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Language in aviation: The relevance of linguistics and relevance theory

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Abstract

English and a semi-artificial sublanguage based on English play the dominant role as the means of communication in aviation, especially in the communication between pilots and air traffic controllers and in international contexts. The first part of the paper surveys this state of affairs from the viewpoint of (English) linguistics. In its course, attention is drawn to aviation incidents and accidents, some of which with extremely severe consequences, where the role of language, or of English in particular, was critical. The second part of the paper argues that insights provided by relevance theory can be effectively used in the analysis and explanation of some of the communication problems. Given that relevance theory has not figured as a conceptual tool box with which to approach such problems so far, it is argued that it ought to be employed, especially as it emphasises that linguistic expressions are semantically underdetermined in principle. This means that the utterance of virtually any linguistic expression, including those of the semi-artificial aviation sublanguage, is dependent on pragmatic inferencing for the recovery of what was intended to be conveyed, an important aspect in the evaluation of the role that such a sublanguage may play in principle.

1 Introduction*

Problems of communication have been found to be an important or even the decisive causal factor for many critical incidents as well as near and actual accidents in aviation (see, among others, Cushing, 1994; Helmreich & Merritt, 1998: 202ff.; Isaac, 1999: 131ff.; Jones, 2003; Krifka, Martens & Schwarz, 2003; Maschke, 1994: 57f.; Silberstein & Dietrich, 2003: 10; Tajima, 2004; Turner & Nübold, 1981). This holds for both the communication among members of the crew in the cockpit and the communication between pilots and air traffic controllers. Among the languages used as the means of communication in aviation, English plays the dominant role. A substantial share of flights are and have been set within a national context where English is the official language; English serves most often as a *lingua franca* among the members of an international cockpit crew; a semi-artificial sublanguage based on English

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serves as the standard means of verbal communication between pilots and air traffic controllers both in English-speaking countries and where international airports are involved. This suggests a significant relevance of the linguistic study of English as well as of communication conducted in English for safety issues in aviation. Surprisingly, however, there has been comparatively little work done by linguists – in the sense that includes linguistic pragmatists – or in collaboration with linguists in this area. As pointed out by Sexton & Helmreich (2003: 71): "Cockpit communication is a rich area of study for language investigators, and it has been relatively underresearched given the critical role it plays in flight safety."[1]

The ultimate aim of the present paper is to draw attention to a basic and central insight from linguistic pragmatics, namely that utterance interpretation is crucially based on non-demonstrative inferences in addition to the decoding of the narrowly linguistic (grammatical and lexical) aspects of the utterance, and to questions that this insight raises for communication in aviation. As far as I can see, this issue of utterance interpretation being essentially inferential in nature, a point that has been emphasised especially within relevance theory, has not so far been prominently addressed in discussions of safety-relevant aspects of communication in aviation. In order to prepare for the points to be made about the relevance of this pragmatic insight in the aviation context, the paper will first provide an introduction into more general aspects of communication in aviation and its key role in safety issues, and it will refer to some of the pertinent research that has been carried out . That is, the paper demonstrates the relevance of general linguistics and English linguistics in this domain of communication both by drawing on work that has already been done and by raising new questions and opening up new perspectives for research.

2 Some examples of the causal role of language in aviation incidents and accidents

In this section, the statement from the beginning of this paper about the causal role of communication problems in incidents and accidents in aviation is exemplified.

The following problem, which involves homophony, led to the crash of an aircraft on its approach to Kuala Lumpur, Malaysia, in 1989 (see Cushing, 1994: 14; Helmreich & Merritt, 1998: 202f.).

(1) *The controller clears the aircraft to descend "**two four** zero zero". The pilot reads the clearance back as "**OK. Four** zero zero". "The controller did not catch the readback error, perhaps because he was not a native English speaker" (Helmreich & Merritt, 1998: 202f.). The aircraft descends to 400 feet rather than the appropriate altitude of 2,400 feet and crashes into a mountain peak at 481 feet.*

In the next example the controller, as communicator, and the pilot, as addressee, associated different referents with the word *things*. This prevented the pilot from becoming aware of the problem the controller was referring to (see Cushing, 1994: 18f.).

(2) *On approach to Miami International Airport, the crew is having a problem with a light on the plane's nose gear. At the same time the aircraft inappropriately declines in eleva-*

[1] Referring to official accident reports issued by the US National Transportation Board, Jones (2003: 247) writes: "No linguist is required to sign as approving these reports, hence no formal attention is paid to the degree to which miscommunication contributes to accidents." Tajima (2004: 468) concludes that "linguistics and language educators can greatly contribute to this yet-to-be-extensively-researched area".

