The final contribution to this section is by Rogers Hollingsworth and Ellen Jane Hollingsworth. Based on comparative and narrative methods, as well as a historical approach, the authors examine which structural and cultural characteristics of research organizations influence the making of major discoveries in twentieth-century biomedical sciences. A comparison of institutions with different success rates and at different times in their history yields a portrait of the central properties of research organizations that are associated with scientific breakthroughs. Two extensive case studies of highly integrated but small research institutes are presented in detail. The examples of the Rockefeller Institute/University and the California Institute of Technology indicate that two concepts are significantly associated with repeated major discoveries: interdisciplinary and integrated culture across diverse fields of science, and a leadership form that gave particular attention to creating and maintaining a nurturing environment accompanied by rigorous standards of scholarship.

As research organizations respond to the growing complexity of fields of knowledge and increase in size and diversity, they tend to experience more social and cognitive differentiation, which is in turn accompanied by increases in hierarchy and bureaucratic coordination. These transformations tend to be associated with a decline in the possibility of major discoveries, although they may lead to the production of a significant number of scientific papers. Hollingsworth and Hollingsworth discuss strategies for adding diversity and enhancing integration in such large research organizations.

Beyond One’s Own Perspective: The Psychology of Cognitive Interdisciplinarity

RAINER BROMME

Only rarely has interdisciplinary thought and behaviour been made the object of empirical-psychological research. Existing empirical studies on work in research laboratories have mostly been carried out from a microsociological perspective and are based mainly on qualitative methods. In addition, there have been surveys and case studies by researchers about experience with interdisciplinary research, as well as bibliometrical studies (Kocka 1987; Klein 1990, 1996; Weingart 1995a; Parthey 1996). In contrast, psychological studies on the conditions and processes of interdisciplinarity are virtually absent.

In what does a specifically psychological perspective on interdisciplinarity consist? In this essay, I will try to answer that question. My intention is to sketch some empirically treatable questions on the cognitive conditions and processes of interdisciplinary thought and activity. The first part will discuss some obvious psychological variables, like the individual traits of the researchers involved in interdisciplinary projects. It will be shown, however, that the factors that at first glance are considered to be psychological do not really represent a viable approach to the psychological analysis of interdisciplinarity. Instead, I would like to make the differences between disciplinary (and subdisciplinary) conceptual structures the principal point of departure. Hence, I propose to analyse interdisciplinarity by way of a research focus on the processes of confrontation between different structures of knowledge, or perspectives.

For the sake of developing a psychological approach on interdisciplinarity, the phenomenon of interdisciplinarity will be reduced to the cognitive prerequisites and consequences of communication between interacting persons endowed with different conceptual structures. The
confrontation of different perspectives is a condition for any kind of cognitive development (cf. Schön 1963), both in interdisciplinary dialogue and in individual thought. Even where individual thought tackles a new perspective, an encounter of hitherto different perspectives occurs. Nevertheless, the following analysis will be confined to the confrontation of perspectives taken by at least two persons.

Why Personality Variables Do Not Offer a Viable Approach for Psychological Studies of Interdisciplinarity

From the perspective of other disciplines, psychology is commonly expected to analyse the personal conditions of human activity. In order to understand why humans differ in their actions and views, why some relate well to others while some have difficulties doing so, one must get to know people's individual traits and motives. Psychology is expected to provide an analysis of such personal traits.

The debate on interdisciplinarity contains many hints that personal traits matter in interdisciplinary work. One example is the identity or ego-strength of the persons that may collaborate. Often, interdisciplinary work is like moving about in foreign territory. Participants in such work must have sufficiently strong personal identities to abide with situations where fundamental assumptions about the legitimacy of their own discipline-specific views are challenged, or where the latter's self-evidence remains at least unaccepted (cf. Schneider 1988). Furthermore, the self-assertiveness and self-confidence of scholars is supported by their being well qualified in their own disciplines, a feature consistently emphasized in the discourse on interdisciplinarity.

On the other hand, however, the very specialization obtained in a long process of professional training and the identity formation connected with it can be problematic for interdisciplinary cooperation (Hubenthal 1991: 150). The essential prerequisites, these authors suggest, are to partially dissolve traditional disciplinary views and to accept new or different problem definitions. There is also the hypothesis that a strong personal identification with and commitment to one's own discipline may impede openness for the perspectives represented by other disciplines. The debate on interdisciplinarity thus calls for properties that concern the very ability to stand back from one's own attitudes and experiences. In the best of cases, both features are presumably combined in one person: a stable disciplinary identity and flexibility. There is no contradiction between these requirements - they are an expression of the necessary tension to which an individual is exposed in interdisciplinary work.

