stored is the connection strengths between the units that allow the patterns to be recreated (McClelland, Rumelhart and Hinton 1987: 9).

Edelman's (1987, 1992) 'neural Darwinism' seems to yield a viable perspective for understanding how situated action might work in terms of neural networks (or 'neuronal groups', as he calls them). Here, the development of neural groupings, in patterns of connected neural activity, is seen as evolutionary, and more specifically as Darwinian, in that neuronal groups are too a large extent randomly generated, and then selected and reinforced according to success in the actions that they generate. In this way, the selection environment for individual action 'generates', by selection, mental structures in the way that in evolutionary economics the competitive and institutional environment 'generate', by selection, organizational structures. This yields an explanation of how activity gets internalized in the form of neural structures.

As an example of context-dependence of cognition, according to Edelman memory, both short and long term, is not the 'retrieval' of some entity, but a process of re-categorization; of re-activating, and in the process possibly shifting, the process of selection among neuronal groups. Hence, memory also is context-dependent, and that the process of recall may affect the template of future recall.

The difference between connectionist models of PDP and neural selectionism is that the former aims to operate on some notional, abstract level between symbols and neural networks (Smolensky 1988) whereas the latter operates directly on the level of neuronal groups. PDP retains symbols as some higher level, aggregate, emergent outcome of lower level processing.

There is further evidence for the constructivist, activity based view from other modern research of cognition, in addition to the work of Edelman.[2] While the brain has some domain specificity, i.e. localization in the brain of cognitive functions, this specificity is plastic, i.e. is not fixed prior to experience, but is constructed from input. For example, blind people have been shown, with brain imaging techniques, to employ the visual cortex for object recognition. Another result that illustrates activity based cognition is that after people learn to use objects as tools, accompanied by activity, observed with brain imaging, in motor areas of the brain, the mere observation of the tools triggers brain activity not only in the visual cortex, but also in that motor area. It has been shown that people from different cultures focus on different parts of images, and observe change in patterns differently.

In this way, Edelman's work, and other results from recent cognitive research, underpin the activity-based, constructivist view and its criticism of the earlier representational-computational view, which was still part of Herbert Simon's view, and of some contemporary artificial intelligence.

The central point here is that a mechanism of selection among neuronal structures shows in what way performance may precede competence; how meanings may be constructed from discourse (sense making) and knowledge from action (intelligence as internalized action), and provide the basis for ongoing action. This account seems consistent with Johnson-Laird's (1983) account of mental models and Hendriks-Jansen's account of how children learn language. This approach indicates how mental structures might emerge from

---

[2] Source: 'Cognition: From molecules to mind', conference at the Royal Dutch Academy of Arts and Sciences, Amsterdam, 29 March 2006.

experience in a way that allows for openness and variability across contexts. It offers an evolutionary perspective rather than a perspective of rational design. The programmatic significance of evolutionary theory is that it forces us to explain development not as the result of conscious, goal-directed, top-down, rational design by decomposition of functions, but as selection from among a repertoire of activity sequences, on the occasion of the demands and opportunities of specific contexts.

Summing up, as a basis for situated action theory, and the interactionist, constructivist view of knowledge and meaning that it supports, I employ an evolutionary, connectionist theory of cognitive development. On the occasion of experience, selections and re-combinations are made from partly overlapping and competing patterns of neural connections (Rumelhart and McClelland 1987, Edelman 1987, 1992, Rose 1992). According to these theories, performance, in interaction with and with support from the context, yields competence as much as competence yields the basis for performance. This underpins a principle of 'methodological interactionism'.

Embodied cognition

The principles of situated action, internalized action and neural Darwinism yield what has come to be known as the perspective of embodied cognition. Embodied cognition lends further support to an interactionist, constructivist theory of knowledge that is adopted, explicitly or implicitly, by most authors in the literature on organizational cognition and learning (for surveys, see Hedberg 1981, Cohen & Sproull 1998, Meindl, Stubbard & Porac 1998). According to this view, people

1. *construct* their cognitive categories, or mental models, by which they perceive, interpret and evaluate phenomena,
2. *in interaction* with their physical and, especially, their social environment.

This view also appears in the 'symbolic interactionism' of G.H Mead (1934, 1984), in sociology, and has later been called the 'experiential' view of knowledge (Kolb 1984) and the 'activity' view (Blackler 1995). In the organization literature, this view has been introduced, in particular, by Weick (1979, 1995), who reconstructed organization as a 'sense-making system'.

The mental frameworks that result from construction constitute 'absorptive capacity' (Cohen & Levinthal 1990). People can turn information into knowledge only by assimilating it into those frameworks, and thereby they shape and mold it. Consequently, to the extent that people have developed their cognition in different environments or conditions, they interpret, understand and evaluate the world differently (Berger & Luckman 1966). As a result, there is greater or lesser 'cognitive distance' between people (Nooteboom 1992, 1999).

A constructivist perspective can slide, and has done so, into radical post-modern relativism. According to the latter, the 'social constructionist' notion of knowledge entails that since knowledge is constructed rather than objectively given, any knowledge is a matter of opinion, and any opinion is as good as any other. This would lead to a breakdown of critical debate. Embodied realism saves us from such radical relativism in two ways. First, our cognitive construction builds on bodily functions developed in a shared evolution, and possibly also on psychological mechanisms inherited from

evolution, as argued in evolutionary psychology (Barkow et. al. 1992). Second, by assumption we share the physical and to some extent also a social world on the basis of which we conduct cognitive construction. That constitutes a reality that is embodied (Lakoff & Johnson 1999). As a result of shared psychological mechanisms of cognitive construction and a shared world from which such construction takes place, there is a basic structural similarity of cognition between people. This provides a basis for debate. Indeed, precisely because one cannot 'climb down from one's mind' to assess whether one's knowledge is properly 'hooked on to the world', the variety of perception and understanding offered by other people is the only source one has for correcting one's errors.

A key characteristic of embodied cognition is that it sees cognition as rooted in brain and body, which are in turn embedded in their external environment. This is consistent with the 'situated action' perspective indicated above. The embodiment of cognition entails a continuum rather than a Cartesian duality between rational evaluation, feelings and underlying physiological processes in the body. This view that cognitive functions build on non- cognitive, bodily and emotional functions was also prominent in the philosophy of Merleau-Ponty (1942, 1964), and was present, to some extent, in the work of Simon (1983). See also Nussbaum (2001). It plays an important role in Lakoff and Johnson's (1999) book on 'philosophy in the flesh'. Building on the philosophy of Spinoza, Damasio (2003) demonstrated a hierarchy of cognition, where rationality is driven by feelings, which in turn have a substrate of physiology, in a 'signalling from body to brain'.

