Structural Features of Language and Language Use

1 Introduction

While language is not only used for communication (think of thinking out loud, as in organizing one's thoughts), communication is one of the prime uses of language. And while communication is possible without language (think of gestures, signs, pictures, alarm sounds), language certainly facilitates communication, and arguably is necessary for the communication of complex content. Communication in turn is essential for the coordination of joint actions in groups or teams.

This chapter discusses language and communication behavior in groups in high-risk environments. Its purpose is to point the reader to studies that are relevant for such groups. The general way of thinking about communication developed in linguistics is important to appreciate the role communication plays for the coordination within a group, and for the way how a group copes with difficult situations. Its approach is rather eclectic, as communication has been approached from quite different angles, and with different means.

The chapter first introduces the notion of common ground, which is central for the understanding of communication. It goes on to discuss some specifics of human language that facilitate communication. Communication is then related to the threat and error management model that is central to the GIHRE project. It outlines the benefits, and potential problems, of standardization in technical settings. Then a number of theoretical frameworks for the study of communication are discussed: Speech Act theory, Conversation Analysis, and theories concerned with thematic coherence. Finally some specific problems of communication under stress and high work load are discussed. In general, the emphasis is on structural features of language and language use, as contrasted to language processing, which is the main topic of chapter 5.

2 Common Ground and Shared Mental Models

Understanding past and future behavior of others requires the ability to imagine how other persons perceive, think, and act. Such assumptions about the minds of others are called a theory of mind. Working together in a group is facilitated if each member of the group has a theory of the mind of the other members, which will also include the knowledge that others have a theory of the mind of oneself. The prime task of communication is to facilitate the establishment, maintenance and modification of such shared assumptions about each other's minds, the so-called

common ground (see Clark 1996 for discussion). Communication consists in particular in updating the common ground, that is, in adding information to it or modifying it in a way that is obvious to all members of the group. If such modifications are accepted, all members take it for granted that all members know that the modifications became part of the common ground, and will act accordingly. In this way, common ground is the basis for shared mental models that give coherence to the actions of a group (cf. Cannon-Bowers e.a. 1993).

What types of information do we find in the common ground? Everything the participants of the group uttered with the intention to be understood by the other participants, and whether or not this was understood often is indicated by acknowledgements like *okay*, verbal gestures like *mm-hm*, or non-verbal gestures like nodding). Such utterances may be factual claims, like *We have an underexcited fault light on number 3*, uttered by a pilot in an aircraft cockpit. Typically, if other participants do not contradict such claims, they become part of the factual knowledge of the common ground, and henceforward are taken to be known by all participants, and it is taken to be known that, in turn, all participants know that. Such utterances may be questions, like *Is the fault light still on?*, or commands, like *Switch essential power off of number 3*, which request certain kinds of actions by other participants – to give information that answers the question, or to perform non-linguistic acts that carry out the command. Crucially, the common ground does not only consist of factual knowledge that the interlocutors agreed on, but also includes the common goals and objectives, as well as the tasks that the interlocutors have agreed on to achieve these goals and objectives. We might call this the common agenda, but in the following we just see it as part of a more general notion of common ground.

Two remarks are in order here. First, not all attempts to modify the common ground, or the common agenda, are successful. The other group members may not understand the attempt to modify it, or may not understand it correctly, or they may refuse the proposed modification. In the latter case, the common ground will at least contain the information that one group member has, or had, a certain belief or certain intentions that did not become part of the common ground. Even if such contributions do not lead to a modified common agenda, they do lead to shared theories of the mental models of the members. Second, the common ground also changes by actions that are not primarily intended to communicate something. If a pilot reacts to an alarm signal in a way that the co-pilot can notice, the common ground will contain the information that the pilot recognized the alarm signal and reacted to it in a particular way. In many cases, acts of communication and other actions are tightly integrated, and the modification of common ground can only be properly understood if they are analyzed together.

Beyond the pieces of information that are modified in conversation, the common ground contains the huge background knowledge that is supposed to be shared by the group by virtue of their membership to language communities, societies, professional cultures, regional affiliations, and others. Speakers flag their allegiances by dress codes, speech style and, in more formal settings, uniforms and

other identifiers. The members of the group need not have the same allegiances – consider, e.g., a surgeon and a lab technician. It suffices that they know about relevant allegiances, which leads to certain believes about the background knowledge of each other. Reliance on background knowledge makes it possible to develop shared mental models for particular situations much quicker, and – in the case of linguistic background knowledge – is crucial for the very ability to change the common ground: Speakers assume that addressees speak the same language, and hence can rely on the rules of language to change the common ground. Lack of background knowledge will not only require more work to communicate effectively; if the lack of background knowledge is not apparent to the participants, it will result in errors of communication.

Maintaining and extending the common ground has a purpose – this even holds for casual talk. In the cases of interest here, the purposes are to secure proper functioning of complex devices, like a power plant, or to carry out complex tasks, like to safely fly an airplane. It is typical for such settings that not only the common ground is changing; the world of the participants is changing too. Problems occur and are reported; solutions are proposed and discarded or adopted. Linguists and conversation analysts typically have concentrated on discourses in stable environments, like in telling a story or constructing an argument. The dynamics of the situation itself was largely neglected, even though it is an important factor of communication: Things happen while we are talking; these events have to be evaluated and attended to in an appropriate way, which may shift the specific goals of communication into new directions.

3 Language as a tool to manage the common ground

The most important device by which common grounds can be maintained and changed is language. The idea that language is such a device has been a very fruitful one in linguistics, and there are many important properties of language that can be understood under this perspective. One prominent formal theoretical model is the one of ‘dynamic interpretation’, which understands the meaning of utterances as their propensity to change common grounds (cf. Groenendijk & Stokhof 1999). The field of linguistics that investigates the use of language is called **pragmatics**; see Levinson (1983) for a classic overview, and Levinson (2000) for a more recent treatment of more specific aspects.

One example is the use of articles such as *the* and *a*: A noun phrase with an indefinite article *a(n)* indicates that a new entity is introduced into the common ground; a definite pronoun like *it* or a noun phrase with the definite article *the* usually picks up an entity that is present in the common ground because it was introduced before or is part of the background knowledge. Example: In *We’ll give you a holding pattern* the indefinite article indicates that the holding pattern is newly introduced to the common ground; in *please change the holding pattern* the definite article indicates reference to a previously introduced object. And in *do the*

standard holding pattern (where no holding pattern was mentioned before) the definite article indicates that the entity referred to is part of background knowledge.

The use of definite articles is an example of a **presupposition**, a piece of information that is supposed to be already present in the common ground (cf. van der Sandt 1988, Beaver 1997). Some other examples of presuppositions: When a captain informs the copilot *I think there is one on the other side too* the use of *one* is justified because in the situation at hand *that ground proximity warning switch* was uttered 12 seconds earlier, hence *one* refers to the ground proximity switch. The use of *other* is justified because the captain had mentioned that he got the warning switch on his side, and the use of *too* is justified because at this point the common ground entails that there is another warning switch. The utterance *Okay, we can't* makes sense in the context of the preceding utterance, *It says if we can identify the faulty system*; it means: 'We cannot identify the faulty system (and have to work things out under this assumption)'. What these presuppositional devices have in common is that they help to integrate new information into existing information in the common ground. They often also allow for shorter utterances, thus overcoming a serious bottleneck of speech, its slow transmission rate (generally estimated to be of the magnitude of 10 bytes per second when counting the information inherent in phonemes, the distinctive sounds of speech).