Among the personal traits of a scholar that are deemed to be conducive to interdisciplinary research are 'reliability, flexibility, patience, resilience, sensitivity to others, risk-taking, a thick skin, and a preference for diversity and new social roles' (Klein 1990: 183). In addition, personality traits that are requirements for dealing with representatives of other disciplines (or, for that matter, inhabitants of other territories) are tolerance for ambiguity, willingness to learn new things, and ability to engage in divergent thinking. Curiosity and courage are also important, as are modesty and the ability to subordinate one's own personality and views to new goals that are at least partly controlled by outsiders (foreigners). In his report on his experience with an interdisciplinary project at the Bielefeld Center for Interdisciplinary Research (ZiF), Klaus Immelmann (1987: 86) named the necessity of abandoning 'imposing behavior' as a second objection against a trait-oriented approach to the psychology of interdisciplinarity.

Two critical objections come to mind upon considering this list of personal traits. The first concerns the stability and predictive validity of these personal traits. The second relates to the specificity of these traits for interdisciplinarity.

The theoretical constructs of 'cognitive flexibility,' 'rigidity,' and 'tolerance of ambiguity' were developed in personality research to describe stable interindividual differences (traits) between persons and thus also to predict differences in behaviour. To this purpose, questionnaires were constructed to measure how marked a trait is in a person. What emerged, however, is that the actual behaviour that is assumed to reflect traits is very dependent on situation and on context. Therefore the predictive value of interindividual trait differences for interindividual behavioural variance is relatively low. This is a significant result that contradicts everyday folk psychology. Actually, people in everyday life tend to systematically underestimate the situation-specific variability and temporal instability of behaviour preferences in themselves and others (Norem 1989; Mischel 1990).

A second objection against a trait-oriented approach to the psychology of interdisciplinarity follows from its lack of specificity for interdisciplinary communication and cooperation. Would it be possible to make decisions on how to compose interdisciplinary teams on the basis of personality tests? It is obvious that traits such as tolerance of ambiguity or creativity are not exclusively or specifically required for interdisciplinary work. Interpersonal communicative skills (ability to listen, toler-
The concepts of the personality trait approach are simply not sufficiently specific for a psychological analysis of the preconditions for and the processes of interdisciplinary communication and cooperation.

The conclusion is that looking for stable personal conditions (personal traits) for interdisciplinary thought and activity does not represent a viable approach for psychological research into interdisciplinary. Nevertheless, neither the phenomenological nor the practical significance of flexibility and ambiguity tolerance for interdisciplinary communication and cooperation can be disputed. This essay will attempt to reconstruct these dimensions by taking the conceptual structures of researchers as a point of departure for understanding interdisciplinarity.

The psychological approach to interdisciplinarity sketched here, however, has been prompted not only by the above difficulties encountered with the trait approach in psychology. It is also founded in the assumption that communication between different conceptual structures is the core of interdisciplinarity itself (see also Maasen, Weingart, this volume). Communication between individuals endowed with different conceptual structures is not simply a precondition for attaining interdisciplinary insights, but is an essential component. If such processes are analysed with psychological methods and concepts, such an approach, while remaining discipline-specific (and one-sided thus far) is also concerned with a prime topic of the discourse on interdisciplinarity: the question of how new insights emerge from interdisciplinary research. This is why I designate the psychological analysis of the confrontation of different conceptual structures the psychology of cognitive interdisciplinarity.

The Interaction between Different Perspectives: Interdisciplinarity’s Cognitive Core

The concepts of curiosity and ambiguity and the tension within a personal identity (which is both stable and flexible) already point towards the cognitive core of interdisciplinarity: the semantic (sometimes also syntactic) diversity of the knowledge systems introduced into the interdisciplinary interaction by the participants. This diversity is both motive (‘overcoming specialization,’ cf. Klein 1990) and condition for attaining the productive border-crossings of which interdisciplinary research consists in its most productive sense (Weingart 1995b).

While the knowledge offered by the participants should be different, it should also show enough interfaces to permit linkage or at least contact with the concepts and methods resulting from an interdisciplinary discourse. This also means that the boundary between disciplinary and interdisciplinary is flexible, because it depends on the participants’ specific knowledge systems.