*tion. The crew is unaware of this second problem. The controller, who is aware of the second problem, wants to check on the crew's actions about it. He asks "how are **things** comin' along out there?". The pilot, believing that the controller refers to the nose gear problem, replies "**OK**, we'd like to turn around and come, come back in." The controller takes the 'OK' to mean that the elevation problem is under control. The crew, however, is still unaware of the elevation problem. The aircraft crashes into the Everglades about 30 seconds later.*

The next example involves an erroneous inference on the pilot's side (see Cushing, 1994: 28). Fortunately, this did not have serious consequences. But the dangerous potential of the type of problem is obvious.

(3) *The pilot, cruising at flight level 230 (i. e. 23,000 feet), requests permission to ascend to flight level 310. Controller: "310 is the wrong altitude for your direction of flight; **I can give you 290** but you will have to negotiate for higher." Pilot: "Roger, **cleared to 290**, leaving 230." This erroneous readback is not challenged by the controller. Later realising that the aircraft is at a wrong altitude, the controller states: "I did not clear you to climb; descend immediately to FL [flight level] 230".*

In the fourth and last example for the moment a conversational behaviour which is appropriate in many everyday communicative situations, namely behaviour that exhibits linguistic politeness, contributed to an accident (see Linde, 1988: 379), which, fortunately, did not cause any casualties.

(4) *At landing, the copilot realises that the aircraft is considerably faster than appropriate. The captain is apparently not aware of this. Linde (1988: 379) comments on the ensuing communicative problem in the following way:*

[t]he interesting point is that the copilot mentioned in his interview that he 'tried to warn the captain in subtle ways, like mentioning the possibility of a tailwind and the slowness of the flap extension.' […] The copilot said that he thought that the captain understood the meaning of these remarks and would take the appropriate action. The captain said that he didn't interpret the copilot's remarks to mean that they were going too fast […]. This example should serve to demonstrate some of the real-world dangers of excessive mitigation.

Many more examples of safety-critical communication problems in aviation have been reported on in the literature.[2] Some more will be supplied in the course of the paper. Still many more could be identified, for instance, by following the example of Cushing (1994), who studied the reports in the newsletter *Callback*, where aviation personnel anonymously describe their observations concerning critical incidents, or by investigating internet sources such as those mentioned by Jones (2003: 245) in his "References and Annotated Bibliography". Another source of data may become increasingly available through the recordings and transcripts obtained from simulated flights. This has been the sort of data used by the linguists involved in a research project on cockpit communication reported on in Dietrich (ed.), 2003.

[2] For a list of "[c]rashes with ties to language" from 1971 to 2002, see Jones (2003: 237ff.).

3 Scripted aviation language and ATC-English

As already mentioned, a conspicuous feature of the communication between pilots and air traffic controllers in an international context is the use of a semi-artificial English-based sublanguage which is employed as a standardised code for the exchange of information via radiotelephony. Following Philps (1991), I call this sublanguage ATC-English (*ATC* being the common abbreviation for *air traffic control*). Authorities and aviation companies very often require scripted wordings to be used also for the communication between crew members within the cockpit (see e. g. Arminen, Auvinen & Palukka, 2010: 448); in the majority of cases the underlying language for these scripts is English too. In the following I will concentrate on ATC-English, but will occasionally refer to (examples of) scripted language use between pilots in the cockpit as well.

There are several varieties of ATC-English in existence, most prominently the one recommended by the International Civil Aviation Organization (ICAO) and the one prescribed by the US Federal Aviation Administration (FAA) (see Jones, 2003). The study of ATC-English and its use clearly belongs in the domain of research into languages for specific purposes (LSP) and English for specific purposes (ESP). And some linguists with interests in this domain have indeed been concerned with it (e. g. Sullivan & Girginer, 2002; Turner & Nübold, 1981; Varantola, 1989; Vatnsdal, 1987). On the whole, however, as with the study of language in aviation in general, ATC-English has only played a very modest role in LSP and ESP research. This is also reflected by the fact that there is not a single reference to ATC-English in the subject index for the more than 2500 pages of the two volumes of the international *Fachsprachen/Languages for special purposes* handbook (Hoffmann, Kalverkämper & Wiegand (eds.), 1998-1999).

ATC-English is characterised by the following main features (see Philps, 1991; cf. also Vatnsdal, 1987):

1) rules about the order of priority between different types of messages;
2) a spelling code for letters and numbers;
3) rules for the expressions of callsigns (by which aircraft and ground stations are identified);
4) rules about the message structure;
5) rules about which messages to send in cases of emergency;
6) a list of conventional expressions and their meanings;
7) a set of skeleton messages, i. e. a phraseology.

