

## ERROR-CHALLENGING STRATEGIES: THEIR ROLE IN PREVENTING AND CORRECTING ERRORS\*

Ute Fischer  
Georgia Institute of Technology  
Atlanta, Georgia

Judith Orasanu  
NASA-Ames Research Center  
Moffett Field, California

Two studies were conducted to identify effective communication strategies for calling attention to problems and getting action on them from other crew members. In Study 1, pilots in both crew positions relied primarily on one status-consistent strategy to request action of another crew member: Captains generally preferred to use commands, while first officers predominantly used hints. However, when asked to rate the effectiveness of various strategies in Study 2, captains and first officers favored communications that appealed to the crew concept rather than to any particular status-based model.

Maintaining safety in high risk engineered environments like aviation is a team effort that depends crucially on the team members' efficiency in monitoring each other's performance and on their effectiveness in intervening if they consider a decision or action to be unsafe. Redundancy between crew members is thus essential to prevent pilot errors from escalating into accidents. Unfortunately, analyses of aviation accidents and incidents (Jentsch et al., 1997; NTSB, 1994) indicate that pilots, in particular junior pilots, have frequently failed in this important crew function, especially in situations in which their interventions posed a direct challenge to another crew member's judgment and decision-making skill. As a case in point, consider the following accident.

On January 13, 1982 an Air Florida Boeing 737 crashed into the Potomac River due to excessive snow and ice on the airplane and a frozen indicator which gave the crew a false engine power reading. While awaiting their takeoff clearance, the following conversation took place among the crew (NTSB, 1982):

First Officer: *Look how the ice is just hanging on his, ah, back, back there, see that?* (...)

First Officer: *See all those icicles on the back there and everything?*

Captain: *Yeah.*

After a long wait following de-icing,

First Officer: *Boy, this is a, this is a losing battle here on trying to de-ice those things, it (gives) you a false feeling of security, that's all that it does.*

Shortly after being given clearance to take off, the first officer again expressed his concern:

First Officer: *Let's check those tops again since we've been sitting here awhile.*

Captain: *I think we get to go here in a minute.*

Finally, while they were on their takeoff roll, the first officer noticed that something was wrong with the engine readings.

First Officer: *That don't seem right, does it?* [three second pause]  
*Ah, that's not right . . .*

Captain: *Yes, it is, there's 80.*

First Officer: *Naw, I don't think that's right.* [seven-second pause]  
*Ah, maybe it is.*

The first officer apparently was quite concerned by the ice build-up on the wings and later on by the engine reading. Yet he did not succeed in getting the captain to take his concerns

seriously and to act on them. While we certainly do not want to minimize the captain's role, we suspect that the first officer's use of indirect speech may have also contributed to the accident. He only hinted at the possibility of a problem and never told the captain explicitly that he thought they should discontinue the takeoff. This type of communication failure has been identified as a "monitoring/challenging error" by the NTSB (1994) and was found to occur in over 75% of the accidents reviewed. Moreover, monitoring/challenging failures appear to contribute to "plan continuation errors" (Orasanu, Martin, & Davison, in press). These are errors in which the crew continues with its planned course of action in the face of cues suggesting that reconsideration of the plan may be prudent. In this paper we will examine how specific communication strategies may prevent --or contribute to--plan continuation errors.

From the dialogue above, one may conclude that crew members ought to be maximally explicit and direct in their error challenges. The call for maximal explicitness and directness, however, underestimates the important role that social considerations play in interactions. Human communication is not just a matter of conveying information; often speakers intend to influence what their addressees do (Searle, 1969). How speakers can best assure listener compliance varies with their relationship (Herrmann & Grabowski, 1994). Superiors, by virtue of their social status, may be licensed to give direct commands to their subordinates. If subordinates use the same linguistic strategy, however, superiors may perceive them as threatening or rude and may refuse to comply. To avoid this kind of confrontation, subordinates are likely to use more polite and indirect ways of communicating (Brown & Levinson, 1987). However, by being indirect one runs the risk of being misunderstood or of not being heard (Linde, 1988).