Natural language facilitates communication in several other respects, besides the use of presuppositions. One important feature is that it heavily relies on so-called implicatures, a concept developed by the philosopher H. P. Grice. It refers to those aspects of meaning that a speaker wants the addressee to understand, without them being part of the literal meaning of what the speaker says. Implicatures are a pervasive phenomenon of communication, a fact that is often is not recognized at all by naive speakers. If a captain utters the command *Pull up!*, then this is normally understood as 'pull up *now*!', not, say, 'pull up in 20 seconds!'. If a pilot planning to divert around a thunderstorm asks *Is the Southern okay?* and gets the reply, *The way around north is*, the implicature is that the southern route may be not okay. And if a pilot of a three-engine plane says *We have two engines working*, what is meant is that only two, and not three, engines are working. Implicatures can be derived under the assumption that speakers follow certain rules, so-called maxims of conversation. For example, one maxim says that speakers should be as informative as possible. In the last example, the utterance *we have three engines working* would have been more informative than the utterance *we have two engines working*, and hence would have been preferred; the fact that it was not uttered gives rise to the implicature that the utterance *we have three engines working* would have expressed something false. Note, again, that reliance on implicatures allows for a more efficient use of communication, a point stressed in Levinson (2000).

There are various ways in which natural language signals the relevance of a particular information for the common ground. Consider the use of *but* in *But we'll dragging the gear around*. It indicates that the information that the plane flies with released landing gear is contrary to some information or goal in the common

ground. In the context of this utterance, it is an issue whether the plane has enough fuel for a second approach landing; the immediately utterances where *Fifteen on the gas right now. / I guess that's enough for a second approach, probably, huh?* The information that the landing gear is released is contrary to the information that there is enough fuel for a second approach landing, as released landing gear means higher fuel consumption. There are many so-called discourse particles that direct the integration of new information into the common ground, like *well*, *however*, *actually*, *now*, *you know* or *luckily* (cf. Schiffrin 1988). Also, intonation can perform similar functions, often of a very general nature (cf. Pierrehumbert & Hirschberg 1990).

Natural language can also highlight what is new or particularly important in a piece of information. Many languages, including English and German, mainly rely on intonation for this purpose; others, including Romance languages, make use of syntactic reorganizations of the sentence. For example, the sentences *The left engine is WORKING* and *The LEFT engine is working* express the same information (they are true in the same circumstances), but they do so with different emphasis: The first sentence could be uttered out-of-the-blue, with no previous information that there is something going on with the engines. The second sentence presupposes that some engine is working, and adds as new information that it is the left engine. The first sentence could be an answer to a question like *What's going on?*, the second one, rather, an answer to a question like *Which engine is working?* The identification of new parts helps the hearer to integrate information into the common ground, in two ways: First, it allows for a quicker phonetic realization of the old parts (they are deaccented, pronounced faster and often elided; as in *the LEFT engine* or *the LEFT engine*). Second, it suggests to the addressee that the speaker had a notion of the common ground that required a specific type of information, and thus helps to maintain a shared notion of the common ground.

4 Threat and error management in communication

Even though language is an excellent tool for the maintenance of common ground that was shaped and sharpened by evolutionary pressures over much of the development of *homo loquens* and was crucial for the success of our species, errors, sometime fatal ones, do occur.

The Texas Aviation Threat and Error Management Model (TEMM) identifies Communication Errors as one of five fundamental types of error; this is the reason why there is a chapter on language and communication behavior in this book. But communication itself can be seen under a TEMM perspective. An error in communication consists, essentially, of a lacking or failed update of the common ground. Perhaps the common ground was not updated at all because a group member thought that this was not necessary or did not feel secure enough to do so. Or a group member attempted to update the common ground but did so in an inefficient or misleading way. Or the update was performed quite well, but other members

failed to perceive and integrate this update in the intended way. The result are mental models of the situation for the participants that differ in crucial respects, which will lead to misunderstandings and uncoordinated actions.

There are a number of distinguishable threats, that is, factors that increase the likelihood of communication errors. For example, high workload distracts the attention of team members and may impede the ability to produce and understand utterances; background noise or restricted information channels such as intercom lines reduce the acoustic and visual information of utterances; faulty terminology may invite misunderstandings; attempts to save face, in particular in socially asymmetric crews, may induce crew members to withhold or to disregard information. And there are techniques that lead to the better management of errors. They may be directed at reducing the threats, such as improving terminology, communication technology, or communication procedures. Or they may be directed at discovering errors as early as possible; for example, increasing redundancy, repetition of information, explicit verbalization of presuppositions, thinking out loud, or vigilance for apparently incongruous communication behavior may be helpful to detect errors in an early stage.

Reducing the threats, and improving management of error, may sometimes be relatively straightforward, like by arranging consoles in such a way that allows for eye contact, by introducing a term like *roger* for acknowledgments (used to identify the letter R, for "message received", as used in Morse code). But improvements often are either difficult to achieve, or may have detrimental side effects. For example, increasing redundancy and repetition of information, or making inherent presuppositions explicit, also strains the linguistic and cognitive resources of crew members. As a case in point, the Linguistic Factors project found that captains with an overall poor rating produced relatively *more* speech acts that informed or reminded the first officer of relevant states of affairs. Any attempt to reduce threats stemming from communication will have to walk a narrow path between the conflicting goals of ensuring sufficient redundancy on the one hand, and avoiding distracting verbosity on the other. Human communication in general walks along this path, as recognized by the philosopher H. P. Grice in his conversational maxim of quantity, which states: (i) Make your contribution as informative as is required (for the current purpose of the exchange), and (ii) Do not make your contribution more informative than is required.

5 Requirements of Terminology: Expressiveness, Economy , Standardization

One obvious important factor in the efficiency of communication is the development of an adequate terminology to deal with situations that may be encountered during the execution of a task. This terminology should be expressive enough to clearly distinguish classes of such situations wherever necessary, and in particular when misunderstandings would lead to serious consequences. It also should be

economic in the sense that situation types that occur frequently or objects referred to often can be identified with shorter expressions than rarer situation types or objects addressed more rarely. Natural languages, by natural processes of language change, show clear evidence for this kind of optimization (Zipf's laws, e.g. *automobile > auto*). The use of acronyms, such as *ILS* for *Instrumental Landing System*, is the most obvious feature of regimented technical languages for shortening frequent expressions, but there are many other abbreviated set phrases that often are not codified; for example, a surgeon might refer to the caval vein by *cava*. Economy should be a principle for design of technical languages, but one should keep in mind that economy might result in reduced redundancy and increased ambiguity, both of which may lead to errors in communication. An expression like *Flaps 2*, while short, could be either a statement, or a command.