As a result, in this chapter, the terms 'knowledge' and 'cognition' have a wide meaning, going beyond rational calculation. They denote a broad range of mental activity, including proprioception (i.e. use of hands and grope, feel and grasp objects), perception, sense making, categorization, inference, value judgments, and emotions. Note that the notion of cognitive distance then also refers to a variety of dimensions of cognition. In particular, people may be close in their normative ideas about how people should deal with each other, while they are very different in their substantive knowledge. That is what we often find in organizations, where people with different, complementary competence come together with a shared purpose and style of interaction.

In the construction of meaning from actions in the world people employ metaphors, as discussed by Lakoff and Johnson (1980). We grasp our actions in the physical world, in which we have learned to survive, to construct meanings of abstract categories, starting with 'primary metaphors' that build on proprioception. Thus, for example, good is 'up', because we stand up when alive and well, while we are prostrate when ill or dead. The analysis is important not only in showing how we cope in the world, but also in showing how metaphors can yield what Bachelard (1980) called 'epistemological obstacles'. I suspect that the primary metaphors, informed by experience with objects in the world, yield a misleading conceptualization of meanings, for example, as objects. Since objects retain their identity when shifted in space, we find it difficult not to think of words retaining their meaning when shifted from sentence to sentence. Underlying this is the 'museum metaphor' of meaning: words are labels of exhibits that constitute their meaning, and the 'pipeline metaphor of communication': with words meanings are shipped across a 'communication channel'. Meanings and communication are not like

that, but we find it difficult to conceptualize them differently. In short, in abstract thought, we suffer from an 'object bias'.

IMPLICATIONS FOR METHODOLOGY, THEORY OF THE FIRM, AND INNOVATION

Methodological interactionism

If knowledge arises from assimilation of perceptions into cognitive structures that have been constructed in interaction with the world, the self is social, in that it is constructed from interaction, but also individual, in that its constructions and interpretations are to some extent idiosyncratic since they depend on individual life trajectories. This yields a principle of methodological interactionism that transcends both the methodological individualism that forms part of the 'hard core' (in the sense of Lakatos 1970, 1978) of the 'research programme' of mainstream economics (Weintraub 1988), and the methodological collectivism of (some) sociology, according to which individuals are programmed by their social environment.

As a result, embodied cognition may yield a perspective for integrating economics and sociology in a new behavioural science. What this can yield, more specifically, in terms of the theory of the firm, including a theory of inter-organizational relationships, and theory of innovation in inter-organizational relationships, is shown, to some extent, in the remainder of this chapter. This chapter cannot exhaust the full potential of methodological interactionism. For example, that principle opens economics and management up to insights from social psychology in human interaction and decision making that are of great importance, particularly in matters that involve combinations of rationality and feelings, as in conflict resolution and the making and breaking of trust (Nooteboom 2002, Six 2004). Here, the focus is on more general theory of organization.

For that, I make a connection with the sociology of Georg Simmel. Simmel (1950, first published 1917) and Maslow (1954) proposed that people have different *levels* of needs, motives and cognitive make-up, where lower level needs must be satisfied before higher levels can come into play (called the principle of 'prepotency'), and people are more similar on the deeper levels than on the higher levels. In the classic categorization of Maslow, on the deepest level we find the most instinctive, automatic, unreflected and difficult to control drives of bodily physiology, such as hunger and sexual appetite, which are highly similar between different people. Next, we find needs of shelter, safety, and protection. Next, love and affection. Next, social recognition, esteem and legitimation. Finally, on the highest level, individual expression and self-actualization. Higher levels are more idiosyncratic, and hence show greater variety between people, than lower levels.

While there is some empirical evidence for a hierarchy of needs (Hagerty 1999), especially the principle of pre-potency is far from accurate. The 'higher level' need for esteem and self-actualization can lead people to make great sacrifices on the 'lower levels' of safety, shelter, and food. Man has a strong, basic, and perhaps even instinctive drive, it appears, toward metaphysics, as exhibited in the form of religious rituals of burial in the earliest forms of Homo Sapiens Sapiens. That may even be part of the characterization of our species, in distinction with earlier hominoids. Also, while people

may have the same needs on the physiological level of food and sex, the foods and behaviours they choose in order to satisfy those needs vary greatly. Apparently, higher levels find their expression in a variety of ways of satisfying needs on lower levels, in different 'life styles'.

Nevertheless, in spite of these qualifications and additions, it still seems true that there are different levels of needs and motives, and that people are more similar on lower levels of more basic needs, perhaps including spiritual ones, and more varied on higher levels of more sophisticated needs. This connects with the notion of cognitive distance. If people make sense of the world on the basis of mental categories that are constructed from interaction with the world, they see and interpret the world differently to the extent that they have developed their cognition along different life paths. Cognition is more similar to the extent that the corresponding phenomena are similar, as in mechanics subject to laws of nature, and is more different in abstractions and in cultural and social life.

Simmel (1950) proposed that, as a result, in a randomly composed group of people, what people have in common resides on lower, more basic, unreflected levels of needs and object-oriented cognition as the size of the group increases. What random masses have in common is basic needs and instincts. He also proposed that the larger and more heterogeneous the group, the more norms and rules of conduct for the group are negative, indicating what is forbidden or undesirable, rather than positive, indicating goals and actions to achieve them. The underlying principle of logic is similar to the principle that a theory (with universal propositions) can be falsified but not verified. It is better possible to specify what has been found to be false (in the current context: impermissible) than to specify all that may be possible (here: desirable). To specify what is forbidden entails freedom to do what is not forbidden, while to specify what may be done is either partial, leaving options open, and is then not very functional, or it forbids what is not specified, and then is inherently conservative.

The phenomena of levels and variety of cognition have important implications for organizations and IOR's.

Theory of the firm

While the theory of the firm is a familiar branch of economics, it is more appropriate to develop a theory of organization more widely, in which the firm is a special case, as is the practice in the management literature.

Several economic theories of organization, in particular transaction cost economics (TCE), look at organizations as systems for governance, to reduce transaction costs, by means of incentives, monitoring and control. However, increasingly it is recognized that for a variety of reasons ex-ante incentive design is problematic. Due to uncertainty concerning contingencies of collaboration, and limited opportunities for monitoring, ex ante measures of governance are seldom complete, and need to be supplemented with ex-post adaptation. Such uncertainties proliferate under present conditions of professional work and, especially, under the conditions of innovation that form the focus of this chapter. Professional work requires considerable autonomy for its execution and is hard for managers to monitor and evaluate, let alone measure. Rapid innovation increases uncertainty makes formal governance, especially governance by contract, difficult to specify, which increases the importance of collaboration on the basis of trust. If

specification of detailed contracts is nevertheless undertaken, it threatens to form a straightjacket that constrains the scope for innovation. Furthermore, the attempt to use contracts to constrain opportunism tends to evoke mistrust that is retaliated by mistrust, while in view of uncertainty there is a need to use trust rather than contract.