Thus, a tension exists between informative communication and socially successful ways of communicating. We suggest that effective communication seeks to optimize both informativeness and social appropriateness. How this may be achieved in crew discourse is the topic of the present research effort.

### STUDY 1

The aim of this study was to determine which communication strategies captains and first officers would use to prevent or correct errors by another crew member. Previous analyses of crew

---

\* In Proceedings of the International Ergonomics Association 14<sup>th</sup> Triennial Congress and Human Factors and Ergonomics Society 44<sup>th</sup> Annual Meeting in San Diego, California, August 2000 (pp. 30-33)

discourse during simulated flight (Linde, 1988; Orasanu & Fischer, 1992) found that captains were more direct in addressing first officers than first officers were in addressing captains. However, for both crew positions communications were more direct during problem and emergency situations than during normal flight segments. In addition to risk, we suspected that pilots' communications would be sensitive to the degree to which an error implied a threat to the professional "face" of a crew member. If an other has made an obvious error, interventions may easily involve a direct challenge to his status, judgment or skill. According to politeness theory (Brown & Levinson, 1987), in situations like these speakers will seek to protect their addressee's face and use more indirect speech compared to situations that are less face-threatening; i.e., when errors consist of oversights.

## Method

Male pilots (n = 157, 69 captains and 88 first officers) from three major US airlines received eight short descriptions of aviation incidents and were asked to state how they would correct various pilot errors. Four of the incidents were high-risk and four were low-risk. For participating first officers, the incidents involved errors or oversights on the part of the captain, the pilot-flying. For participating captains, incidents were identical except that they described first officers making errors and oversights. For instance, captain participants saw the following problem description.

While cruising in IMC at FL 310, you notice on the weather radar an area of heavy precipitation 25 miles ahead. First Officer Henry Jones, who is flying the aircraft, is maintaining his present course at Mach .73 even though embedded thunderstorms have been reported in your area and you encounter moderate turbulence.

*You want to ensure that your aircraft will not penetrate this area. Please write out verbatim what you would say to F/O Jones.*

**Table 1.** Classes of Communications

REQUESTS (= OTHER-DIRECTED COMMUNICATIONS)	
<b>Commands</b>	<i>Turn 30° right.</i>
<b>Crew Obligation Statements</b>	<i>We need to deviate right about now.</i>
<b>Crew Suggestions</b>	<i>Let's go around the weather.</i>
<b>Queries</b>	<i>Which direction would you like to deviate?</i>
<b>Preferences</b>	<i>I think it would be wise to turn left or right.</i>
<b>Hints</b>	<i>That return at 25 miles looks mean.</i>
SPEAKER-CENTERED COMMUNICATIONS	
<b>Self-Directives</b>	<i>I am going to get a clearance to deviate around these storms.</i>
<b>Permission-seeking Questions</b>	<i>You want me to ask for clearance to deviate around this weather?</i>

Responses were assigned to eight classes of communication that differed in terms of their focus, explicitness and directness (Blum-Kulka, et al., 1989), as shown in Table 1. The structure of responses was also coded. Simple communications involved only a request or a speaker-centered communication. Complex communications in addition provided reasons for the request or speaker-centered communication. An example of a complex communication is *"I see we have some cells painting on radar. I think we should turn left about 30°."*

## Results and Discussion

Hierarchical loglinear analyses were conducted to examine the association between crew position, communication structure and type of other-directed or speaker-centered communication. Captains and first officers were found to favor different request strategies. Captains most frequently used commands (54% of all requests) to correct first officers while first officers most often used hints (38%) to get action from the captain. This pattern of findings indicates that while pursuing identical communicative goals, captains take a more direct route than first officers do. As expected, captains were more likely than first officers to specify the action that should be taken, and expressed their intentions more forcefully; i.e., there was a stronger obligation for first officers to comply with captains' requests than vice versa.