The requirement that technical languages should be sufficiently expressive to distinguish relevant classes of situations means, among other things, that they be neither ambiguous nor vague where this would have consequences for the tasks to be solved. Here, "ambiguity" refers to cases in which an expression can be alternatively considered true or false, such as *John saw that gasoline can explode*, a syntactically ambiguous sentence that rests on word ambiguities such as *can* 'have the possibility to' and 'container'. In a situation in which John witnessed the explosition of a container of gasoline, this sentence could be considered true or false, depending on its reading. "Vagueness" refers to cases in which an expression can be said to be true to a certain degree; e.g., *The plane lost its fuel* may be considered true, loosely speaking, even if some fuel remained. Many degree expressions, such as *large* or *many*, and even nouns such as *crowd* or *mountain* (in contrast to *hill*) are inherently vague.

Ambiguity is a pervasive phenomenon of natural languages and technical derivatives thereof. It is rarely perceived because either the difference between available readings doesn't matter, or the common ground is such that only one of the readings makes sense at all. In certain types of texts, like legal or diplomatic documents, ambiguity might even be welcome. But there are many cases in which ambiguity has led to catastrophic errors. For aviation, Cushing (1994) has reported a number of hair-raising stories. Ambiguity was arguably involved in the most severe accident in commercial aviation, the collision of two airplanes at the Tenerife airport in 1977, mentioned in the chapter on Determinants of effective communication; it centers around the question whether the phrase *we are now at takeoff* is to be interpreted 'we are now at the takeoff point' or as a kind or progressive tense, 'we are now in the process of taking off'. There are other such word ambiguities or structural ambiguities in aviation language – Cushing mentions the verb *hold*, which means in aviation parlance 'stop what you are now doing', but in ordinary English can also mean, 'continue what you are now doing'. Acronyms can also be a source of trouble; Cushing mentions the use of *PD* as 'pilot's discretion' or 'profile descent'.

There are different types of ambiguity, and only few of them – the ambiguity of words or idiomatic phrases – can be addressed by terminology design.

There is also syntactic ambiguity: For example, *back on the power* can be read as [*back on*] [*the power*], that is, add more poser, or [*back*] [*on the power*], that is, reduce the power. Furthermore, there is pronominal ambiguity, as in *A yacht ran into a ferry. It sank*. Languages differ as to the likelihood in which such ambiguities may occur; for structural reasons, English is more prone to it than German, which has a more articulate gender system. Furthermore, there is indexical ambiguity, which is caused by different possible locations of the center of reference: *the lever left of you* is ambiguous in a way that *the lever on your left* is not. The spatial arrangement of the group members, like face-to-face as in the operating room, or side-by-side as in the airplane cockpit, may lead to potential indexical ambiguity, cf. the chapter on Formative Characteristics. Personnel may be trained to avoid, where possible, such types of ambiguity.

An important ambiguity type not often mentioned is phonetic ambiguity or similarity – an utterance can be understood in two ways because the phonetic realizations are equal, or similar enough, to be confounded. This is especially important in case phonetic realization or recognition is affected because of high workload of the speaker or the addressee, or the phonetic transmission is disturbed, as in the use of intercoms or the presence of background noise. Cushing reports cases like *climb two five zero* understood as *climb to five zero*, and *Cleared to eleven thousand* as *He's clear at eleven thousand*. Phonetic ambiguity can sometimes be reduced, as in the realization of *three* as [tri:] instead of [θri:] in aviation, which avoids the high frequency noise of the *th*-sound [θ] that is transmitted incompletely in narrow bandwith transmisstions, or, in German, the use of *zwo* [tswo:] instead of the standard *zwei* [tswai] 'two' to distinguish it from *drei* [drai] 'three'. As many of such ambiguities can hardly be foreseen in advance, it is important to identify them in debriefings, to keep a record of them, and use this for gradually improving terminology and technical communication.

As for vagueness, we generally can observe that the reduction of vagueness increases the task load of the speaker: If one wants to be precise, more information has to be gathered, and verbalized, which runs against economy. But vagueness also increases the task load of the addressee, because more information has to be understood and integrated. So, a crucial question is whether the excess work of being more precise is worthwhile. In many cases, it might be sufficient to talk about a *steep ascend* instead of an *a 12 degree ascent*. One conventional way of indicating vagueness with measure terms is the use of rounded numbers; a term like *one thousand feet* generally allows for a more vague interpretation than *nine hundred sixty-five feet*. It may be necessary to indicate explicitly if a precise interpretation of a round number is intended, such as *exactly one thousand feet* (cf. Krifka 2002).

Common, non-technical language and rules of communication are adaptively optimized for everyday purposes, typically without rules that are stated explicitly or terms that are formally defined. More specialized fields need specialized languages and communication procedures that often are explicitly standardized. Technical fields differ in the amount of standardization required or expected in

communication. While all of them have specialized and standardized terminology, they differ in the extent of standardized communication procedures (see chapter #, Determinants of effective communication). In the three areas studied by the GI-HRE group, the level of standardized communication procedures is high in aviation, somewhat lower in the operation of nuclear power plants, and relatively low in the surgical operating room. This corresponds roughly to the standardization levels in general in these domains.

In aviation communication, the use of standardized phraseology in communication is most highly developed, and generally considered something that pilots should strive for. Also, certain formal rules of communication have been established that strive to minimize misunderstandings, like acknowledgments by the addressee that a message has been properly understood, often by "reading back", or paraphrasing, what has been said. Also, there is a rule of "sterile cockpit" in effect if the plane is below 10,000 feet, which means that only task-related communication is supposed to take place.

For nuclear power plant operations, the operation handbook states many procedures , both during normal operations and in case of difficulties. By this, operators are supposed to pay attention to the essential information in a systematic way. The handbook also contains recommendations regarding verbal communication: The report should be loud and clear, so that it can be understood by all the attendants. The speaker must make sure that a report is understood (eye contact or verbal confirmation), and the addressee should acknowledge procedural steps that are communicated verbally as being properly understood. Verbatim repeat backs normally should not be necessary, but the use of paraphrases is encouraged (IAEA, 1998).

Chapter #, on Determinants of effective communication, discusses whether standardization of communicational procedures is always a good thing. One problem they point out is that it may bind cognitive resources that, in case of an emergency, should better be devoted to something else. In the @@NPP simulator study, the eye tracking data showed that working through a checklist had influence on the distribution of attention: The checklist values are focused more frequently on the screen than values not mentioned on the checklist. Grommes & Grote (2003) analyze cockpit voice recorder data of an aircraft accident caused by the loss of a propeller engine in which the pilots try to follow the single engine emergency checklist but are interrupted and distracted by ATC, which tries to find out the position of the plane, following their own standard procedures. This shows that, while standardization of procedures and communication in general is often of great importance, there may be situations in which it may be necessary to step back and get a broader picture of the situation and its necessities first.

Within the investigation reported in the Project overview of Linguistic Factors we found that poorly performing captains actually showed more instances of standard wording in exactly the same type of situation. This can be interpreted as showing that overly reliance on standard wording may mask communication deficiencies.