‘Knowledge’ in this context does not only comprise special methods or concepts, but also the epistemic styles typical for a discipline or a domain of research activities. Referring to a certain discourse in social as well as in developmental psychology, this kind of knowledge will be called ‘perspective’ in what follows (Markova, Graumann, and Froppa 1995).

We will use the difference of perspectives as a point of departure for the psychological study of interdisciplinarity. The next two sections will be concerned with the question of how mutual communication and comprehension are possible at all in the presence of different perspectives. In the final section, this question will in a sense be reversed by asking why the difference of perspectives can in fact favour the creation of new knowledge.

Communication and Difference of Perspectives: The Theory of ‘Common Ground’

In everyday communication, interaction partners encounter different perspectives. As everyday perception of facts and events depends on the categories we bring to a certain situation, the question of how mutual comprehension in the case of different perspectives is possible arises here as well.

The ‘common ground’ theory tries to find an answer to this question (Clark 1992, 1996). As the significance of subjective construction for perceiving, seeing, and acting became evident in cognitive psychology, it also became clear that successful communication by individuals having different perspectives is a phenomenon requiring explanation. The common ground theory postulates that every act of communication presumes a common cognitive frame of reference between the partners of interaction called the common ground. The theory postulates further that all contributions to the process of mutual understanding serve to establish or ascertain and continually maintain this common ground.

In the following analysis, the description of common ground theory is reduced to the situation of an encounter between two active individuals. Basically, however, common ground theory also applies to writ-
ten communication (e-mail is a quite recent example), to communication among more than two individuals, and to asymmetrical communication, as in a lecture.

The common ground theory assumes that any verbal encounter represents an act of cooperation: When we communicate, we do so to attain a certain goal, to respond to – in most cases – an unspoken question (cf. von Stutterheim and Klein 1989). All contributions to communication are formulated and understood on the basis of background assumptions we make about the situation in question, the object of conversation and its goal: 'Two people's common ground is, in effect, the sum of their mutual, common, or joint knowledge, beliefs, and suppositions' (Clark 1996: 93). This also includes assumptions about the interlocutor's situation and views. If I tell a secretary, 'Please prepare the letter for me,' I assume that we both know which letter is meant, where it is supposed to be prepared, when this should be done, and so on. One's own assumptions on which the conversation is based are designated as one's own perspective and that of the other person as perspective of the other. The common ground also contains a reflexive element; that is, we know that we have a certain perspective about the object and the context of the conversation while knowing that the interlocutor has his or her view as well. These assumptions about the view of the partner of communication are called the presumed perspective of the other. The logically iterative continuation 'A knows that B knows that A knows' normally is not significant for planning and realizing verbalizations. Reflexivity is usually confined to one step; it is part of one's own self-awareness and one's integration into the social environment.

**Categories of People as Sources of Information about Common Ground**

How do people attain a common ground if they meet for the first time or, if they are already acquainted, have not yet talked about the topic of conversation? Clark (1996) distinguishes between two sources of information in such a context: first, the stereotypical presumptions that are activated on the basis of one's own categorization of the interlocutor (communal common ground), and second, the immediate personal experience within the conversation (personal common ground).

The communal common ground is based on categories concerning the interlocutor's cultural, social, vocational, and local background; his or her gender, age, education, and profession; and social roles that are intuitively assessed. These categories result in assumptions about the communal common ground, such as which expertise can be assumed, which language can be used, and so on. Talking about a conflict within my department to a colleague from another university, I use different formulations from those I use when talking about the same episode to my neighbour who has nothing to do with universities in his vocational life. Stereotypical information is usually correlated, making the intuitive 'computational effort' necessary for choosing and forming hypotheses about the knowledge that can serve as common ground in conversation smaller than might be supposed from the long and nevertheless incomplete list of stereotypical information.

Kingsbury (1968, quoted in Krauss and Fussell 1991) has empirically demonstrated the effect of stereotypical information about the conversation partner in an experiment that can be replicated by anyone. He had a trained subject ask for directions to a well-known Boston department store. Depending on the accent (home vs. foreign accent) and on phrasing that betrayed whether the person asking for directions was a Boston resident or not, the answers differed in length and detail; that is, the directions given were based on different assumptions about the common ground of familiarity with the city.

The categories just named that determine how people are perceived (gender, expertise, background, etc.) refer to differences between groups of individuals. More general, ontological assumptions are also assumed as communal common ground in every conversation. These concern, among other things, the distinction between animate and inanimate objects, between causes and events, and between word/sign and the signified. Only a conflictual situation will reveal that all contributions are based on generally shared ontological assumptions. This can be observed, for example, in communication with children who, up to a certain age, differ from adults in drawing the boundary between the animate and the inanimate world (see Keil 1989).