There are differences between natural English and ATC-English on every linguistic level. I will give some examples:

• **Phonology**: e. g. the pronunciation of the digits *three*, *five* and *nine* is [tri:], [faɪf], [naɪnə]; ; this is in order to prevent phonetic confusion and to facilitate pronunciation for many non-native speakers of English (note that especially in radiotelephony [faɪv] and [naɪn] are difficult to distinguish and that the pronunciation of dental fricatives, [θ, ð], is often difficult for non-native speakers of English).

• **Lexis**: the use of specific expressions to convey meanings which are expressed differently in natural English: e. g. *affirm* ('yes', 'of course', etc.), *negative* ('no', 'of course not', etc.), *request* ('I'd like to', 'could I', etc.), *say again* ('repeat', 'sorry?', 'What?', etc.).
• **Syntax**: some items in the phraseology of ATC-English are syntactically identical to their natural English counterparts, most can be described in terms of a systematic modification of their natural English counterpart, such as determiner deletion (e. g. *resume own navigation*; cf. *resume **your** own navigation*), deletion of prepositions of direction, place, purpose, time (e. g. *climb 150*; cf. *climb **to** (flight level) 150*), pronoun deletion (when referring to pilot or air traffic controller) (*will shortly lose radar contact*; cf. ***you** will shortly lose radar contact*).

Actually, almost all of the syntactic modifications of natural English which characterise ATC-English can be described as deletions or ellipsis. This leads Philps (1991: 123) to the following conclusion:

> *Paradoxically, the brachylogical search for clarity, precision and lack of ambiguity in the phraseology […] results in a pronounced tendency towards ellipsis (in the widest sense of the term), rather than, as might have been expected, towards forms of linguistic redundancy (cf. Lyons 1968: 85ff.). This observation may better be formulated as a question: how is it that a codified language such as the phraseology, which sets out to be* explicit, *can be so* elliptical*?*
> *The answer to this question has already been hinted at: the fundamental mechanism that allows the phraseology to function effectively as a communication tool is surely to be found in the interaction between its intra- and extralinguistic levels. The phraseology in fact interweaves two systems: the structural system of an English subgrammar and a system of referential values common to its domain (air traffic control) and to the speech community within this domain. If it were not for this interwoven complex, communication would be jeopardised and linguistic security put at risk.*

While Philps appears to imply that ATC-English functions rather well, Jones (2003) argues that it is riddled with defects. In the FAA-version of ATC-English, the latter identifies "[t]wo sorts of ambiguities [that] need purging. The first sort is due to synonyms, where a meaning has more than one expression. The second sort is the reverse, where a given expression has more than one meaning" (Jones, 2003: 239). In addition, he deplores the differences between the ICAO and FAA varieties of ATC-English, which are said to create "opportunities for disastrous confusion" (*ib.*: 240). However, Jones's criticism is not directed only against ATC-English; for him, English as such is the problem:

> *Without benefit of a scientifically comprehensive plan for aviation phraseology, English, in any of its dialects, was recommended for international aviation in 1951 by the ICAO. Aviation has since been plagued with pilot errors, many of them due to ambiguity in English words and phrases. Non-native English-speaking pilots, about half of the pilots of the world, find it very difficult to deal with the massive irregularities of English. (Ib.: 243)*
>
> *In 2002 it is clearly time for the 'adoption of a more suitable form of speech for universal use in aeronautical radiotelephony communications' as foreseen by the ICAO in 1951. That standard form of speech for aviation must be characterized by formal rules for its grammar and structure. It must be superior to any given variety of English in the clarity of its spoken form. Its root word acquisition must be subject to the discipline of*

> *an Academy whose members are drawn from many nations. Perhaps here there is a practical solution in Esperanto, which might, with standardized terminology and phraseology, become the language for permanent use in international aeronautical communication. The inability of English to express specific instructions to pilots without confusion would seem to disqualify it as a language for permanent use by aviation. (Ib.: 243f.)*

Although Jones (*ib.*: 243) also recommends that "foreign aviation personnel should receive more training in English", his more general position seems to be that natural English is thoroughly unsuitable as a language to be used in aviation, both as the basis for a standardised, more or less artificial, sublanguage and as a medium for communication in those cases where the use of the sublanguage is suspended.[3] His reference to Esperanto can be taken to implicate a suspicion that other natural languages may not be much more suitable in these respects.