6 The role of speech acts in maintaining common ground

The idea that communication can be seen as maintaining and elaborating the common ground between the participants of a conversation has been developed by language philosophers such as Robert Stalnaker and David Lewis. Another fruitful idea of natural language philosophy of the 20th century was that linguistic utterances should be seen as actions in well-defined rule-governed activities with social impact – this is the theory of speech acts as developed by John Austin (1962) and John Searle (1968), with roots in the late work of Ludwig Wittgenstein, especially his notion of language games. The two approaches are intimately related: Speech acts performed by interlocutors have the purpose of establishing, maintaining and developing the common ground.

The main insight of speech act theory is that linguistic utterances do not just express propositions that are true or false, but are acts that change the social reality in which we live. With speech acts we can ask questions, make promises, give orders, express feelings, and even – if we are in the right position – hire and fire people, baptize them, or declare them guilty of a crime. The second group consists of examples of so-called performative speech acts that change aspects of social reality in general. The first group of speech acts mentioned change and maintain a particular aspect of social reality, the common ground. These are communicative speech acts, and they are of particular interest here.

Austin distinguished three aspects of speech acts beyond the physical act of uttering something itself, and these are still worth keeping in mind. Assume a pilot of plane p says at time t to ATC *We are low on fuel*. In this he says something, namely that p is low on fuel at t; this is the "locutionary act". In saying that, the pilot informs ATC of something, that p is low on fuel at t, and asks him to recognize the consequences of this fact; this is called the "illocutionary act". By saying that, the pilot has a particular intention beyond communication itself, e.g. that ATC will afford preferential treatment in the landing process; the intention to bring about such an effect is the "perlocutionary act". There is a natural connection here to the notion of common ground or common agenda: The illocutionary act changes the common ground between the participants; after the pilot's utterance, ATC knows that plane p is low on fuel, the pilot knows that ATC knows that, and ATC knows that the pilot knows that ATC knows that. The perlocutionary act aims at something beyond communication and maintenance of common ground; it refers to certain expectations that the addressee behaves in a particular way.

Speech acts have been analyzed in a number of ways. One well-known system due to Searle (1975) distinguishes five classes: (i) representatives, which commit the speaker to the truth of an expressed proposition; (ii) directives, by which the speaker tries to get the addressee to do something; (iii) commissives, which commit the speaker to some future action, (iv) expressives, which express a certain psychological state of the speaker, and (v) declarations, by which a speaker

in the right position can change social or institutional states. As the class of expressives should also comprise things like apologies and congratulations which not necessarily have to be accompanied by the appropriate psychological states, they are called "acknowledgements" in other classifications, like the one in Bach & Harnish (1979). Rather comprehensive systems of speech act classifications have been developed, e.g. by stating lists of conditions for particular speech acts, as in Searle's work, or by developing a formal representation language for speech acts, as in Vanderveken (1990). The empirical evidence for certain speech acts typically came from speech-act verbs like *promise*, *guarantee*, or *offer*, the idea being that if a language has a word for a certain linguistic action, this action must be recognized in the community that speaks the language. Also, the possibility that language communities differ in their speech act inventory or in the context in which certain speech acts are used was investigated (cf. Blum-Kulka e.a. 1989, Geis 1995, Grass e.a. 1996).

While speech act theory was developed within language philosophy, and was not immediately applied to the analysis of real-life communication, there are several attempts to use it as an insightful empirical research tool, including the work cited on speech acts in different linguistic communities (but see Taylor & Cameron 1987 for a critique). For example, Diegritz & Fürst (1999) contains a considerably refined catalogue of speech act categories which was applied to analyze teacher-student interaction in the classroom.

The Linguistic Factors project in the context of the GIHRE project also made crucial use of speech acts as analytic tools. The project settled on a detailed inventory of speech acts called STACK (a German acronym for Speech act Type-inventory for the Analysis of Cockpit Communication), derived from Diegritz & Fürst (1999) for the particular application of cockpit communication. STACK distinguishes between the following groups of speech acts called *Information*, *Request*, *Agreement/Negotiation*, *Dissent*, *Question*, *Expressive* and *Interaction Markers.* See the overview of the Linguistic Factors project for a more thorough discussion, as well as a listing of the speech act categories employed by STACK. Classifying a particular speech act follows the procedure of Qualitative Progression Analysis, as outlined in Diegritz & Fürst (1999) and described as well.

In that project overview, some of the results were given that were obtained by applying this technique on a set of simulation flights that followed the same scenario, where the success of the crews was independently rated. We found that good crews showed proportionally more speech acts of the type MAKE SURE, and in general more speech acts that ensured that communication went well, like CONFIRM, ACKNOWLEDGE and REAFFIRM. Poorly performing crews, interestingly, had a higher incidence of REMIND, suggesting that they had to make use of this repair strategy more often. Good captains uttered more AGREE acts, and fewer CONTRADICT acts, thus positively acknowledging and encouraging contributions by the first officer. They also structured conversation better with STRUCTURE signals. Good first officers showed more CLAIM and SUPPOSE acts, perhaps indicating a communication climate in which it is easier to speak up for the lower-ranked crew

member. We take this to be good evidence that the speech act classification, as outlined above and in the project overview, provides good tools to identify certain general features of communication, and even points to specific communication habits that may be accessible to communication training.

Speech act theory does not typically address larger structures of conversation, but this can be integrated by in the preconditions that have to hold if certain speech acts are felicitous. The structural dialogue analysis of Franke (1990) is especially promising, which distinguishes between initiating speech acts and reactive speech acts, such as questions and answers (or refusal to answer), assertions and agreements (or refutations), and suggestions and accepting or rejecting a suggestion. Franke discusses cases in which speech acts retract previous speech acts, revise them, or re-iniate them.

On a methodological point, speech act theory is relatively easy to apply to spoken text, and yields results that can be compared for different groups and different types of situations. On the other hand, one should be careful to apply results obtained by speech act theory directly to training. For example, if REMIND speech acts indeed occur more often in poorly performing crews, it is still not to be recommended to teach speakers to avoid them. Sometimes a REMIND speech act might be just the best thing to perform in a given situation.

7 Conversation Analysis

Another approach to communication was developed under the term of Conversational Analysis (CA), which largely follows the ethnomethodological approach of Garfinkel (1967). Garfinkel investigated social reality with the methods applied by the members of a culture to interpret social action as meaningful. In this tradition, CA, as developed by Harvey Sacks, attempts to avoid premature theorizing, and avoids the definition of 'ideal' types because they can have only a vague and indeterminate relationship with any specific set of events. Rather, the implicit methods of interpretation of the participants in social interactions should be uncovered, and applied to the analysis of conversation. This focus on the formative principles on the specific subject area of investigation – be it small talk at the breakfast table or the verbal interaction of a doctor with a patient – is a guiding principle of CA. This makes the methodologies developed by CA well suited for the analysis of communicative interaction of groups in technical settings, as investigated in the GIHRE project, as CA forces the investigator to look at the specific conditions that determine group interaction there. On the other hand, results obtained for one type of group cannot as easily be generalized to others. It is rather the methodology itself that can be transferred from one application to the next.