Beyond governance, we should look at competence or capability (Nooteboom 2004). Inspired by the work of Penrose (1959), much research of management and organization sees the firm (or organization more widely) as generating firm-specific organizational capabilities. The present chapter can be seen as extending, or deepening, the Penrosian view on the basis of the perspective of embodied cognition. From a competence perspective, incentives by individual rewards may obstruct teamwork, while if the interactionist view of learning is true, that is crucial for innovation. As noted before, if the situated action view of competence is true, then canonical rules, i.e. all-encompassing and codified rules, for executing work are an illusion, since they can never cover the richness and variability of situated practice, which require informal improvisation and workarounds that have a large tacit component that cannot be included in codification of rules, as recognized in the literature on COP (Brown & Duguid 1991).

In conclusion, there is a need for an alternative to ex ante incentive alignment, and a basis for ex post adaptation. Using the perspective of embodied cognition, the view in this chapter is that organization functions primarily as a cognitive 'focusing device', for reasons of both competence and governance. In order to achieve a specific joint goal, on a higher level than basic needs, the categories of thought (of perception, interpretation and value judgment), of the people involved must to some extent be aligned and lifted to a higher level than the basic instincts that a random group would share (Kogut & Zander 1992, Nooteboom 1992, 2000). Alignment entails that cognitive distance must be limited, to some extent and in some respects.

More precisely, organizational focus has a dual *purpose*. The first is to raise shared cognition to a *level* higher than basic needs and instincts, consistent with, and supporting the goal of the organization. Also, while outside an organization, in society more widely, norms or rules of conduct tend to be negative, indicating what actions are forbidden or undesirable, organizations need positive norms, indicating goals and ways of achieving them. The second purpose of organizational scope is to reduce cognitive distance, in order to achieve a sufficient *alignment* of mental categories, to understand each other, utilize complementary capabilities and achieve a common goal. Note that, given the wide notion of cognition used here, focus has perceptual, intellectual and normative content. It includes views of how people 'deal with each other around here'.

To achieve such focus, organizations develop their own specialized semiotic systems, in language, symbols, metaphors, myths, and rituals. This is what we call organizational culture. This differs between organizations to the extent that they have different goals and have accumulated different experiences, in different industries, technologies and markets. Organizational culture incorporates fundamental views and intuitions regarding the relation between the firm and its environment ('locus of control': is the firm master or victim of its environment), attitude to risk, the nature of knowledge (objective or constructed), the nature of man (loyal or self-interested) and of relations between people (rivalrous or collaborative), which inform content and process of strategy, organizational structure, and styles of decision-making and coordination (Schein 1985).

Organizational focus also has a dual *function*, of selection and adaptation. In selection, it selects people, in recruitment but often on the basis of self-selection of personnel joining the organization because they feel affinity with it. In adaptation, it socializes incoming personnel, with initiation, and focuses their capabilities, in training. To perform these functions, focus must not only have cognitive content, but must also be embodied in some visible form. Such form is needed for several reasons. For people to share cognition they need expression in language or other signs. Form is also needed to stabilize the mental processes underlying organizational focus. As such, organizational focus has the same function as the body has for individual cognitive identity. In the theory of embodied cognition it has been recognized that cognition, with its drives of multiple feelings, is diverse and volatile, and often limitedly coherent, and lacks a clearly identifiable, stable, mental identity of the ego, and that such identity, in so far as it can be grasped, is due, in large part, to the body as a coherent source of feelings and their underlying physiology. Similarly, cognitive activities in an organization require some embodiment to crystallize, direct and stabilize cognition and communication within and outside the organization.

To perform its functions, organizational form has a number of possible features, corresponding with different ways in which organizational focus can work. For both the internal function of adaptation, with expression, crystallization, stabilization and direction, and the external function of selection by signalling, we find symbols, such as logo's, 'mission statements', advertisement and external reporting. More for the internal function we find the exemplary behaviour of organizational heroes, often a founder of the organization, corresponding myths, and rituals. Culture, with its signs, heroes, myths and rituals, aims to represent and engender a certain style of behaviour (Simmel 1950: 341) whereby the individual becomes part of a collective intentionality. More formalized forms of organization are procedures, for reporting, decision making, recruitment, contracting, and the like. An important more formal organizational form is legal identity, aimed at securing the interests of different stakeholders. Legal identity varies with the focal stakeholders and their interests. Legal identity is needed to regulate ownership and decision rights, liability, contracting, and the like. Here, firms distinguish themselves from organizations more generally. A firm is defined as an organization of capital and labour aimed at profit, in contrast with, for example, a foundation that is not aimed at profit, and where profits are re-absorbed in the organization. The legal identity of firms varies according to the regulation of liability, ownership, availability of shares, employment status, tax, and the like. Here, there still is a connection with TCE, in that under the authority of an employment relationship norms and forms of conduct can be imposed without having to engage in a contract for each individual transaction. As such, legal identity functions to formalize and consolidate organizational culture.

Elements of this idea of organization are not new. It connects with the idea, in the organization literature, that the crux of an organization is to serve as a 'sensemaking system' (Weick 1979, 1995), a 'system of shared meaning' (Smircich 1983) or 'interpretation system' (Choo 1998). I propose that this yields a more fundamental reason for firms to exist than the reduction of transaction costs, although transaction costs are also part of the story (Nooteboom 2000). In a firm, people need to achieve a common purpose, and for this they need some more or less tacit shared ways of seeing and interpreting the world and regulating collaboration.

Boundaries of the firm

A theory of the firm, or of organizations more widely, should account for the boundaries of the organization and for inter-organizational relationships (IOR's). Effects of firm size have formed a central subject in economics. On the competence side are effects of static, productive efficiency, in scale and scope, which can take a variety of forms, including division of labour, and effects of dynamic efficiency, in Schumpeterian debates on whether large or small firms are the more innovative. A discussion of the literatures on those subjects lies beyond the scope of the present chapter. The point to be made here is that debates on effects of firm size have turned out to be somewhat misguided in that small firms may compensate for their weaknesses by collaboration in networks (or clusters, or industrial districts), while large firms may compensate for their weaknesses by a greater or lesser disintegration or decentralization of units within the firm. Here, clusters of firms are also forms of organization, but they are not firms, while large firms can operate more or less as clusters. The difference lies in the 'cohesiveness' of cognitive focus and in legal identity.

Here I propose the general principle that the boundary of an organizational entity in general, and of a firm in particular, is determined by the *cohesiveness* of the focus, in combination with its legal formalization. Note that the notion of organizational focus does not entail the need for people to agree on everything, or see everything the same way. Indeed, such lack of diversity would preclude both division of labour and innovation within the firm. As discussed in Nooteboom (1999) there is a trade-off between cognitive distance, needed for variety and novelty of cognition, and cognitive proximity, needed for mutual understanding and agreement. In fact, different people in a firm will to a greater or lesser extent introduce elements of novelty from their outside lives and experience, and this is a source of both error and innovation (Dimaggio 1997). Nevertheless, there are some things they have to agree on, and some views, often tacit, which they need to share, on goals of the organization, norms, values, standards, outputs, competencies and ways of doing things.