Other researchers as well as pilots and controllers share Jones's view that ATC-English needs to be improved but do not share his scepticism as to whether such improvements can lead to a satisfactory result in principle, a scepticism due to the fact that ATC-English is derived from natural English. They emphasise that a very high proficiency in natural English, in addition to mastery of ATC-English, is a key factor in optimising safety in the domain of communication. The interviews with Turkish pilots and controllers carried out by Sullivan & Girginer (2002), for instance, revealed that

> *pilots and ATCs both stated that they needed to improve their conversational English, not just Airspeak, since they are called upon to communicate in situations in which Airspeak is insufficient. This correlates to the findings of Chatham and Thomas (2000) as well as of Morrow et al. (1994) who found that nonroutine transactions between pilots and ATCs contained more conversational English, more complex syntax, and more vague terminology than routine transactions. This use of English in nonroutine transactions can be particularly problematic if one or both of the interlocutors are not native English speakers since they may differ in their use of vocabulary and conversational discourse conventions. (Ib.: 402)*

Modifications of the standards of ATC-English and the use of natural language between pilot and controller have frequently been observed to occur (see e. g. Beneke, 1993: 13; Morrow, Rodvold & Lee, 1994: *pass.*; Mell, 1994; Nevile, 2004: 195, 200ff., *pass.*; Philps, 1992: *pass.*; Sullivan & Girginer, 2002: 400ff.; Thomas, 1989: *pass.*; Turner & Nübold, 1981: 13). Morrow, Rodvold & Lee's (1994) empirical study shows that controllers and pilots actually tend to use natural language in emergencies (see also Dumazeau, 2008: 56f.; Mell, 1994). The gist of Nevile's (2004) studies and conclusions is that the occurrence of deviations from a prescribed, coded script in aviation communication is inevitable and that these deviations are often beneficial for the maintenance of safety and sometimes necessary in the prevention of disasters (see e. g. *ib.*: 202f.).

[3] "'Can you make the runway?' asked a Seattle controller to a Russian pilot. His answer might have been, 'Making a runway requires construction equipment and material.' As it was, he was merely confused and tried to land on a Seattle street – an illustration of the fact that when a controller's working language and native language are the same he is apt to lapse into puzzling idioms and to make assumptions about the pilot's command of English" (Jones, 2003: 243). "This short review of miscommunication in aviation can offer some recommendations for improving safety until English is replaced by a more suitable language" (*ib.*).

The problem of how many and which meanings that might become relevant in aviation one should attempt to code by a lexical item (word or phrase) of a (semi-)artificial (sub)language can be illustrated by referring to a communicative situation mentioned by Arminen, Auvinen & Palukka (2010: 453ff.). The example does not involve communication between pilot and air traffic controller, but between two pilots – commander (CDR) and co-pilot (COP) –, whose verbal interaction also involves regulated language use in certain situations.

> *The pilots are discussing the transfer of control and navigation duties. The COP, who is in control, is giving these to the CDR […] [saying 'Your controls']. The CDR first accepts the duties […] [saying 'My controls'], but then allocates them back to the COP […] with a repair activity. (Ib.: 453)*[4]
> *[…]*
> *The standardized response to 'Your controls' is 'My controls', exactly as the CDR said. The scripted wordings do not include a callout that would enable the airline pilot to formally refuse to take on the control and navigation duties. The standard operating procedures also aim to standardize the pilots' actions by restricting responses to callouts. When standardized responses to standard callouts are inappropriate, pilots may need to remedy the scripted wordings with practices from ordinary talk, such as repairs or pre-sequences. (Ib.: 455f.*)

This example suggests that it may neither be intended nor possible to provide standardised utterances drawn from a (semi-)artificial (sub)language for every foreseeable and safety-relevant communicative situation in aviation – nor for any unforeseeable one, of course, a trivial but nevertheless important point in view of the fact that semi-artificial sublanguages like ATC-English differ from natural languages in that they are deliberately designed so as to be capable of expressing only a limited set of meanings.

The observations made in most of the works mentioned above point in the direction that Helmreich & Merritt (1998: 205) are right in claiming "[t]he simple reality is that a very high level of linguistic proficiency is needed before one can communicate effectively at the level that a time-critical, non-standard or emergency situation may dictate". This raises what Varantola (1989: 182) calls "one of the eternal questions in all LSP teaching programmes", namely, "How much general language is needed then?". The answer to this question that most researchers give amounts to saying: as much as possible, plus knowledge of varieties of English.[5]

4 The relevance of some fields and theories of linguistics

We have already seen that phonological, lexical, semantic and syntactic knowledge is needed, for example, in the analysis and potentially the improvement of ATC-English. Basic knowledge in disciplines such as these, which belong to what Aitchison (1972/1999: *pass.*) calls the "inner circles" of linguistics, also help in becoming aware and describing certain types of problems which may occur in aviation communication. In the following I will con-

[4] The reason for this repair is that the CDR needed to make sure first that another task was completed.
[5] As concerns national varieties of English and the relevance of their existence for communication in aviation, see Seiler, 2009 among others.

centrate on some aspects which rather belong to the "outer rings" (Aitchison 1972/1999: *pass.*) of linguistics.