According to Bergmann (1991) it is important to pay attention to seemingly irrelevant details like intonation, mispronunciations, pauses, overlaps and interruptions, which must be captured carefully in the transcript because they often turn out to be crucial for the analysis of communicative interaction. For the analy-

sis, sequences of verbal or non-verbal utterances should be isolated and interpreted as attempts to attain the goals and resolve problems of the interaction at hand. The CA analyst then can describe these underlying goals and problems, and investigate the methods that the participants of the conversation relied on in attaining the goals and solving the problems, and the methods that are available to speakers in general (cf. Levinson 1983).

The detailed observation and analysis of communication also allows researchers to investigate how it is embedded in other activities. Nevile (2002) is a study of how operating hand movements of pilots are integrated into the flow of communication, which provides for a better overall communication. For example, Nevile reports a sequence in the cockpit of a non-simulated flight in which the captain orders a new flight level. The first officer doesn't reply immediately, but moves his left hand to the Altitude Alert Indicator (AAI) knob in a way that is visible to the captain. Turning it, he utters *okay:*, with a lengthened last vowel, which indicates that he is busy following the order. He finally utters *that's set* and removes his hand ostensibly from the knob. Obviously, the visible movements contribute as much to the communication here as what is uttered.

Even though CA argues against rash theorizing across different communicative domains, there are certain features that can be observed in many if not all instances of human communication. One form of interaction investigated prominently in CA are routine sequences of actions in conversation, which we often find in communicative interactions. Sacks (1992) assumes different types of such 'action sequences' like greeting – return of greeting, or question – answer; the sequence assertion – acknowledgement might be particularly important in technical settings. According to Sacks, the adjacency relationship between utterances is the most powerful device for relating utterances because of their institutionalized nature. Incidentally, recall that such sequences were often neglected in speech act analysis, hence the two theories genuinely are interested in complementary aspects of communication.

Another focus of CA has been the organization of so-called "turntaking" in conversation. We find that in most conversations, typically only one person is talking at a time, without doubt to optimize understanding by reducing processing load – even though there are many exceptions, and different cultural or situational preferences to endure or prohibit speaking in parallel. The turns, or transitions from one speaker to the next, often are smooth, without overlaps or pauses, but overlaps and pauses sometimes do occur. There are mechanisms for regulating turn taking; a speaker can select the next speaker, or an addressee can signal the wish to speak, using linguistic means such as questions or demands to speak, paralinguistic means such as falling intonation, or non-verbal means, gestures like hand waving. In more formal settings, a third party can assign the right to speak. These mechanisms do not guarantee smooth turn takes, and so there are repair mechanisms. Often, one person will stop speaking to avoid overlap, even if this was not planned. Evidently, we can deduce from that the relative power of the participants.

Sacks, Schlegloff & Jefferson (1978) have investigated the rules of turn-taking. According to them, turns consist of conversational units that contain so-called 'transition relevant places' (TRPs) that are evident to speaker and addressee. At TRPs, the current speaker can assign the right to speak to the addressee, or the addressee can assume this right. Often, the content of the turn of the current speaker indicates some preference for the content of the turn of the next speaker: assertions want to get affirmed, an invitation wants to get accepted, a biased question wants to get answered in the direction of the bias.

For institutionalized settings of groups in high risk environments, turn-taking is a particularly interesting issue that has been little investigated. One important point is that the dynamics of the situation can make it necessary to override normal turn-taking rules; e.g., if a pilot becomes aware of something of immediate relevance, he might interrupt turns at any moment. The situational setting might make it hard to rely on the usual channels that regulate turntakes: The background noise might be too high to capture paralinguistic features like falling intonation or creaky voice at TRPs, and limited eye contact, as for pilots in the cockpit or for operators in front of computer consoles, or complete lack of eye contact in radio communication, might make it difficult or impossible to use facial expressions or gestures for this purpose. The Nuclear Power Plant project found that eye contact was observed quite rarely, only if the participant was very unsure with the current situation or given information.

As an example of an analysis of the turn-taking structure, we will discuss the segment of cockpit communication (from a simulated flight) introduced in chapter #Linguistic Factors. Here is the transcript of the sequence, following the transcription principles of Selting e.a. (1998), which encourages a rather narrow description that also includes pauses. Relevant events are numbered, and their timing and duration is specified (the part starts with 36 minutes 54 seconds into the simulation flight, and the whole sequence lasts only 17 seconds). Pauses are indicated as follows: (.) is a short pause, (-), (--) etc. are increasingly longer pauses, and notations like (1.4) indicate a pause of 1.4 seconds.

1	36:54-54	Cpt:	so
2.	36:55-56	Ps:	(1.4)
3.	36:57-58	Cpt:	wie weit sin mer, (.) flaps ham wa twenty
			how far are we (.) *flaps we have twenty*
4.	36:58-01	Ps:	(2.9)
5.	37:01-02	F/O:	ja dann warten wa bis auf n intercept
			alright then we'll wait for the intercept
6.	37:03-06	Cpt:	ah weißte wir sollten alles raussetzen (--) gear down und flaps thirty. dann ham wa das schon
			you know we should get everything ready (--) *gear down and flaps thirty then we already got that*
7.	37:06-08	Ps:	(1.4)

8.	37:08-09	Cpt:	is keen problem für uns okay? *that's not a problem for us okay?*
9.	37:09-10	Ps:	(1.0)
10.	37:10-10	F/O:	.hh hmm
11.	37:10-11	Ps:	(1.0)
12.	37:11-13	F/O:	ich bin mir nich sicher ehrlich gesacht aber gut (.) versuchn wa s mal *I'm not sure to be honest but alright let's try it*

By uttering the particle *so* in (1) the Cpt signals, that he considers the previous discussion to be over. Even though there is a pause of 1.4 seconds (2), this does not mark a transition relevance point, because with the particle the Cpt initiated a change of topic. The Cpt makes it clear that he is claiming the right to talk at this moment. He initiates the next turn by asking himself as well as the F/O a question with slightly rising intonation (3). Again, this is not a TRP, even though a question normally implies a turn switch, because the question can be seen as one posed to the crew, which includes the speaker. This is supported by the fact that the Cpt does not wait for an answer from the F/O but rather gives an answer himself after a very short pause. A long pause of 2.9 s follows (4), until the F/O finally replies (5). The pause especially stands out, as pauses after questions are generally dispreferred; a good answer satisfies the informational need expressed by a question as quickly as possible. In the following, the Cpt's question is not answered, but the F/O makes a suggestion about how to proceed, namely to wait for the intercept, i.e. for further radio communication. In (6) the Cpt makes a suggestion that appears to be cooperative (it is not a command) but that has a content that he assumes to be dispreferred by the F/O (notice the short delay). The reason why it is dispreferred becomes apparent, as he is suggesting exactly the opposite of what the F/O has proposed: The Cpt does not want to wait but rather get everything ready. He immediately gives a reason for this in order to strengthen the dispreferred suggestion. The F/O does not respond, note the pause of 1.4 s in (7). In (8), the Cpt self-assertively reaffirms his point. The question tag *okay?* makes it clear that it is now the F/O's turn, and that a confirmation is expected. The prosody of the utterance also indicates that the Cpt is requesting a confirmation and does not want to tolerate objections. Yet, there is a pause (9), clearly a silence of the F/O, and then the F/O signals by audibly breathing and by the verbal gesture *hmm* that he does have objections (10). He pauses once again (11) and then (12), after hedging and further delaying the expected reaction, finally concedes to the Cpt.