The cohesiveness of organizational focus has two dimensions, at least, of *inclusiveness or scope* and *tightness*. If the life world of people has many dimensions, inclusiveness denotes the number of dimensions included in organizational focus. This is closely related to the point, made earlier, that cognitive distance entails difference in a variety of dimensions of cognition. Tightness denotes similarity, or proximity, in the dimensions involved. A large inclusiveness or scope of focus entails that there is alignment on many issues, and tightness entails that on each issue there is little ambiguity and variety of meaning, norms and standards. A highly inclusive scope entails that more of a person's life world is included in the organization, in 'thick' relationships, carrying many aspects of the life world and of personality, and a less inclusive scope entails less personalized, 'thinner' relationships.

The notion of the cohesiveness of focus connects with the distinction Simmel (1950) made between a person's function in an organization, which takes up only part of his personality, and his full personality. This is echoed in the distinction that Ring and van de Ven (1994) made between roles that people play and behaviour 'qua persona'. In a cohesive focus, role and persona get closer. With a highly cohesive focus, the liberty of people and variety among them are constrained. Extremes of this are found in cliques, and especially in clandestine, secluded or secret societies (Simmel: 345-376). Outside freedom,

to engage in external relationships, is constrained by the high inclusiveness of organizational focus, by which there are few dimensions of the life world left that are not in some way already regulated within the group. Inside freedom is constrained by the tightness of focus, with little room to deviate from narrow norms. Both inside and outside sources of variety, and hence of innovation, are highly constrained.

While inclusiveness and tightness are separate dimensions of scope, high inclusiveness does tend to generate tightness, as follows. When high inclusiveness forms an obstacle to outside relationships, which occurs to the extent that organizational focus imposes meanings not shared outside, then people are cut off from sources of fresh or different ideas, and they will tend to gravitate towards meanings shared inside the organization, which increases tightness, not because it is imposed by focus, but because it emerges from decreasing cognitive distance. Thus large scope and tightness together tend to reinforce themselves.

An implication of the notion of a focusing device is that the need to achieve a focus entails a risk of myopia: relevant threats and opportunities to the firm are not perceived. To compensate for this, people, and firms, need complementary sources of outside intelligence, to utilize 'external economy of cognitive scope' (Nooteboom 1992). This yields a new perspective on inter-organizational relationships, next to the usual considerations, known from the alliance literature. It also fits well with the prevalent idea in the literature on innovation systems that innovation derives primarily from interaction between firms (Lundvall 1988).

The notion of a firm as a focusing device yields an alternative to TCE, for an explanation of the boundaries of the firm. The present theory yields a prediction that is opposite to that of classical transaction cost economics, and which is particularly relevant in innovation. With increasing uncertainty, in terms of volatility of technology and markets, firms should not integrate activities more, as transaction cost theory predicts, but less, because the need to utilize outside complementary cognition is greater. The argument from TCE was that under uncertainty one needs the greater power of management by fiat within a firm, to monitor behaviour and resolve conflicts. Here, the counter-argument is that under the volatility of innovation the risk or organizational myopia is greater and hence there is a greater need for outside complementary cognition, with 'external economy of cognitive scope'. The prediction of less rather than more integration under uncertainties of innovation has been confirmed empirically by Colombo & Garrone (1998), who found that in technologically volatile industries, as measured by patent intensity, the likelihood of alliances rather than mergers and acquisitions is higher than in the absence of such volatility.

Communities and firms

A firm may consist of a single community of practice (COP), as the smallest unit of organization , typically with a relatively cohesive focus, or it may be a 'community of communities' (Amin & Cohendet 2003), with a less cohesive focus. Recall that a focus can be cohesive in either or both of two ways: relationships in the community are thick, comprising many dimensions of personality, or they are tight, with little variety in the relevant dimensions, or both. In fact, the notion of COP allows for a great variety of different kinds of community (Bogenrieder & Nooteboom 2004). One type, apparently

closest to the original idea of a community of 'practice' (Brown & Duguid 1991, Lave & Wenger 1991) is a thick and tight community where people interact on many issues (highly inclusive), on a daily basis, with little ambiguity of meanings (tight), in the execution of a practice. Another type is that of a community of professionals from different contexts of action, who exchange knowledge, such as scholars at a conference, for example. Here, focus is narrow in scope but often tight, with people talking precisely about few things. One can have a group with wide focus and little tightness, with people talking vaguely about many things, such as practitioners from different practices talking about many aspects of their practice. Strangers typically talk vaguely about few things. A cohesive group, with small internal distance in many dimensions of cognition, is likely to be very efficient in a static sense, or in *exploitation,* but inefficient in a dynamic sense, or in 'exploration' (March 1991, Nooteboom 2002). To keep cohesive groups from cognitive inertia, it may be needed to rotate people across them, to keep up variety, i.e. to maintain some cognitive distance. A cohesive group can increase variety on the basis of outside contacts, but must then relax its tightness, to allow for variety of meaning.

The *size* of the smallest community depends on how 'systemic', as opposed to 'stand–alone' (Teece 1986, Langlois & Robertson 1995, Postrel 2002), the structure of the activity is. Exploitation is systemic when there is a complex division of labor, with many elements and a dense structure of connections between them, with tight constraints on their interfaces. These connections yield interdependence, with different types, as recognized by Thompson (1967): sequential (output of one step is input for the next), reciprocal (inputs and outputs both ways) and pooled interdependence (common use of a shared resource). An example of high systemicness is an oil refinery. In more stand-alone systems, elements of the system are connected with few other elements, and connections are loose, allowing for some ambiguity and deviation from standards on interfaces. This allows for separate communities with a high degree of autonomy. An example is a consultancy firm. A third type is a modular system. Here, there are also multiple, connected elements, as in the systemic case, but different elements embody different, separable functions, and standards on interfaces between them allow for variety, where different modules can be plugged into the system as alternative ways of performing specific functions. Then, modules may be separate communities.

The small firm often has a limited *range* or portfolio of technologies, products and competencies. The firm typically coincides with a single COP, with this smaller unit having separate legal identity, while in large organizations the smaller communities do not have such separate legal identity. As a result, they are vulnerable, with limited diversification of risks, limited specialization in functions, limited economies of scale and scope, and limited career perspectives. They also have both the potential advantages and disadvantages of a cohesive scope. They often, though not always and not necessarily, have a cohesive focus, in relatively thick and tight, often highly personalized relationships. One cause of high inclusiveness, and perhaps the most important one, lies in limited specialization of labour, due to lack of scale and scope. As indicated before, high inclusiveness generates tightness if inside norms or meanings are incompatible with outside ones. This may result from radical novelty, where the firm is generating new, unfamiliar meanings. High tightness may also result from the cognitive stamp that the entrepreneur puts on his small organization, where he interacts directly with his personnel. In this way, radically innovative, small firms

may isolate themselves and thereby close themselves off from the sources of application and further innovation.