Hopkin (1995: 268) makes an observation which is very familiar from sociolinguistics. "There is extensive anecdotal evidence, though relatively little experimental evidence, that controllers and pilots base judgements about each other and about their colleagues on speech". A few paragraphs later he states that "[t]he soundness of the judgements themselves has not been tested" (*ib.*: 269). A linguist trained in sociolinguistic theory and methodology will be able to provide experimental evidence for correlations between features of speech and judgements concerning speakers who display them. Subsequent tests of the soundness of such judgements may turn out to be very revealing for the practitioners and may thus advance their understanding of the linguistic aspects of their profession.

Linde (1988) applies concepts from politeness theory in an investigation of aircraft crew communication. She found out "that crews classified as high in safety performance have a higher rate of mitigation than poor crews. This finding is both surprising and important because many suggestions have been made that crews should be trained in linguistic directness" (Linde, 1988: 395). As an answer to the question of why this may be so she mentions that mitigation "can help to prevent the development of interpersonal or relational misunderstandings or animosities" (*ib.*: 396). For communication training in aviation she draws the conclusion that crew members should be prepared for situations in which directness might be interpreted as a challenge of the hierarchical relationship of crew members. And she proposes to offer training "in forms of communication that can challenge a superior's assessment of a situation, while indicating respect for the superior's position" (*ib.*). In the same vein, Morrow, Rodvold & Lee (1994: 255) recommend that "training in ATC communication should emphasize collaborative principles rather than focusing on terminology or isolated practices ('speak slowly', 'enunciate clearly')".

Concepts, categories and methodologies from speech act theory, politeness theory, discourse analysis and conversation analysis are applied in the studies documented by the various articles in Dietrich (ed.), 2003. The main focus of the researchers involved here is the relation between workload in high risk environments on the one hand and communicative behaviour and success on the other hand, primarily in the cockpit. The data in these studies were obtained by recording the cockpit communication during simulated flights. Krifka, Martens & Schwarz (2003: 99), for instance, conclude that "[t]here is evidence that linguistic features of communication correlate with the performance of crews and with the level of task load". An example of a more specific finding by these researchers, which supports the one by Linde just mentioned, is that "[p]oliteness elements occur slightly more often in good crews. Interestingly, good crews have fewer politeness elements in segments of high task load, just the opposite to poor crews" (Krifka, Martens & Schwarz, 2003: 90). Another interesting point, which is made by Silberstein & Dietrich (2003: 36), concerns differences in the communicative behaviour between crews of different cultural backgrounds. According to these authors, crews consisting of members from a western cultural background tend to use more informal language, whereas the register employed among crew members from Far East and Muslim cultures is pervasively formal.

To dwell on the issue of interculturality in aviation for a little longer: It has actually been known for some time that the communicative encounter of interlocutors from different cultural backgrounds may be a source of danger in aviation. Consider, for instance, the example given by Beneke (1993: 13) of Japanese pilots approaching San Francisco airport.

> *The pilots were sometimes not quite certain as to the exact meaning of the ATC […] instructions. When they were asked, however, whether they had understood the instructions, they would always say, Yes. It was found that many of the American controllers did not stick closely enough to standard phraseology, but tended to use idiomatic American English. The Japanese pilots, on the other hand, neither complained nor did they ask back. Rather, they would give the impression that they had perfectly understood the message.*

These Japanese pilots can be said to be culturally primed not to complain in a geographical context in which they considered themselves as guests, nor to reveal what they felt to be a linguistic weakness by admitting that they had not properly understood. Observations such as these made researchers aware of the necessity to investigate the intercultural aspects of the communication between pilots and air traffic controllers. Some research in this direction has actually been done, less so, however, by linguists, but rather by social and organisational psychologists (see e. g. Helmreich & Merritt, 1998; Isaac, 1999: ch. 4).

This is the appropriate place to point out that a more intensive study of the respective work by social and organisational psychologists on the part of the linguists and vice versa as well as a closer co-operation between these disciplines are certainly fruitful for both sides. Interdisciplinary work in this domain is of course not restricted to the topic of intercultural communication but extends to all topics and questions where models and theories of language and language use are employed in empirical studies. A very important part of the contribution by linguists in this kind of co-operation is their competence in analysing the relation between the form and the function of verbal expressions.