The hierarchical structure in the cockpit is quite evident here. Notice that the doubts of the F/O are not clearly articulated but do become apparent through the abrupt sentence endings and the long pauses. In the same time, he easily could have explained the problems he sees with the Cpt's proposal. Even though it is obvious that the F/O does not agree, the Cpt does not ask why he objects. The cooperative style that one might deduce from the question in (3) and the appeal to crew obligation in (6) is only an apparent one, at least in this segment.

8 Group structure and communication

The social structure of the groups in which communication happens explains a lot about the type of communication in the crews. As detailed in the chapter on Determinants of effective communication, crews in high-risk environments can be of quite different nature: They can be small (like the two pilots in a commercial airliner, plus the air traffic controller), medium-sized (like the doctors and nurses in the operating room), or rather large (like the workers on a large construction site). The members of the crews can be rather familiar with each other (as, typically, doctors and nurses in a hospital, or operators in a power plant), or they might work together for the first time (which is often the case with pilots in big airlines).

Familiarity of crew members has a natural advantage, as they know each other's behavior better and know how they behave in times of crisis. As a side effect, the frequency of communication should become lower. But there are disadvantages of this situation: If a regular crew member has to be temporally replaced, the newcomer has a special status. And familiarity of crew members may lead to a certain sloppiness in behavior that might be avoided if crew members do not know each other that well. In many languages there exist linguistic markers for familiarity, like the use of *sir* in English, or politeness variations in the pronoun system like *du / Sie* in German or *tu / Usted* in Spanish that reflect, and influence, the general group climate. If the members of crews are less familiar with each other, their professional training and the company culture in particular have to guarantee the background knowledge in order to establish sufficient common ground. Also, the familiarity of crew members increases during working together in the crew; for example, Sexton & Helmreich (2000) report that the use of crew-referring *we* of captains in flight crews increased during ongoing flights.

Crew members might have essentially the same professional background, as pilots or power plant operators, or the crew members might be more specialized, as in the operating room, were we find surgeons, anesthetists, and nurses of various specializations. Quite typically, there is a rank difference, often correlated with age and experience (and also, gender), that leaves obvious traces in the nature of communication. The piece of conversation analyzed between captain and first officer analyzed in the previous section is by no means untypical in this respect.

The professional cline in the cockpit and its effects on communication was the subject of several studies. In the study of cockpit communication, cf. the progress reports of the Linguistic Factors project and the Coordination project, it was found that the captain produced significantly more utterances than the first officer, both in the American and in the German data, and that the first officer in turn produced more utterances than the engineer in the American data. This may reflect differences in the task structure for captain and first officer, but as either the captain or the first officer might fly the airplane, it can also be seen as evidence that

the social position itself results in different propensities to actively engage in communication.

Perhaps more interesting than numbers of utterances are observations regarding the nature of utterances. Linde (1988) reports studies in which she investigated the effect of the status difference in aircraft. Her crucial finding was that the lower-ranked pilots expressed things in a more subdued, **mitigated** way, compared to the higher-ranked captain. This means that potentially crucial information might not get the attention that it deserves. A typical case that illustrates this point is the remark *Not very much more fuel* by the engineer to the captain of a United Airlines plane near Portland in 1978, few minutes before the engine stopped.

The reasons, evidently, have to do with **politeness**, a pervasive concept in human communication, as detailed in Brown & Levinson (1987). According to that study, politeness strategies have the function of **saving face**, where 'face' refers to the self-image that an individual wants to project, the self-esteem that he or she wants to maintain in public. Brown & Levinson distinguish between positive face, the way how persons want to be seen, and negative face, the claim to personal territories and rights that might be violated by the act of others. As with communication in general, saving face is a reciprocal action: People want their face to be saved, and hence try to save the face of others, by avoiding face-threatening acts, or by mitigating them if they cannot be avoided. One strategy is to use off-record communication that can be understood ambiguously, where one meaning is not face threatening, as in *It's messy here* instead of the bald on-record command *Clean up your room*. With on-record strategies, speakers can refer to the positive face by appealing to the goals of the addressee, by expressing sympathy with the speaker, by including them in a group and refer to the goals of the group, or by making promises: *Wouldn't you like it better here if the room were more tidy?* or *If you clean your room, you will get ice cream.* Or they can refer to the negative face, by using apologies, hedges, or impersonalizations, like *I know you would rather play right now, but first you should clean up your room* or *Kids should clean up their room themselves*.

All face-preserving strategies (except of course the one of not saying anything at all) result in expressions that are generally longer and more complex. This can be interpreted by saying that the speaker explicitly shows that he puts in greater effort in the act of communication, or puts himself in a handicap, thus indicating the worthiness of the communicative goal that he wants to achieve (cf. Zahavi & Zahavi 1998). By binding cognitive resources, politeness may well be a handicap (van Rooy 2003), a luxury that should be avoided in situations of high work load that stress these resources otherwise. In the American data of the study reported in Krifka, Martens & Schwarz (2003), fewer politeness markers, like *please* and *sir* or conjunctive verb forms like *would you* were used in situations of high work load in the well-performing crews, but, interestingly, more politeness markers were used in those situations in poorly performing crews.

Obviously, the power structure between the participants, as well as the familiarity between them, goes a long way in explaining which strategies can be

employed: Powerful participants, or participants that are familiar with each other, need not resort to face-saving strategies in the same way as less powerful or familiar participants do, and by disregarding or employing such strategies the power cline between the participants itself gets reinforced.

Fischer and Orasanu (1999) have investigated mitigation in aircraft crews. In one study, male pilots, 69 captains and 88 first officers, were confronted with a weather description that strongly suggested a diversion of the flight route. The subjects were asked to imagine themselves in the role of the flying pilot that apparently is not aware of the weather situation. They were presented with a number of possible verbal reactions by the non-flying pilot that varied in focus, explicitness and directness (and quite generally, in their politeness). This included direct requests, in particular commands (*Turn 30 degrees right*), crew obligation statements (*I think we need to deviate right about now*), crew suggestions (*Let's go around the weather*), queries with presuppositions *(Which direction would you like to deviate?*), preferences (*I think it would be wise to turn left or right*) and hints (*that return at 25 miles looks mean*). And it included self-centered communications, like self directives (*I am going to get a clearance to deviate around these storms*) and permission-seeking questions (*you want me to ask for clearance to deviate around this weather?*). The result was quite predictable: More than 50% of the captains preferred a direct command (as compared to less than 20% of the first officers), and about 40% of the first officers preferred a hint (as compared to about 10% of the captains). Captains were more likely than first officers to specify the action to be taken; and permission requests were only uttered by first officers. In situations of threat, captains used even more commands, but interestingly also more hints, the latter probably to minimize face-threat to the first officer. First officers, on the other hand, increased their commands, and also statements of crew obligations, a more indirect form.