This yields one of several paradoxes of the small firm. On the one hand, small size, personalized, thick, informal relationships, integration of tasks among few people, and direct contacts, internally and outside, e.g. with customers, enable high flexibility and motivational power of identification with the firm. On the other hand there is potential for suppression of freedom and variety, and of isolation from the environment (cf. Nooteboom 1994).

The large firm typically has a wider range of activities, with more or less cohesive focus in internal communities with a narrower range of activities, and an overall organizational focus which has limited scope, with people having less in common across the organization, but possibly with a high degree of tightness in a few aspects of cognition, particularly concerning normative issues of overall purpose and style of interaction.

Small firms may compensate for their weaknesses with collaboration in networks or industrial districts, to spread risks, and to obtain economies of scale and scope, mimicking large firms in some of their features. Somewhat perversely, perhaps, for dynamic efficiency the greatest benefit of industrial districts may be that there is flexibility of configuration from the fact that firms that do not fit in new constellations can more easily be dropped than departments of firms can be. Large firms can obtain the benefits of smallness by mimicking small firms in COP, while maintaining benefits of integration in the form of economies of scale and scope, and diversification of risks. Their limited scope of overall organizational focus allows for a wide variety competence, and for personal freedom. However, the tightness of focus needed for governing a wide range of activity, in combination with limited opportunities for shedding parts of the organization, due to their inclusion in an overall legal entity, may inhibit the flexibility of configuration and variety of purpose that is conducive to radical innovation.

Innovation by interaction

Especially from an evolutionary perspective (Nelson & Winter 1982), heterogeneity or variety is a crucial source of innovation, and this has been taken up in the alliance literature (Stuart & Podolny 1996, Almeida & Kogut 1999, Rosenkopf & Nerkar 2001, Fleming 2001, Rosenkopf & Almeida 2003, Ahuja & Katila 2004). However, that literature does not explain how, precisely, heterogeneity produces innovation. Furthermore, heterogeneity in networks has two dimensions that are seldom explicitly distinguished. One is the number of firms involved, and the pattern of ties between them, and the other is the difference, in particular cognitive distance, between them. Between firms, in contrast with people, cognitive distance is the difference between the cognitive foci of firms, with two main dimensions of technological knowledge/competence and moral principles for internal governance.

A large steam of literature has indicated only the problems rather than also the benefits of such cognitive distance. In a study on alliance formation in the semi-conductor industry, Stuart (1998) argued that the most valuable alliances are those between firms with similar technological foci and/or operating in similar markets, whereas distant firms are inhibited from cooperating effectively. In a similar vein, the diversification literature argues that most is to be learned from alliance partners with related knowledge and skills

(Tanriverdi & Venkatraman 2005), or from areas that firms already possess capabilities in (Penner-Hahn & Shaver 2005). In the literature on international business also, a pervasive view is that cognitive distance is a problem to be overcome. Johanson & Vahlne (1977, 1990) employed the notion of 'psychological distance', which is seen as having an adverse effect on cross-cultural communication. When learning is discussed, in that literature, it is mostly seen as learning to cope with transnational differences, by accumulating experience in cross-border collaboration (e.g. Barkema et al. 1997), rather than taking those differences as a potential source of learning to change home country products or practices.

Nooteboom (1999) proposed an interaction between the advantages and disadvantages of distance, as follows. The ability to understand each other (in absorptive capacity) and to collaborate declines with cognitive distance, whereas the novelty value of the relationship, i.e. its potential to generate Schumpeterian novel combinations, increases with distance. If the two effects are linear with respect to distance, and if learning or innovation performance of the relationship is proportional to the mathematical product of novelty value and mutual absorptive capacity, the result is an inverted-U shaped performance as a function of distance, as illustrated in Figure 1. This implies an optimal cognitive distance, which is large enough for partners to offer each other something new, but not so large that they cannot understand each other or come to agreement.

Figure 1 about here

In Figure 1, the downward sloping line of absorptive capacity is not fixed. It is subject to an upward shift, as a function of the accumulation of knowledge in relevant fields and experience in IOR's. That yields a shift to higher optimal cognitive distance, as illustrated in the figure.

Wuyts et. al. (2005) put the hypothesis of optimal cognitive distance to two empirical, econometric tests. The first test was conducted on a combination of the basic hypothesis of optimal cognitive distance with the second hypothesis that cognitive distance decreases with increased frequency and duration of interaction. As argued by Gulati (1995) and others (Simmel 1950, McAllister 1995, Lewicki & Bunker 1996), familiarity may breed trust, which is good for governance. However, it may also reduce variety of knowledge, which is bad for innovative performance. This yields the hypothesis of an inverted U-shaped relation between radical technological innovation and the extent to which firms ally with the same partners over time. That hypothesis was tested on data on vertical alliances between biotech and pharma companies, and was supported.

In fact, the derived hypothesis is subject to nuance. If two partners have access to other, non-overlapping partners, so that they are continually being refreshed with new, non-overlapping knowledge, cognitive distance between them is maintained, so that the relationship may remain innovative even when it lasts long. This is, in fact, the point, or part of the point, of Burt's (1992) notion of bridging structural holes.

The second test by Wuyts et al. was conducted on a combination of the basic hypothesis of optimal cognitive distance with a second hypothesis that the likelihood of a collaborative alliance increases with the expected performance of collaborative

innovation. This yielded the derived hypothesis that the likelihood of an alliance for innovation has an inverted U-shaped relation with cognitive distance. That hypothesis was tested on data on horizontal alliances in ICT industries. Cognitive distance was measured by differences in degrees of specialization in different dimensions of technology, inferred from patent data. Partial support was found. Technology-related measures of cognitive distance were not found to have any significant effect, but several indicators of differences in firms' organizational characteristics proved to have the expected inverted U-shaped effect. Several considerations were offered to explain why organizational aspects turned out to be more important than technological ones in ICT industries.

Nooteboom et al. (2005) conducted a more complete empirical, econometric test, on the basis of a large set of data on inter-firm alliances over a ten-year period, in a variety of industries. Cognitive distance was reduced to technological distance, which was measured on the basis of correlation between profiles of technological knowledge composed from patent data. Innovative performance was measured as new patents, in successive years, with a distinction between exploratory patents, in new patent classes, and exploitative patents, in patent classes in which a firm already has patents. Absorptive capacity was made endogenous, in that the downward sloping line of absorptive capacity (cf. Figure 1) was taken as a function of cumulative past R&D. The hypothesis of performance as an inverse-U shaped function of cognitive distance was confirmed, including the further hypothesis that optimal distance is higher for exploration than for exploitation. The latter can de attributed to a higher slope of the novelty line, in Figure 1.