Language variation has turned out to be a source of problems in aviation communication too, so that a good understanding of the phenomena in this field is also important. The following is a real-life example from Helmreich & Merritt (1998: 203):

> *(Diabolical dialects.) With the introduction of transponders to aviation, the terms Mode A, Mode C and Mode S arrived with an interesting communicational problem. On approach to Melbourne, one particularly strong-accented Australian was heard to call 'Mayday'. The ATC tower was gripped with excitement as they tried to ascertain the cause of the emergency. Several more calls later from a remarkably calm-sounding crew led to the discovery that he was saying 'Mode A' not 'Mayday' and so the practice of calling 'Mode Alpha' was born. (Graham Braithwaite, British safety researcher working in Australia.)*

Helmreich & Merritt (1998: 204f.) also remark on "a Pakistani pilot who spoke with a perfect 'BBC English' accent. Referring to the heavy American accents he encounters at New York Air Traffic Control, he said, 'Forget about us foreign pilots, how about getting those guys in the Tower to speak English?'". If meant seriously, the manner in which the problem was stated by this pilot will appear as a misrepresentation to a linguist. The linguist's assessment will be that the pilot has something important to learn about language in general and English in

particular. If meant more or less as a joke, the remark nevertheless emphasises that there is a problem here which may be attended to by linguists (as more recently done by Seiler, 2009).

5 The relevance of relevance theory

In the final section of this paper the role relevance theory (RT) may play in a linguistic approach to communication in aviation is discussed. In particular, attention is drawn to the tension between, on the one hand, the insight emphasised especially within the RT framework that coded meaning only plays a triggering and partial role in the interpretation of utterances in ordinary communicative situations and, on the other hand, the fact that a rigorously coded (semi-)artificial (sub)language has been considered indispensable in the aviation context by most researchers.[6]

So far, it seems, RT (see Wilson & Sperber, 1981; Sperber & Wilson, 1986/1995; Wilson & Sperber, 2004 among many others) has not been made use of in the aviation context. Just like the Gricean theory of implicature (see Grice, 1989; especially Grice, 1967/1989), RT stresses the importance of pragmatic inferencing in the interpretation of verbal utterances, but differs in some respects from the Gricean approach and from the so-called neo-Gricean school as represented by Levinson (e. g. 2000), for instance. I will now present the basic ideas of RT in a nutshell.

In RT, the linguistic meaning of a sentence used in an utterance, which is decoded on the basis of the hearer's knowledge of the language, "is just one of the inputs to a non-demonstrative inference process which yields an interpretation of the speaker's meaning" (Wilson & Sperber, 2004: 607). Being 'non-demonstrative' means that the inference process does not guarantee the recovery of the speaker's meaning. The other inputs to such an inference process are drawn from the context, that is, the set of assumptions held by the hearer at the time when the utterance is to be interpreted. The set of assumptions drawn from comprises those that the hearer holds about the world in general, about the specific situation of the communicative exchange and about assumptions held by the addressee. It may be mentioned as an aside that there is no incompatibility between approaches pursued in social and intercultural pragmatics on the one hand and RT on the other hand. Quite to the contrary, the linguistic phenomena which are revealed and studied within social and intercultural pragmatics certainly arise from the mental models constructed by interlocutors as contexts used in utterance interpretation.

One basic supposition of RT is that the part of the human cognitive system which is concerned with utterance interpretation strives for the generation of so-called positive cognitive effects. One type of positive cognitive effect is the generation of a new assumption, that is, one which could not have been derived from the input alone, nor from the context alone, but only from both together. Other types of positive cognitive effect "include the strengthening, revision or abandonment of available assumptions" (Wilson & Sperber, 2004: 608). Another basic supposition is that the generation of positive cognitive effects is constrained by the

[6] Tajima (2004), for instance, who like many others stresses the importance of a very high proficiency in natural English for aviation personnel, also recommends that "we should sincerely and rigorously strive to create an error-resistant and mistake-free language environment" (*ib.*: 467). Recall also the quotation from Jones 2003 in section 3 above where he mentions "Esperanto, which might, with standardized terminology and phraseology, become the language for permanent use in international aeronautical communication".

amount of cognitive effort invested in the interpretation process. The relevance of an utterance for an interpreting individual results from weighing processing effort and positive cognitive effects against one another along the following lines (*ib.*: 609):

a. Other things being equal, the greater the positive cognitive effects achieved by processing an input, the greater the relevance of the input to the individual at that time.
b. Other things being equal, the greater the processing effort expended, the lower the relevance of the input to the individual at that time.

Now, the essential claim made by relevance theory is that the specific inferences that are made in the interpretation of an utterance in addition to the decoding of its linguistic meaning are guided by two principles. The "Cognitive Principle of Relevance" states that "[h]uman cognition tends to be geared to the maximisation of relevance (Wilson & Sperber, 2004: 608). The "Communicative Principle of Relevance" states that "[e]very ostensive stimulus [i. e. an utterance in verbal communication] conveys a presumption of its own optimal relevance" (*ib.*: 612). These two principles together imply a certain strategy for the process of utterance interpretation on the part of the addressee: It is most rational for the addressee to apply a least effort strategy and to take the first interpretation which satisfies his expectations of relevance as the most plausible hypothesis about the intended meaning on the part of the communicator. However, as pointed out by Wilson & Sperber (2004: 614), "[s]ince comprehension is a non-demonstrative inference process, this hypothesis may well be false; but it is the best a rational hearer can do".