As far as personal knowledge is concerned, our assumptions about what our interlocutor knows (i.e., the presumed perspective of the other) are to a large part based on what we know ourselves and on what we believe to know. When I am scanning my memory for certain information, for instance, I am able to assess rather well beforehand whether I really have this knowledge, even if I have not yet reactivated the information itself. This 'feeling of knowing' also is the basis of assumptions about which information we may expect in other people (Jameson et al. 1993). Krauss and Fussell (1991) have presented images of public figures in the United States to students, asking them to judge how many
of their fellow students would be able to identify these persons. In addition, Krauss and Fussell empirically established how many students actually knew these public figures. A rather high correlation between the presumed perspective of the other and the actual social distribution of this information was found, as well as a tendency among subjects to overestimate the distribution of information they knew themselves. This is the so-called ‘false consensus effect’ (Ross, Greene, and House 1977).

THE PROCESS OF GROUNDING

The stereotypical assumptions brought to the situation by the interlocutors constitute only the starting point for establishing the common ground. The most important basis for developing the common ground are current common experiences and common activity (personal common ground). When I realize that my office neighbour hears the same students in the corridor, I may presume that this perception belongs to our common ground. I may for instance remark, 'They are loud today' and be sure that he knows whom I mean (but not that he shares my sensation). If we both tell the students to calm down a bit, this event will belong to the common ground of our experiences. The particular history of jointly seen episodes and jointly executed actions forms the basis of knowledge for the momentary formation of assumptions about the common ground.

The sources of information just described form the knowledge basis for getting at the required concrete and specific assumptions about the common ground pertaining to the particular topic of conversation or for establishing this common ground from scratch. Clark (1996) designates the establishment of common ground as ‘grounding.’ If interlocutors, for instance, agree on a concept’s referential context, this is a process of grounding. This happens, for instance, as the result of activities designed to point out objects.

In oral, direct communication, we have a comprehensive repertoire of signs at our disposal to agree on the actual status of the common ground used mutually to inform one another whether the flow of conversation can be continued or whether ‘repair measures’ must be undertaken to re-establish the common ground. This is done by changing emphasis, by using assertive terms like ‘ugh,’ ‘yeah,’ by repeating parts of phrases while changing the accent to a question or exclamation mark, by making speech pauses, and by varying the length of our verbalizations until we signal that we expect the other person to take a turn.

Clark’s theory of common ground has not remained without criticism. In particular, it has been questioned whether it is necessary that the common ground assumptions of the interlocutors actually agree. Everyday communication is often very imprecise, but it still works if we understand approximately what the interlocutor means (Johnson-Laird 1982; Sperber and Wilson 1986). Besides, it has as yet not been empirically shown how strong the presumptions about the common ground really influence the adaptation of verbalizations during conversation to the listener, the so-called ‘audience design’ or ‘recipient design’ of the contributions to communication (Krauss and Fussell 1990).

Against these objections, it may nevertheless be noted that a certain measure of common ground is indispensable, because a complete explanation of the intended meaning of a verbalization in interaction is both logically and psychologically impossible. Whether a real interpersonal agreement of the assumptions about common ground is required or whether the subjective conviction (the illusion of common ground) is sufficient also depends on the purpose of communication. If the purpose, for instance, is to coordinate activities, the common ground assumptions must at least partially agree. The potentially positive function of differences in perspectives and possible modes of coping with the illusion of common ground are discussed later in this essay.

The Theory of Common Ground as a Psychological Approach to Interdisciplinarity

The reports from interdisciplinary work groups contain many hints at initial difficulties of communication, and at the sometimes considerable amount of time that passes until a feeling of mutual understanding has been reached (see Hollingsworth and Hollingsworth, Klein, Maasen, and Scerri, all in this volume). Frequently, developing a common language and introducing colleagues from other disciplines to one’s own perspective are described as the key problems of interdisciplinary cooperation. These descriptions can be interpreted as indications of the problems that arise in creating a common ground of interaction. The reports about problems of understanding in interdisciplinary work groups show that the agreed-upon research topic as a rule does not suffice as common ground for further communication, since a large part of scientific work consists in the theoretical reconstruction and hence in the produc-
tion of the problems under study – in other words, in the continuous theoretical and methodical reconstruction of the object of research (see also Weingart, this volume).