The study also tested for an effect of cumulative experience in alliances on absorptive capacity, but found none. It did yield an additional effect that was not hypothesized. The results indicated that cumulative experience in R&D not only raises the level of absorptive capacity (in an upward shift of the corresponding line, see Figure 1), but also that the upward slope of the line denoting novelty value decreased. This implies a principle of decreasing returns to knowledge, or a 'boredom effect'. The more knowledge one accumulates, the further afield one has to go, to more exotic sources or partners, to still learn something new.

Conclusion

This chapter explores the implications of a theory of embodied cognition for the fields of economics and management in general and for the theory of the firm and theory of innovation in particular. In general, embodied cognition yields a perspective for transcending the methodological individualism of economics and the methodological collectivism of sociology, in a principle of methodological interactionism, which may enable an integration of economics and sociology, in a new behavioural science.

Embodied cognition yields the notion of cognitive distance between people, which poses a problem of organization. In order to achieve a shared purpose, cognition must be aligned to some extent. This yields the notion of organization as a focusing device, in a reduction of cognitive distance between people. The boundary of an organization in general and a firm in particular is determined by the cohesiveness of organizational focus, i.e. the scope of cognition involved, and the tightness of cognitive alignment, together

with the legal form in which focus is embodied. Organizations vary in size, according to their range of activities and the cohesiveness of their scope.

Organizational focus yields myopia, which generally needs to be compensated in relationships with outside organizations, at a greater cognitive distance than within the organizations. Here, between organizations, cognitive distance is defined as differences in organizational focus. For learning by interaction, there is a trade-off between negative effects of cognitive distance, in lack of mutual understanding and ability to collaborate, and positive effects, in yielding cognitive variety as a source of Schumpeterian novel combinations. This yields the notion of optimal cognitive distance in interaction for innovation.

Many extensions and related issues could not be discussed in this chapter. The analysis of innovation by collaboration between firms extends into the analysis of network effects of structure and strength of ties (Gilsing & Nooteboom 2005). There is much more to be said about instruments of governance within and between firms. The analysis far from exhausts the potential of methodological interactionism. Embodied cognition yields the basis for a theory of invention as a function of shifts in context (Nooteboom 2000). It also yields an opening for the integration of insights from social psychology (Nooteboom 2002, Six 2004).

References

Ahuja, G., & R. Katila (2004). 'Where do resources come from? The role of idiosyncratic Situations'. <u>Strategic Management Journal</u>, 25(8-9): 887-907.

Almeida, P. & B. Kogut (1999). 'Localization of knowledge and the mobility of engineers in regional networks'. <u>Management Science</u>, 45(7): 905 –917.

Amin, A. & P. Cohendet (2003). <u>Architectures of knowledge: Firms, capabilities and communities.</u> Oxford: Oxford University Press.

Bachelard, G. (1980, 11th edition), <u>La formation de l'esprit scientifique.</u> Paris: J. Vrin.

Barkema, H.G., O. Shenkar, F. Vermeulen, & J.H.J. Bell (1997). 'Working abroad, working with others: How firms learn to operate international joint ventures',<u>Academy of Management Journal,</u> 40: 426-442.

Barkow, J., L. Cosmides and J. Tooby (1992). <u>The adapted mind: Evolutionary psychology and the generation of culture</u>, Oxford: Oxford University Press.

Berger, P. & T. Luckmann. (1967). <u>The social construction of reality</u>, New York: Doubleday.

Blackler, F. (1995). 'Knowledge, knowledge work and organizations: An overview and interpretation'. <u>Organization Studies</u>, 16/6, 1021-1046.

Bogenrieder, I. & B. Nooteboom (2004). 'Learning groups: what types are there?', <u>Organization Studies</u>, 25 (2004)/2: 287-314.

Brown, J.S. & P. Duguid (1991). 'Organizational learning and communities of practice: Toward a unified view of working, learning, and innovation', <u>Organization Science</u>, 2/1: 40-57.

Brown, J. S. & P. Duguid (1996). 'Organizational learning and communities of practice'. In M. D. Cohen & L. S. Sproull (eds.), <u>Organizational learning</u>, London: Sage: 58-82.

Brown, J. S. & P. Duguid (2001). 'Knowledge and organization: A social-practice perspective', <u>Organization Science</u>, 12/2: 198-213.

Burt, R. (1992). 'Structural holes: the social structure of competition', in N. Nohria & R. Eccles (eds.) <u>Networks and organizations: structure, form and action</u>. Boston: Harvard Business School Press: 57 - 91.

Chesbrough, H.W. (2003). <u>Open innovation: The new imperative for creating and profiting from technology</u>, Boston: Harvard Business School Press.

Choo, C. W. (1998). <u>The knowing organization</u>, Oxford: Oxford University Press.

Cohen, M.D. & L. S. Sproull (eds.) (1996). <u>Organizational learning</u>, London: Sage, 58 - 82. First printed in 1991 <u>Organization Science</u>, 2/1.

Cohen, M.D. & D.A. Levinthal (1990). 'Absorptive capacity: A new perspective on learning innovation'. <u>Administrative Science Quarterly</u> 35: 128-52.

Colombo, M.G. & P. Garrone (1998), 'Common carriers entry into multimedia services', <u>Information Economics and Policy</u>, 10, 77-105.

Damasio, A. R. (1995). <u>Descartes' error: Emotion, reason and the human brain</u>, London: Picador.

Damasio, A. R. (2003). <u>Looking for Spinoza</u>, Orlando: Harcourt.

Dellarosa, D. (1988). 'The psychological appeal of connectionism', <u>Behavioral and Brain Sciences</u>, 11/1, 28 - 29.

Dimaggio, P. (1997). 'Culture and cognition', <u>Annual Review of Sociology</u>, 23: 263-287.

Edelman, G. M. (1987). <u>Neural Darwinism; the theory of neuronal group selection</u>, New York: Basic Books.

Edelman, G. M. (1992). <u>Bright air, brilliant fire; On the matter of mind</u>, London: Penguin.

Eijck, J. van, & H. Kamp (1997). 'Representing discourse in context', in J. van Benthem and A. ter Meulen, <u>Handbook of logic and language</u>, Amsterdam: Elsevier: 179 - 237.

Fleming, L. 2001. Recombinant uncertainty in technological search. <u>Management Science</u> 47(1): 117-132.

Fodor, J. A. (1975). <u>The language of thought</u>, New York: Thomas Y. Crowell.

Frege, G. (1892). 'On sense and reference' (in German), <u>Zeitschrift fur Philosophie und philosophische Kritik</u>, 100: 25-50.

Geach, P. & M. Black (1977). <u>Philosophical writings of Gottlob Frege</u>, Oxford: Blackwell.

Gilsing, V.A. & B. Nooteboom (2005). <u>Density and strength of ties in innovation networks: An analysis of multi-media and biotechnology</u>. Paper in review.