RT highlights the following insights that ought to be taken into consideration in the study of communication in aviation: First, that the linguistic expressions as such that are used in order to convey meaning in natural verbal communication constitute only a part, if an important one, of the resources that are employed in the effort of recovering meaning. Whereas the code model of verbal communication suggests that human communicators are decoders, perhaps with an inbuilt noise-eliminator, RT suggests that linguistic expressions *per se* are semantically underdetermined in principle and that human communicators are constructors of meaning who take the denotation of linguistic expressions into account as one of the sources of information for constructing an interpretation alongside information provided by the context assumptions. The code model insinuates a robustness in the conveyance of information which may be deceptive. RT makes us aware of the fact that the success of communication is, although often achieved, a very subtle affair. Linguistic and communicative training in the aviation context may thus consider dispensing with any variety of the code model of communication, in which the linguistic expression – i. e. words, phrases, sentences – is conceived as the carrier of the information content from sender to receiver.

While this view of RT applies to natural communication by means of natural languages, it nevertheless raises the question whether a (semi-)artificial sublanguage that allegedly consists of an unambiguous lexicon and an unambiguous syntax does and can in principle really supply what it is intended to. The answer to this question is a clear 'no' for all those indeterminacies of meaning in verbal communication that are not due to natural language lexical or syntactic indeterminacies. For all a (semi-)artificial sublanguage can optimally do is provide a (semi-)artificial lexicon (potentially including a phraseology) and a (semi-)artificial syntax whose items (lexicon) and structures (syntax) are mapped in a one-to-one fashion onto senses of lexical items and disambiguated syntactic structures of a natural language. The point here is

that the meaning of the items and structures of the (semi-)artificial language are necessarily coded by making reference to items and structures of a natural language. That is, the addressee of an utterance transmitted in a (semi-)artificial language necessarily translates its coded meaning into a natural language equivalent. The interpretation of this equivalent is, in principle, subject to all those kinds of indeterminacies that an utterance directly transmitted in a natural language is subject to, except for indeterminacies due to ambiguous or vague senses of lexical items and ambiguous syntactic structures. It is true, the determination of the relevant senses of lexical items (given that this is possible in a technical context) and the disambiguation of syntactic structures that may be achieved by this detour via a (semi-)artificial language is important for communication in aviation and may have been able to prevent a large number of misunderstandings. However, they cannot in principle forestall misinterpretations due to inferences that do not serve the determination of communicator-intended senses of lexical items and syntactic structures, but are rather triggered by aspects of meaning interpreted adequately at this level.

The following is a simple example where the pragmatic inferences performed by a controller in order to determine the referent of the pronoun *we* leads to an interpretation that was not intended by the speaker and consequently to a dangerous situation.

> *One of two fighters on instrument route developed mechanical problems and stated ([5]a), after which the controller then issued an IFR [i. e. Instrument Flight Rules] clearance, to which the aircraft replied ([5]b).*
>
> *([5]a)We need a clearance back to base.*
> *([5]b)We are in a left turn and we are climbing to 17,000.*
>
> *The controller interpreted **we** as meaning that both aircraft were returning to home station, when in fact only the lead aircraft wanted to return […]. 'The wing man continued on the original IFR clearance and completed out the military route through the airspace of two centers.' (Cushing, 1994: 18)*

The conceptual meaning (see, among others, Ariel, 2010: 149ff.) that is encoded by the item *we* sanctions both the interpretation intended to be conveyed by the pilot and the interpretation arrived at by the controller. In this situation, where, for certain assessments, the two planes have to be conceived of as a pair, the interpretation of *we* as referring to both planes is the first interpretation imbued with sufficient relevance generated by the controller and is consequently the one attributed to the speaker. From Nevile's (2004: 45ff.) discussion of the use of *we* in cockpit communication, it can be inferred that its use in this example is non-prescribed by the regulations for talk in aviation; and this would be in agreement with what I pointed out in section 4 about the deletion of pronouns in the code provided by ATC-English.[7] The important point in the present context is that a deletion of the pronoun as possibly prescribed would not have changed anything about the potential for misinterpretation. It would of course be possible in principle to construct a code which avoids problems of this

[7] Nevile (2004: 77), for instance, writes: "By saying 'we've captured flight level X', rather than the prescribed 'captured flight level X' the pilot is able to represent the altitude as something achieved by the crew in their conduct of flight".

specific type. However, the limits of the effectiveness of a generalised procedure in which one tries to find a coded solution for the prevention of every type of conceivable misinterpretation are obvious. It is likewise obvious that communication in aviation generally cannot dispense with the flexibility afforded by natural language for conveying information about situations that may evolve but have not been foreseen by the designers of a coded sublanguage.