If the distinctiveness of perspectives in the scientists concerned is the very constitutive feature of interdisciplinarity, then we must empirically examine the process of developing a common ground, that is, investigate grounding and its cognitive prerequisites. The theory of common ground, however, has been developed for everyday interactions and not for scientific communication, and must thus be tested as to whether it works as a heuristic for a psychology of interdisciplinary thought and activity. What empirical questions arise from this heuristic?

**Presumptions about the style of thought within the other discipline: one’s own perspective on the other**

Inquiring into the stereotypical representations and previous knowledge about the other disciplines with which scientists enter into interdisciplinary work situations offers a first approach for empirical analyses. The assumptions about the epistemic style (Weingart 1995b) or style of thought (‘denkstil’ in German; see Fleck [1935] 1979) of the other disciplines involved seem to be particularly promising. What do the participants know about the other disciplines’ mode of work and of arguing, what is deemed to be in need of justification, what is considered presupposed, which type of data and proof are accepted, and how important historical change is within the other discipline?

A proven method of mutually establishing such representations about the other disciplines is the qualitatively oriented interview (see Hollingsworth and Hollingsworth, and Scerri, this volume). One of the difficulties of such an approach is that the epistemic style a discipline honours is itself no homogeneous corpus of knowledge (cf. Klein, this volume). Therefore the normative pattern that is necessary as background to understand the more personal, sometimes idiosyncratic ‘versions’ of a discipline’s epistemic style is difficult to reconstruct. Epistemic style also comprises the practice of obtaining scientific insights, not only their normative theory. On the other hand, it is possible to conduct such interviews, as they can be confined to such aspects of another discipline that might potentially be critical for the intended cooperation.

Which aspects of epistemic style are of particular interest here? First, we are interested in those components of epistemic style that found or reflect differences in the social status of scientific disciplines. Summing up studies on the social psychology of interdisciplinary cooperation, Klein (1990: 127) reports: ‘Teamwork has been compromised by the disdain scientists have for engineers, mathematicians for physicists, pure scientists for applied scientists, physical scientists for social scientists and humanists and vice versa.’ As a discipline’s epistemic style contains a significance guiding both activity and cognition and thus also a normative component, it may well be expected that it contributes to stereotypes of this kind. This again affects how open-minded a researcher will be about data, proofs, and refutations obtained on the basis of other epistemic styles.

We have a second interest in the assumptions about duration and conditions of the learning processes typical for the discipline concerned or, in other words, its implicit theory of learning and education. If a discipline, for instance, stresses the role of intuitively obtained insights over empirical experience, this is sometimes accompanied by notions of giftedness, that is, by a widespread presumption that the partner in cooperation coming from another discipline must be similarly ‘gifted’ in a particular way (say, mathematically) to be able to understand the concepts alien to his or her own field.

Third, we are interested in the metatheoretical conceptions about interdisciplinarity itself. The discourse on interdisciplinarity (in this volume as well) contains views according to which successful interdisciplinarity depends on a large number of personal and institutional margin conditions and is thus bound to be a special case that cannot be significantly influenced, as well as the view that there is in principle no difference between problems of interdisciplinary communication on the one hand, and problems and features of the discourses taking place within the disciplines concerned on the other. These views are again influenced by the epistemic style of the discipline concerned, and it is reasonable to expect that they are significant for interdisciplinary communication.

Empirical analysis both of one’s own perspective and of the presumed perspective of the other is a way of getting beyond understanding the differences in status and obstacles to communication merely as a problem arising from the individual psychologies of the participating scientists. It is useful to be able to empirically reconstruct the extent to which stereotypes about other people as well as lack of open-mindedness in oneself is enhanced or maintained by one’s own epistemic styles. To the individuals involved, personal stereotypes often appear as indi-
vidual attitudes and biases (resulting from traits) that can only be countered by an appropriate selection of researchers. The proposal sketched here aims at clarifying empirically the extent to which personal stereotypes about other disciplines are also based on epistemic style assumptions in interdisciplinary communication.

ASSUMPTIONS ABOUT THE SOCIAL DISTRIBUTION OF ONE’S OWN KNOWLEDGE: THE PRESUMED PERSPECTIVE OF THE OTHER

As described above, we base our everyday-life hypotheses about common ground on our own feeling of knowing while tending to overestimate the distribution of our own knowledge and our own beliefs (the false consensus effect). The presumed exclusive character of his or her own professional knowledge, however, is part of the scientist’s self-awareness as a specialist. This raises the intriguing empirical question as to what perspective is presumed in the other: What presumptions do the members of an interdisciplinary team have about the social distribution of their own knowledge among colleagues coming from other disciplines?