Gulati, R. (1995). 'Familiarity breeds trust? The implications of repeated ties on contractual choice in alliances', <u>Academy of Management</u> Journal, 38: 85-112.

Habermas, J. (1982). Theorie des kommunikativen Handelns, Teil 1 und 2, (Theory of communicative action), Frankfurt: Suhrkamp.

Habermas, J. (1984). Vorstudien und Ergänzungen zur Theorie des kommunikatieven Handelns, (preliminary studies and elaborations to the theory of communicative action) , Frankfurt: Suhrkamp

Hagerty, M.R. (1999). 'Testing Maslow's hierarchy of needs: National quality of life across time', Social Indicators Research, 46/3: 249-271.

Hedberg, B. L. T. (1981). 'How organizations learn and unlearn', in P. C. Nystrom & W. H. Starbuck (eds.), Handbook of organizational design, New York: Oxford University Press, Vol. 3 - 27.

Hendriks-Jansen, H. (1996). Catching ourselves in the act: Situated activity, interactive emergence, evolution and human thought, Cambridge MA: MIT press.

Janssen, Th. M. V. (1997). 'Compositionality', in J. van Benthem and A. ter Meulen (eds.), Handbook of logic and language, Amsterdam: Elsevier, 417 - 73.

Johanson, J. & J. Vahlne (1977). 'The internationalization process of the firm – a model of knowledge development and increasing foreign market commitment', Journal of International Business Studies, spring/summer: 23-32.

Johanson, J. & J. Vahlne (1990). 'The mechanism of internationalization' International Marketing Review, 7/4: 11-24.

Johnson-Laird, P. N. (1983). Mental models, Cambridge: Cambridge University Press

Jorna, R. (1990). Knowledge representations and symbols in the mind, Tübingen: Stauffenburg Verlag.

Kogut, B. & U. Zander, (1992). 'Knowledge of the firm, combinative capabilities, and the replication of technology', Organization Science, 3: 383- 397.

Kolb, D. 1984. Experiential learning: Experience as the source of learning and development, Englewood Cliffs, NJ: Prentice-Hall.

Lakatos, I. (1970). 'Falsification and the methodology of scientific research programmes', in I. Lakatos and A. Musgrave (Eds.), Criticism and the growth of knowledge, Cambridge: Cambridge University Press.

Lakatos, I. (1978). The methodology of scientific research programmes; Philosophical papers vols. 1 and 2. edited by J. Worrall and G. Curry, Cambridge: Cambridge University Press.

Lakoff, G. and M. Johnson (1980). <u>Metaphors we live by</u>, Chicago: University of Chicago Press.

Lakoff, G. & M. Johnson (1999). <u>Philosophy in the flesh</u>, New York: Basic Books.

Lave, J. & E. Wenger (1991). <u>Situated learning; Legitimate peripheral participation</u>. Cambridge: Cambridge University Press

Lazaric, N. & E. Lorenz (Eds) (2003). <u>Knowledge, learning and routines</u>, Cheltenham: Edward Elgar, 2003

Lewicki, R.J. & B.B. Bunker (1996). 'Developing and maintaining trust in work relationships', in R.M. Kramer T.R. Tyler eds , <u>Trust in organizations: Frontiers of theory research</u>, Thousand Oaks: Sage Publications: 114-139.

Lewontin, R. (1983). 'The organism as the subject and object of evolution', <u>Scientia</u>, 118: 63 - 82.

Lundvall, B. A. (1988). 'Innovation as an interactive process: from user-producer interaction to national systems of innovation', in G. Dosi, C. Freeman, C. Nelson, R.

Maslow, A. (1954). <u>Motivation and personality</u>. New York: Harper.

Meindl, J. R., C. Stubbart & J. F. Porac (eds.), <u>Cognition within and between organisations</u>, London: Sage.

Merleau-Ponty, M. (1942). <u>La structure du comportement</u>, Paris: Presses Universitaires de France.

Merleau-Ponty, M (1964). <u>Le visible et l'invisible</u>, Paris: Gallimard.

McAllister, D.J. (1995). 'Affect- and cognition based trust as foundations for interpersonal cooperation in organizations', <u>Academy of Management Journal</u>, 38/1: 24--59.

McClelland, J. L., D. E. Rumelhart and G. E. Hinton (1987). 'The appeal of parallel distributed processing', in D. E. Rumelhart, J. L. McClelland and the PDP research group, <u>Parallel distributed processing; Explorations in the microstructure of cognition, Vol. 1: Foundations</u>, Cambridge MA: MIT Press: 3-44.

Mead, G. H. (1934). <u>Mind, self and society; from the standpoint of a social behaviorist</u>, Chicago: Chicago University Press.

Nelson R. R. & S. Winter (1982). <u>An evolutionary theory of economic change</u>, Cambridge: University Press.

Nooteboom, B. (1992), 'Towards a dynamic theory of transactions', <u>Journal of Evolutionary Economics</u>, 2: 281 - 99.

Nooteboom, B. (1994). 'Innovation and diffusion in small business: Theory and empirical evidence', <u>Small Business Economics</u>, 6, p. 327-347. Reprinted 2002, in N. Krueger (ed.), <u>Entrepreneurship: Critical perspectives on business and management</u>, London: Routledge, Vol. III: 327-347.

Nooteboom, B. (1999). <u>Inter-firm alliances: Analysis and design</u>, London: Routledge.

Nooteboom, B. (2000). <u>Learning and innovation in organizations and economies</u>, Oxford: Oxford University Press.

Nooteboom, B. (2002). <u>Trust: Forms, foundations, functions, failures and figures</u>, Cheltenham (UK): Edward Elgar.

Nooteboom, B. (2004). 'Governance and competence, how can they be combined?', <u>Cambridge Journal of Economics</u>, 28/4: 505-526.

Nooteboom, B., W. Van Haverbeke, G. Duijsters, V. Gilsing & A. V.d.Oord (2005), <u>Optimal cognitive distance and absorptive capacity</u>, paper Academy of Management Conference.

Nussbaum, M.C. (2001). <u>Upheavals of thought, The intelligence of emotions</u>, Cambridge UK: Cambridge University Press.

Penner-Hahn, J. & J. Myles Shaver. 2005. 'Does international research and development increase patent output?', An analysis of Japanese pharmaceutical firms. <u>Strategic Management Journal</u>, 26: 121-140

Penrose, E. (1959). <u>The theory of the growth of the firm</u>, New York: Wiley.

Polanyi, M. (1962). <u>Personal knowledge</u>, London: Routledge.

Putnam, H. (1957). <u>Mind, language and reality: Philosophical papers</u>, Vol. 2, Cambridge: Cambridge University Press.

Ring, P. & A. van de Ven (1994). 'Developmental processes of cooperative interorganizational relationships', <u>Academy of Management Review</u>, 19/1: 90 - 118.

Rose, S. (1992). <u>The making of memory</u>, New York: Doubleday.