In follow-up studies, Fischer and Orasanu looked at various factors that may influence the differential behavior of captain and first officer. A replication with pilots from three European nations showed less differentiation in communication behavior (which contrasts with previous findings indicating a greater power distance than with American pilots). A replication with female US pilots showed no significant differences to male pilots in terms of the captain / first officer differentiation, but the female pilots reacted more often with problem or goal statements to requests and with speaker-oriented communications. In yet another study, pilots were asked which type of communication addressed to them in a given situation they would consider most effective. The findings were that communications that were supported by a problem or goal statement were considered more effective. The preferred strategy was one that is neither too direct and blunt, like commands, nor too indirect, like permission requests. Captains judged crew obligation statements, preference statements and hints by the first officer to be more effective than commands, and first officers thought that captains were more effective with crew obligation statements than with commands, queries, hints, self-directives or permission requests. In high-risk situations, pilots generally preferred more direct

communication strategies, but even then crew obligation statements were preferred over commands. With highly face-threatening situations, as when embarrassing mistakes had occurred, hints were judged most effective, together with crew obligation and preference statements.

In the introduction of this chapter, we introduced the concept of a common ground, resulting in a shared mental model of the group. However, it should be stressed that effective crews also work on the principle of division of labor, which also applies to shared information. The quality of information sharing is, in a sense, curvilinear: Too much of it leads to information overload of the crew members, too little of it to incoherent actions. Of course, it is important for each crew member to know what is relevant for other crew members to carry out their own actions. This calls for the definition of interfaces between the crew members. For example, in the context of the operating room, the team around the surgeon and the anesthetist form two natural subteams, typically even visually separated by a curtain, that deal with separate but interdependent tasks and have to inform each other of critical events. The flow of information might be asymmetric; the surgeon should generally be shielded from information relevant to the anesthetist except if there is an emergency; on the other hand, the anesthetist should be informed about important details of the operation because this is relevant for the administering of drugs by the anesthetist. It is often debatable how much information should be shared.. For example, how much should the pilot of a rescue helicopter know about the state of a patient? One could argue that this should be only relevant for the doctor or the nurse and irrelevant for the pilot because it is distracting information. On the other hand, the pilot could perform risky maneuvers even in cases in which the patient is in a stable condition.

A very important aspect of crew communication is briefing before crew sessions or critical situations, as well as debriefing after. Briefing establishes or confirms a measure of common ground that is necessary to deal with a critical situation; it reduces the danger of misunderstandings in the situation and makes the crew members aware of options. Debriefing allows for an informed assessment of how a situation or a crew session was handled, which is crucial for the development of better strategies in the future. Debriefing allows for opportunities that individuals from different perspectives join together to establish an informed opinion. It is crucial for this that the institutional setting requires or at least strongly encourages such briefing and debriefing sessions.

9 Coherence: The objects talked about

Monological texts, or dialogical conversations, can be smooth and tightly integrated, that is, coherent; or rather patchy, with parts that are only loosely connected, that is, incoherent. Of course, coherent texts and conversations achieve their communicative goal more effectively than less coherent ones that lead ad-

dressees into cul de sacs and make them fill in much of the necessary background that is necessary for understanding.

Coherence can be established in different dimensions. One is the way how so-called discourse referents, the persons, objects, events and facts mentioned in a text, are managed. As already mentioned, in English, a rather elaborate system of definite and indefinite articles, demonstratives and pronouns is used to track discourse referents in communication. For example, consider the following passages from the conversation of a captain and an engineer in a simulated flight:

(28)	Eng.	We have an underexcited trip light on, uh, number 3.
(29)	Capt.	Uh, say it again please?
(30)	Eng.	Underexcited fault light on, uh, number 3.
(31)	Capt.	Why don't we go to the book and see what you can do about it.
(…)		
(72)	Capt.	You've just got a fault light, right?
(73)	Eng.	Just got a fault light.
(…		
(94)	Capt.	Hey, with this fault light, would you switch essential power off of number 3, please, for me?
(…)		
(111)	Eng.	I think what that light was, was when that field relay tripped.
(113)	Eng.	That's probably what it was.
(114)	Eng.	Well, I just saw it – it may have been there for awhile – I just saw it when I pulled and reset it.

The discourse referent for an underexcited fault light is introduced in (28) with a noun phrase with an indefinite article, the typical way for introducing new discourse referents. In (30), we find a noun phrase without any article, which is possible in certain types of texts, like headlines or reports in a military or technical setting. Note the variation in wording: *trip light* vs. the more standard *fault light*. In (31), the fault light is referred to by a pronoun *it*, which is typically used for referring to recently mentioned discourse referents. Pronouns are short and efficient, but the price is potential ambiguity. For example, in (29), *it* does not refer to the trip light, but to the utterance (28); here the potential ambiguity does not matter because one cannot 'say' a light. Another, more elaborate way of referring to discourse referents is by definite NPs like *the fault light*, which does not occur in the excerpt analyzed here. Rather, (31) shows another use of the definite article in *the book*: Here, reference is to some entity that is identifiable due to the background knowledge of speaker and hearer as the operating handbook of the plane. Another important use of the definite article is called 'bridging': If a thunderstorm was introduced before, we can talk about *the clouds* because thunderstorms come with clouds. The fault light is mentioned again three minutes later, with an indefinite NP (see 72), which is rather unusual. A definite NP *the fault light* could have been used here, which would have led to greater coherence. About half a minute later,

the discourse referent surfaces again, this time with the help of a noun phrase with a demonstrative, *this fault light*, and then *that fault light*. Demonstratives are often used in texts if the discourse referent is introduced, but was not mentioned very recently, or if the intervening part of text was concerned with other things (as is the case here).

The introduction and maintenance of discourse referents has been studied extensively in linguistics, for example in Centering Theory (Grosz, Joshi & Weinstein 1995) and Discourse Representation Theory (Kamp & Reyle 1993). Centering Theory in particular offers a number of interesting case studies relating planning strategies and discourse structure.

10 Coherence: Relations between parts of discourse

Another dimension of coherence is approached by Rhetorical Structure Theory, as developed by Mann & Thompson (1988). RST assumes that coherent texts are hierarchically structured, where each part stands in one of relatively few semantic relations to other parts. There are relations like background, cause, circumstance, contrast, concession, condition, elaboration, evaluation, evidence, interpretation, justification, motivation, result, preparation, purpose, restatement, or summary. The text is divided in parts, which then are hierarchically structured. As an example, consider the following small text, a beginning of a scientific article:

> (0) Lactose and Lactase. (1) Lactose is milk sugar, (2) the enzyme lactase breaks it down. (3) For want of lactase most adults cannot digest milk. (4) In populations that drink milk the adults have more lactase, perhaps through natural selection.

RST assigns to the parts of this text the following relations:

> (0) is a preparation of (1)-(4),
> (1)-(2) is a background of (3)-(4),
> (1) is elaborated by (2) (3) contrasts with (4)

RST has been mainly applied to written texts, to work out the structure of well-constructed texts and show the problems of bad ones. It has been applied, for example, to analyze passages of operating manuals or textbooks. But RST has also been used for the analysis of spontaneous spoken texts, and even of conversations.