It may be assumed that there are discipline-typical conceptions about the degree of exclusiveness of access to the disciplinary knowledge in question, and that these conceptions are also influenced by the public discourse about the role of the discipline in question within a given culture. Thus, disciplines like mathematics or philosophy with basic elements of knowledge are considered to be part of general education; these basic elements are part of the standard curriculum in schools. For other disciplines, such as engineering or linguistics, this is not true. Besides, considerable interpersonal differences are to be expected according to the degree of personal experience with the other’s perspective.

An interesting question is whether there is a false consensus effect in spite of the exclusiveness that is constitutive for scientific knowledge. We have started a series of studies aiming for an answer to this question. Up to now we have obtained mixed results: Interviewing professionally experienced architects, we found examples of substantial overestimation as well as a few examples of underestimation of the distribution of architectural knowledge among laymen (Bromme and Rambow 1995). This result is surprising, since the exclusiveness of professional knowledge is constitutive for the concept of ‘expert’ not only.

in the relationship between disciplines, but also in that between expert and lay knowledge (Stehr 1994; Bromme and Tillema 1995).

Grounding and Developing a Common Language

The empirical survey of the actual and of the presumed perspective of the other sketched in the previous sections concerns only the cognitive prerequisites (the communal common ground) for an emerging development of a common understanding between the various interlocutors, that is, for the grounding process. Another empirical question is how the personal common ground is negotiated between partners of interaction that have different cognitive perspectives. To a considerable degree, the burden of such negotiation is on verbal and non-verbal signals of understanding well known from everyday communication. While these are of practical importance in interdisciplinary communication, they are of no further interest in our context here.

In everyday communication, a part of grounding consists in negotiating a shared referential context for the concepts used, and under some circumstances also in developing a new terminology (Isaacs and Clark 1987; Garrod and Doherty 1994). Newly established work groups spend some time developing a group-specific language of their own in order to inform one another about the meaning of disciplinary concepts and to facilitate certain terminological clarification. In interdisciplinary communication, differences in common ground are frequently discovered only when the partners of cooperation find out that they use the same concepts with different meanings, or that they use different codings (terms, symbol systems) for approximately the same concepts. The discourse on interdisciplinarity contains many examples of the fact that participants experience this discovery as a burden, and cope with it as a process of mutual misunderstanding.

The elaboration of a common, group-specific language is an empirical phenomenon that suggests other empirical investigations.

First, we need to know how the development of a language used for mutual information about the respective disciplinary perspective is revealing, that is, how signals about the establishment of a common ground are exchanged.

Second, it is important to analyze the cognitive function of the emergence of new terminology, that is, the process within which terms originally only introduced for purposes of fixing references and thus assur-
ing a minimal common ground are gradually filled with intensional meaning. If the development of a group-specific disciplinary language leads to new theoretical concepts, this is an example of the possible cognitive effects of grounding. In the next section, this process will be examined in more detail.

Third, the communicative function of a new terminology for the process of establishing a new field (if interdisciplinarity results in the development of new disciplines) must be analysed. It is fascinating to investigate the reinterpretations of already established terminology as well as the formation of new, group-specific concepts that can transmute into a disciplinary language of their own in relation to outsiders.

On the Uses of Differences in Perspective

It is obvious that a successful agreement on a common terminology in interdisciplinary communication does not dissolve the differences in the disciplinary perspectives. This would not even be desirable. However, this raises the question of how interaction is possible in case of - at least partly - different assumptions about the common ground. I will attempt to sketch an answer by means of the concept of linguistic division of labour.

In the above presentation of the theory of common ground, it has already been pointed out that the assumptions of the interlocutors on the common ground need not agree. Up to a certain degree, an illusion of the common ground will suffice. Several empirical studies have shown that speakers like to shift the burden of understanding to the listeners. Phrasing occurs without regard for special assumptions about the audience, while setting trust in the feedback that will provide occasions for corrections (cf. Krauss and Fussell 1991; Horton and Keyser 1996). Schober (1993) found that individuals will speak in a mode less adapted to their audience if they recognize that the listeners will be able to give feedback than if this opportunity is clearly excluded.

The common ground can also be composed of knowledge that is distributed among the participants of an interaction. It need not be cognitively represented to the same extent and the same content in every participant. Common ground is also socially distributed knowledge (Hutchins 1995). The socially distributed character of common ground explains why interdisciplinary communication cannot (and should not) dissolve the differences between the participants' perspectives but may even benefit from these differences and, as a result, retain such asymmetries in knowledge. Common ground can also comprise agreement on what is not part of the shared knowledge and therefore will fall among the responsibilities of the partners in interaction.