Rosenkopf, L. & Nerkar A. 2001. 'Beyond Local Search: Boundary-spanning, Exploration, and Impact in the Optical Disc Industry', <u>Strategic Management Journal</u>, 22: 287-306.

Rosenkopf, L. & Almeida. P. 2003. 'Overcoming Local Search Through Alliances and Mobility', <u>Management Science</u>, 49:751-766.

Rumelhart, D. E., J. L. McClelland and the PDP research group (1987). <u>Parallel distributed processing; Explorations in the microstructure of cognition, Vol. 1: Foundations,</u> Cambridge MA: MIT Press

Rumelhart, D. E , G. E. Hinton and J. L. McClelland (1987). A general framework for PDP, in D. E. Rumelhart, J. L. McClelland and the PDP research group, <u>Parallel distributed processing; Explorations in the microstructure of cognition, Vol. 1: Foundations,</u> Cambridge MA: MIT Press: 45 - 76.

Schein, E. H. (1985). <u>Organizational culture and leadership</u>, San Francisco: Jossey - Bass

Searle, J.R. (1992). <u>The rediscovery of the mind</u>, Cambridge MA: MIT Press.

Shanon, B. (1993). <u>The representational and the presentational</u>, New York: Harvester/Wheatsheaf

Shanon, B (1988). 'Semantic representation of meaning: A critique', <u>Psychological Bulletin</u>, 104/1, 70 - 83.

Simmel, G. (1950). <u>The sociology of Georg Simmel</u>, Translation Kurt Wolff, Glencoe Ill.: The Free Press.

Simon, H. A. (1983). <u>Reason in human affairs,</u> Oxford: Basil Blackwell.

Six, F. 2004. <u>Trust and trouble; Building interpersonal trust within organizations,</u> PhD dissertation. Erasmus University Rotterdam.

Smircich, L. (1983). 'Organization as shared meaning', in L. R. Pondy, P. J. Frost, G. Morgan and T. C. Dandridge (eds.), <u>Organizational symbolism</u>, Greenwich Conn: JAI Press: 55 - 65.

Smolensky P. (1988). 'On the proper treatment of connectionism', <u>Behavioral and Brain Sciences</u>, 11, 1 - 74.

Stuart, T. (1998). 'Network postions and propensities to collaborate: an investigation of strategic alliance formation in a high-technology industry', <u>Administrative Science Quarterly</u>, 43: 637-668

Stuart, T. & Podolny J. (1996). 'Local search and the evolution of technological capabilities', <u>Strategic Management Journal</u>, Summer Special Issue 17: 21–38.

Tanriverdi, H. & N. Venkatraman (2005). 'Knowledge relatedness and the performance of multibusiness firms', <u>Strategic Management Journal</u>, 26: 97-119

Thiel, C. (1965). <u>Sinn und Bedeutung in der Logik Gottlob Frege's</u>, Meisenheim am Glan: Anton Hain.

Thompson, J. D. (1967). <u>Organizations in action</u>, New York: McGraw-Hill.

Vygotsky (1962). <u>Thought and language</u>, edited and translated by E. Hanfmann and G. Varkar, Cambridge MA: MIT Press.

Weick, K.F. (1979). <u>The social psychology of organizing</u>, Reading, MA: Addison - Wesley.

Weick, K.F. (1995). <u>Sensemaking in organisations</u>, Thousand Oaks CA: Sage.

Weintraub, E. R. (1988). 'The neo-Walrasian program is progressive', in N. de Marchi (ed.), <u>The Popperian legacy in economics</u>, Cambridge: Cambridge University Press.

Wenger, E. & W. M.Snyder, (2000). 'Communities of practice: The organizational frontier', <u>Harvard Business Review</u>, jan-feb: 139-145
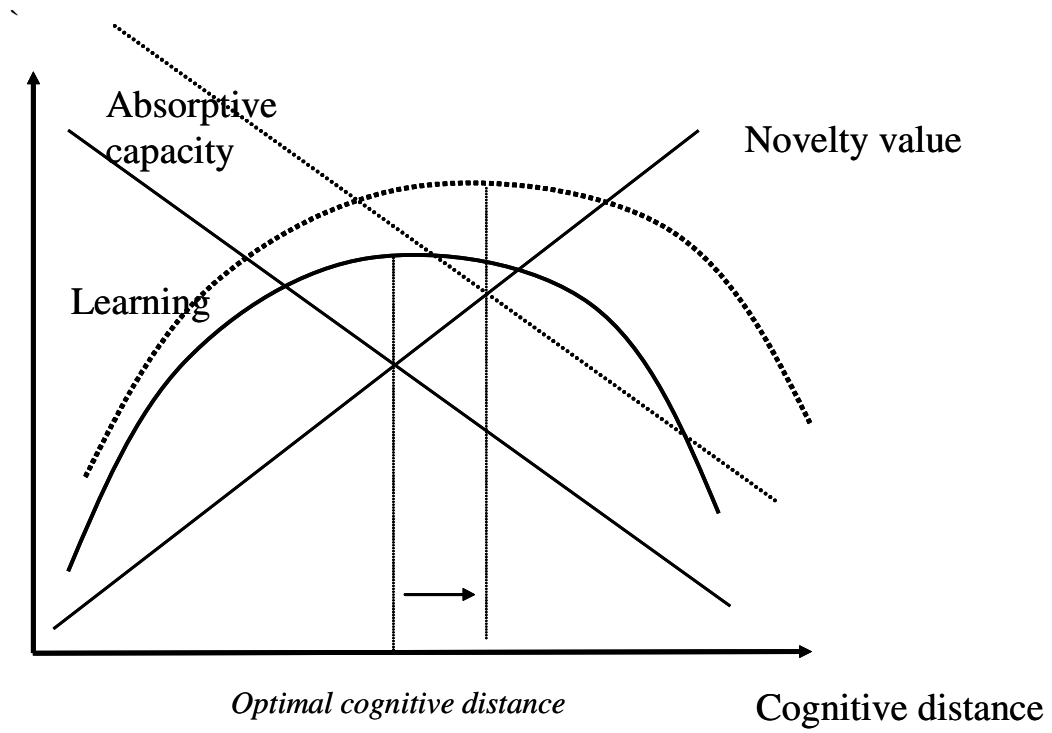
Werner, H. & B. Kaplan (1963). <u>Symbol formation</u>. New York: Wiley.

Winograd, T. (1980). 'What does it mean to understand language?', <u>Cognitive Science</u>, 4, 209 - 41.

Wittgenstein, L. (1976) (first published in 1953). <u>Philosophical investigations</u>, Oxford: Basil Blackwell.

Wuyts, S, M.G. Colombo, S. Dutta & B. Nooteboom, (2005). 'Empirical tests of optimal cognitive distance', forthcoming in <u>Journal of Economic Behavior and Organization</u>.

Figure 1: Optimal cognitive distance

Optimal cognitive distance

Source: Nooteboom (1999)