Another important point highlighted by RT is the possibility that human beings in general cannot help interpreting certain utterances in a certain way under certain conditions. We cannot in general help reading meaning into and above what the linguistic expressions used by a communicator denote. Example (3) of the communicative problems mentioned in section 2 is an illustrative case in point. In terms of RT, we may argue that the pilot could not help interpreting the controllers utterance of *I can give you 290* as a clearance for ascending to flight level 290. This is certainly the first interpretation which achieves sufficient relevance for the pilot who has just asked for permission to ascend to flight level 310 and was additionally told "but you will have to negotiate for higher". It is true, in terms of ATC-English the controller's utterance was no clearance, and the pilot should have reacted accordingly. But the fact that he interpreted the utterance as he did in spite of his familiarity with ATC-English seems only to emphasise the cognitive pressure towards optimisation of relevance as stated by the cognitive principle of relevance.

The final link in the causal chain that led to the disastrous collision of a passenger plane and a cargo plane over Lake Constance in 2002 may perhaps also be accounted for by a relevance theoretic consideration. Here the pilot of the passenger plane received contradictory instructions by the automatic warning system on the one hand and by the controller on the other hand. The chain of events concerning the passenger plane (TU154M) can be summarised as follows (see BFU 2004).

(6) *43 seconds before the crash, the controller instructs the crew to immediately descend. 7 seconds later the crew initiates a descent, but receives simultaneously an instruction to climb by the plane's automatic collision warning system. Another 7 seconds later the controller repeats his instruction to descend, which is verbally confirmed by the crew. 21 seconds later the automatic warning system issues the command to "increase climb". 8 seconds later the passenger plane, which is still descending, collides with the cargo jet, which followed the instruction of its own automatic collision warning system and has been descending as well.*

The investigation report identifies the following circumstance as one of the immediate causes of the collision: "The TU154M crew followed the ATC instruction to descend and continued to do so even after TCAS [i. e. Traffic Alert and Collision Avoidance System] advised them to climb. This manoeuvre was performed contrary to the generated TCAS RA [i. e. Resolution Advisary]" (BFU 2004: 5). The crucial point here seems to be that the pilot of the passenger plane trusted the instruction issued by the human being, the controller, more than that issued by the machine.

Pilots are subject to the regulation that in cases of contradicting instructions by the automatic warning system on the one hand and by controllers on the other to follow the former. However, it seems to be difficult for humans to actually comply with this regulation. Human factor research has revealed that there is a "greater compliance rate that pilots have in following ad-

visories given by a human controller, than those given by an automated algorithm with a synthetic voice" (Wickens et al. (eds.), 1998: 146). An explanation in terms of relevance theory may proceed along the following lines: A verbal utterance made by a human communicator is what Sperber & Wilson (e. g. 1986/1995: 153ff.) call an ostensive stimulus. Such a stimulus makes it manifest to the addressee that the communicator has an informative intention and that the communicator wants the addressee to recognise that she has this intention. To consider an utterance as relevant presupposes that it is treated as ostensive (Sperber & Wilson, 1986/1995: 154). A machine as such is not attributed intention at all by an addressee; a machine may serve as a mediator of human intentions, so that human intention is communicated only indirectly where a machine as mediator is involved. Moreover, the human intention indirectly communicated in this case is associated with anonymous communicators who are not aware of the specific situation in which their communicative intention was made manifest to the addressee by the machine. This anonymity and the separation of the communicative intention from the actual communicative situation reduces the relevance of the communicative intention compared to where a human communicator is directly involved in the actual communicative situation.

6 Conclusion

The potential for problems in communication in aviation that linguists will be able to anticipate in the abstract, i. e. without having looked at the pertinent literature or done pertinent research, does not seem to deviate much from what is actually there. Due to the extremely severe consequences that these problems may have and have had, the topic is, though interesting, also a sombre one. It will not be possible to avoid all of these problems. Quite apart from the disadvantages – and advantages in certain situations – that an unregulated use of language would engender, every piece of regulation that one may want to introduce in order to prevent an identified type of problem may turn out to have disadvantages under unforeseen circumstances. However, conducting research on communication in aviation from the point of view of a linguist certainly contributes to a deeper understanding of the issues involved. Finally, the investigation of language in the context of aviation, where very much depends on communicative success, may make the linguist and the communicative practitioner most sharply aware of and sensitive to the processes and problems involved in linguistic behaviour in *any* field of social interaction.

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