Metaphors as Tools for a Linguistic Division of Labour

The discourse on interdisciplinarity emphasizes the role of metaphors to explain how new insights can arise from the interaction between different perspectives (Klein 1990; Bono 1995). The principle of borrowing is described as one of the fundamental cognitive mechanisms on the basis of which novel insights are produced in interdisciplinary communication.

In agreement with recent approaches in cognitive psychology to metaphors (Lakoff 1987; Gibbs 1994; for a critical position on this view of metaphor: Murphy 1996), metaphors are conceived of, in this context, primarily not as linguistic means but rather as cognitive units of categorical perception, not primarily as tools for illustrating messages but rather as fundamental categories of experience. It is thus clear that metaphors assume a central role not only in interdisciplinary research but also within single disciplines in that they are not only necessary for the 'large-scale' revolution of theories, but also indispensable in everyday research work (cf. Knorr-Cetina 1981).

In our context, the focus should be on a certain variant of metaphors that has been emphasized by Lakoff (1987): metonymies. From a linguistic point of view, metonymies are not metaphors, but the two are distinct types of synecdoches. It is reasonable under cognitive aspects, however, to treat metonymies as variants of metaphors. In case of a metonymy, certain aspects of meaning of a more comprehensive concept are used as placeholders for the whole concept. For example, in the statement 'Bosnia must not become a second Vietnam for the American army,' Vietnam stands for a complex historical event.

The use of metaphors in their metonymic function helps to explain how communication is possible in interdisciplinary research even in the presence of distinct theoretical perspectives. The different perspectives of the participants attach to the jointly used metaphor need not be dissolved even in long-term cooperation. Each of the participants may work with his or her own use of the concept, and there is no compulsion to totally integrate or unify the meanings of concepts.

In his analysis of 'meaning of meaning' Putnam (1975) has pointed out that our intuitive assumptions about a concept's meaning are based
on our knowing that there is a linguistic division of labour. We know that a part of the meaning of the concepts we use is rather more precisely or differently defined - that is, known by specialists - and that we lack their knowledge. Nevertheless, we can use these concepts without difficulty, and we can as a rule defer to the specialists by consulting an encyclopaedia or an expert. Putnam illustrates this point by means of the concept of water. We know that there is a certain chemical definition for water and that it has physical properties that experts can explain, but we do not need to know all these meanings in order to use the concept (Malt 1994).

The communicative implications of the 'linguistic division of labour' have not yet been analyzed. It must be clarified empirically, for example, whether individuals can anticipate how certain concepts can be used when they are at odds with another person's perspective. Especially for well-defined concepts (from science, technology, or mathematics) it must be established whether experts are able to anticipate that these concepts may have an at least partly divergent meaning for non-specialists. We have carried out an empirical study on this subject that demonstrates how data on this question can be obtained (Bromme, Rambow, and Wiedmann 1998).

In the first step our study contributed to a question that is discussed in psychological research on concepts. Can differences in typicality like those found in everyday concepts also be established in the case of precisely defined natural science concepts? Thirty-two chemists from laboratories of a university chemistry department were asked to assess instances of the concept 'acid' on a scale judging how typical the examples are for the general concept of acid. It was shown that hydrochloric or sulphuric acid is considered to be very typical. With respect to other concrete examples, however, there is agreement that there are less typical samples.

In a second trial, our subjects (laboratory chemists) were asked to rate the samples once more, this time from the presumed perspective of a chemistry teacher. The judgments changed in a systematic manner. Certain acid samples remained highly typical for the notion of acid, but depending on the theoretical type of acid there were also changes. These changes agreed with the practical significance of the acids for a chemistry teacher's work. Our results indicate that the subjects of our study had an intuitive understanding of the fact that different extensional aspects of the concept of acid are significant for chemists working within different vocational contexts. The study shows also how the influence of vocational perspective on certain extensional aspects of meaning can be measured, and that this is not only possible for concepts belonging to the humanities, for which a certain fuzziness of meaning might well be expected, but also for natural science concepts.