Yet another approach to coherence is concerned with the topical structure of texts and conversations. Communication is typically "about" something, a topic of common interest, a problem that is to be solved, or an action that has to be coordinated. Typically these topics, problems and actions are complex and can be decomposed into parts. The techniques to decompose them are, to a large degree, part of our background knowledge. We perceive situations as being composed of

events, processes or states, we perceive tasks as consisting of subtasks, we perceive persons as agents or patients, we organize reality using spatial, temporal or causal relations. When describing situations, tasks, persons, and other things, we make use of such standard decompositions of aspects of reality. If one reports a car accident by phone, the police expects to be filled in about the location of the accident, the cars and people involved, whether there are any injuries, and if yes, of which kind. These pieces of information can be seen as answers to a sequence of questions that is informed by the standard ways of how we analyze reality. Coherent communication can be seen as communication that answers such sequences of questions. This view, which goes back to classical rhetorics, has been developed in Quaestio theory, cf. von Stutterheim & Klein (1989) and von Stutterheim (1997). It can be fruitfully applied to communication in technical settings, as shown in the project overview of the Coordination project, cf. also Grommes & Dietrich (2000)

In this work, it is assumed that utterances are in general answers to an underlying "quaestio", which can be explicit or implicit. The interlocutors must recognize these quaestiones, react to them appropriately, and develop new quaestiones that relate to previous ones. Grommes & Dietrich distinguish the following relations between quaestiones: In a *new* quaestio the speaker signals the perception of a new communicative task. A *shift* occurs if the speaker takes up the quaestio of the preceding utterance and constructs a related quaestio that offers additional information. In a *restoration* or *b-shift* the speaker goes back to an earlier quaestio and construct a related quaestio to it. Such jumps can occur because of interruptions, repairs, or intervening non-linguistic events that divert the attention of the interlocutors. In the case of *maintenance* the speaker has no further information to add to the current quaestio.

As an example, consider the following transcript from an operating room. Here a junior surgeon, has to open up the thorax for the purposes of a lung resection. He is supposed to identify the rib at which he wants to cut into the thorax. As he sets out to count the ribs he is interrupted by the senior surgeon, because he started counting with the first rib, which is nearly impossible to touch. The senior surgeon is not very cooperative with respect to the junior surgeon's quaestiones. She frequently restores her quaestio, indicated by the marker "back".

(97)	Junior:	eins. zwei. drei. vier. fünf. das müsste die hier sein. *one two three four five this should be the one.*	new
(98)	Senior:	Und sie ham die erste Rippe getastet? *and you did touch the first rib?*|	shift
(…)			
(103)	Junior:	=dann sind wer ein weniger *then it is one less*	shift
(104)	Senior:	=ihr seid super.= *you (pl.) are great*	back

The quaestio of line (97) is 'Where (in the relation of the ribs) should we cut? To answer this, the junior surgeon counts the ribs and suggests the place where to cut. The senior surgeon develops out of this a new quaestio (98), namely, whether the junior surgeon started from the first rib, which is difficult to identify. This quaestio is not answered directly, but the reaction of the junior surgeon in (103) shows that he understood it very well: the quaestio to (103) is something like 'What follows if the quaestio (98) is answered negatively?' In (104) S apparently shifts back to a previous point in which the quaestio was something like: 'How good are the junior surgeons?'.

Back shifts, which generally indicate some sort of interruption, can occur for a number of reasons. It might be due to the inherent properties of the task at hand, or it might be caused by interruptions by a third party. The speaker might return to issues that were not finished yet but conversation was side-tracked by some other points. And it might also occur because the conversation participants are in conflict with regards to what should be talked about at a given point.

Incidentally, in dialogical conversation, overt questions might provide some indication for the level of coherence. In the GIHRE Linguistic Factors project we identified the questions uttered in simulation flights and determined the proportion of them that were answered. In the American data analyzed in this project, the speech acts of well-performing crews contained a slightly higher proportion of questions, and a considerably larger amount of questions was answered: About 55% of the questions in poorly performing crews, and 80% of the questions in well-performing crews were answered; furthermore, fewer questions were answered by poorly performing crews during high task load, whereas the proportion stayed about the same for well-performing crews. This can be interpreted as saying that well-performing crews showed a more coherent style of conversation, and managed to maintain that even in periods of high task load.

11 Problems of high work load and communication

The last observation leads to the variance of communication related to the level of experienced work load. We observe two people walking and talking. Their conversation gets more involved, they stop, and start to argue with each other. Why did they stop walking? Presumably because communication is a task that uses up mental energies so that speakers sometimes cannot even engage in simple activities such as walking. Obviously, in periods of high work load, this strain on cognitive resources that communication poses must be considered a potential threat to the working of crews.

Grommes & Dietrich (2000) observe that in high work load situations, both in the airplane cockpit and in the operating room, utterances become shorter and more elliptic, and that fewer utterances occur that express background information, like utterances that explain things or give a reason for an act. Obviously,

the cognitive resources are strained by the tasks at hand, and cannot be applied to communication. This increases the danger of errors in communication.

In the mitigation studies by Linde and Fischer and Orasanu, one finding was that speech acts even of lower-ranked crew members become less mitigated and more direct in phases of high work load. It is likely that in such periods the additional cognitive resources for face-saving measures are not available. In our own study, we have observed that politeness markers occur less frequently in situations of high work load, at least in good crews, and that politeness is generally correlated with a greater complexity of expressions. While this leads to more face-threatening acts which might affect the global social climate within the crew, it increases local communicative effectiveness in high work load situations. As a part of CRM training, crew members might be taught to accept a higher level of face-threatening behavior for the sake of greater communicative effectiveness. The transcript analyzed above shows that the energies the first officer put into face-saving measures should have better be invested in making overt the reservations he had about the proposed procedure.

12 Conclusion

This concludes our overview of language and communicative behavior in groups in high-risk environments. We could only touch on some of the relevant issues here, partly due to reasons of space, partly because still so little is known in this field.

One area we did not deal with here is communication in written texts. This is an enormously important field in technical communication that affects a wide range of cases, like user guides that determine how consumers operate an MPEG player, medical textbooks that are used for the training of physicians, operating handbooks of nuclear power plants, or checklists that are referred to in emergency situations in the cockpit. Many aspects of this type of communication are dealt with in the field of technical writing, an important part of human factors research. For a particularly grueling study of problems with medical textbooks that resulted in the death of the author, cf. Baker (1999).

We hope that readers with a main interest in crew resource management have realized that communication should be a topic of central concern in their studies: Good communication is crucial for good crews, and communication deficiencies reflect deficiencies of cooperation in general. We also hope that those readers could get an idea that linguistic approaches, like speech act theory, conversation analysis and theories of coherence, are highly relevant for the study of communication within crews. We also hope that readers whose main focus is in linguistics have noticed that communication processes in groups in high-risk environment is a subject worth studying in detail: It poses serious challenges for theoretical notions and forces researchers to considerable refinements of their theories. And sometimes it can save lives.

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