Concluding Remark

These experimental designs have been discussed for yet another, more practical reason. They are also suited to prompting the participants to reflect on their communication with other colleagues. As soon as somebody inquires into the presumed perspective of another on one's own specialized domain of knowledge, such an interview may prompt reflection on one's self as an expert or as a specialist. As soon as one obtains data on false consensus bias, communicating the data afterwards to the interviewed, this of course will influence their assumptions about the social distribution of their own knowledge. At least some of the empirical designs that have been sketched above can also be transformed into instruments for reflecting on and perhaps improving communication between inhabitants of different cognitive territories. The difference in perspectives is not only an impediment to understanding, but at the same time a condition of successful interdisciplinary communication.

Notes

Many thanks for helpful comments to Julie Klein, Matthias Nückles, Riklef Rambow, Elmar Stahl, and Nico Stehr.

1 In this overview of psychological conditions of interdisciplinarity, I shall also refer to my own personal experience during sixteen years of work as a psychologist at an interdisciplinary research institute for mathematics education, where my interaction was mainly with mathematicians, but also with social scientists and philosophers of science.

2 It is a recurring point of emphasis in the discourse on interdisciplinarity that researchers doing successful work in interdisciplinary research projects must at first develop outstanding excellence in their own field, and this also means a specialized one. Recently, however, some other views have been held. While it remains undisputed that a high personal qualification is required, this is not necessarily seen in a specialization that has been
acquired over a long time, but rather in a so-called 'profound' flexibility of disciplinary identities (cf. Gibbons et al. 1994; Turpin and Garrett-Jones, this volume). This difference of views is due to the fact that Gibbons et al. for instance, are primarily concerned with a scientific activity oriented towards practice (Mode 2 research), an orientation that has in part different cognitive prerequisites than basic (Mode 1) research (cf. Bromme and Tillema 1995).

3 See also Hollingsworth and Hollingsworth, Maasen and Scerri (all in this volume), who use similar notions to characterize both intellectual openness-mindedness and necessary excellence within one's own field.

4 Since Immelmann is a behavioural biologist, it can be assumed that the notion of 'imposing behavior' is based on some experiences within interdisciplinary work that reminded him of his observations of Canada goose and duck behaviour.

5 A similar shift from a trait-oriented focus to a cognitively oriented focus on conceptual structures as it is proposed here for the psychology of interdisciplinarity can be observed in psychological research on individual creativity (cf. Ward, Smith, and Vaid 1997).

6 The boundary is flexible for the very reason that there is already such a considerable differentiation and specialization within most of the traditional disciplines, as well as conceptual and methodological heterogeneity, that border crossing becomes necessary where representatives of the various subdisciplines intend to communicate (cf. Klein 1996 and this volume; Welgart, this volume). The boundary is also flexible because it repeatedly happens in the history of science that interdisciplinary approaches develop the typical social, institutional, and cognitive characteristics of disciplines such as described, for instance, for 'cognitive science' by De Mey (this volume).

7 Of course, talking to each other has additional functions in social interaction besides exchanging information. For example, talking may serve to regulate the social relationship between the partners of interaction. We may, however, do without these other dimensions here.

8 A rewarding source of information for the construction of questionnaires are the reports by scholars who are or have been members of two disciplines (cf. Kingsbury [1987] for interesting observations about the differences in the ways of thinking between psychologists and psychiatrists). As far as fundamental representations about the epistemological principles of the natural sciences are concerned, the survey inventories on 'science attitudes' developed in the context of research on science teaching also offer suggestions for constructing appropriate survey tools (Ledermann 1992).

9 The stereotypes underlying such or other differences in status are of course not only founded in the assumptions about the presumed or actual epistemic style of the respectively other and foreign discipline, but also reflect the social importance of disciplines and subdisciplines within a society. Accordingly, they are also subject to historical change. Just think of the presently occurring change in the status of biochemistry, which seems to supplement or replace physics as the leading science.

10 Latour and Woolgar (1979: 11) describe an example that illustrates the fact that this already occurs within subdisciplines. The concept of the 'illusion of common ground,' however, must not be taken literally here. What is meant is an assumption about the common ground that is based on knowledge about the linguistic division of labour and thus about the differences of meaning inherent in the concepts used. Such a reflexive illusion of common ground may serve to recognize the differences of meaning without perceiving them as mutual misunderstandings that must be dissolved before successful exchange can take place.

12 The result is revealing in itself, because it shows that an abstract and theoretically clearly defined concept like 'acid' is subjectively seen in close connection with certain of its instances, but in a more distant relation to other instances. This is remarkable for the fact that the abstract definition of acid of course holds in the same way for all of the samples used. From a logical point of view there should be no samples that are more typical or less typical in the light of a general and at the same time precise definition that holds true for all instances.