Similar status differences were observed for communications that concerned actions by the speaker. In 57% of their speaker-centered communications, first officers sought assurance that the captain agreed with their planned action. Captains, on the other hand, almost never used permission-requests, relying instead on self-directives (91%).

In addition to status, the risk level inherent in a situation also influenced request strategies. As predicted, both crew positions became more direct when risk increased. Nonetheless, status differences persisted. Captains adjusted to higher risk mainly by issuing even more commands (63% vs. 47% in low-risk situations). In contrast, first officers used four times as many crew obligation statements in high risk as in low risk situations (16% vs. 4%). However, hints remained their predominant strategy, even in high-risk situations.

Pilots' responses to face-threat were not consistent with the predictions made by politeness theory. Captains used more hints but also more commands in high face-threat situations, while first officers were likely to increase commands, crew suggestions and crew obligation statements. Captains apparently focused either on the face-threat implied in the incident, thus preferring indirect interventions for high face-threat errors, or they responded to the magnitude of the error, correcting major errors more decisively than minor ones. First officers seemed to focus on either aspect, depending on the risk level. In low-risk situations, they were more direct when they challenged major rather than minor captain errors. However, when risk levels were high, errors judged to be highly embarrassing to the captain were handled more indirectly than errors assumed to involve less face-threat.

Concerning the structure of pilots' communications, we found that for both crew positions direct requests were usually (63%) accompanied by justifications, as in the following example: *"We are too far left of centerline for parallel approaches - correct right immediately!"* Similarly, captains and first officers supported speaker-centered communications with problem or goal

statements. Supportive statements may serve social as well as cognitive purposes: they may decrease the imposition a speaker places on the addressee (Blum-Kulka, et al.) and they may facilitate the crew's shared problem understanding and problem solving (Orasanu, 1994).

### STUDY 2

This study had several objectives. We wanted to determine which of the communication strategies produced in the previous study would be judged to be most effective in correcting pilot error, and whether supporting statements would enhance strategy effectiveness. Second, we examined whether the perceived effectiveness of strategies varied by crew position, as well as with the levels of risk and face-threat inherent in a situation.

#### Method

Pilots from three major US airlines (n = 116, 59 captains and 57 first officers) received the incident descriptions used in Study 1 and one example of each of the communication strategies listed in Table 1. Participating captains were told that the communications were from first officers. First officers received the same communications and were told that they were from captains. Participants were asked to rate how effective each communication would be in getting them to carry out the speaker's intent. Effectiveness was defined as "highly appropriate to the problem while maintaining a positive crew climate."

In a second task, participants were asked to rate how direct each communication type was; i.e., "how clear it was what the speaker wanted done and how much pressure he put on the addressee to act." The orders of effectiveness and directness ratings were counterbalanced across participants. Half of the participants in each pilot group received communications unsupported by a problem or goal statement, while the other half received communications with supporting statements.

#### Results and Discussion

Two mixed-design analyses of variance were conducted, one on pilots' mean effectiveness ratings for each of the communication types in an incident, and the second one on pilots' mean directness ratings. Due to space limitations, the discussion will focus only on pilots' effectiveness ratings.

In this analysis the following statistically significant effects were observed: (1) As shown in Figure 1, strategies judged to be most effective by both crew positions were neither too direct nor too indirect. Captains judged first officers' preference statements, crew obligation statements, and hints to be significantly more effective than other strategies. First officers thought that captains were most effective when they used crew suggestions, crew obligation statements, and preference statements rather than commands or any of the remaining strategies. (2) The face-threat inherent in a situation, but not its risk level, significantly influenced pilots' effectiveness ratings. Both crew positions judged hints to be more effective when used to correct highly embarrassing mistakes rather than minor errors. In high face-threat situations pilots rated this strategy to be as effective as crew obligation and preference statements, and considered it to be more effective than any other strategy. (3) Airline specific differences between pilots were found

in their evaluations of supporting statements or justifications. While the effectiveness ratings of pilots from US Carrier-3 were not

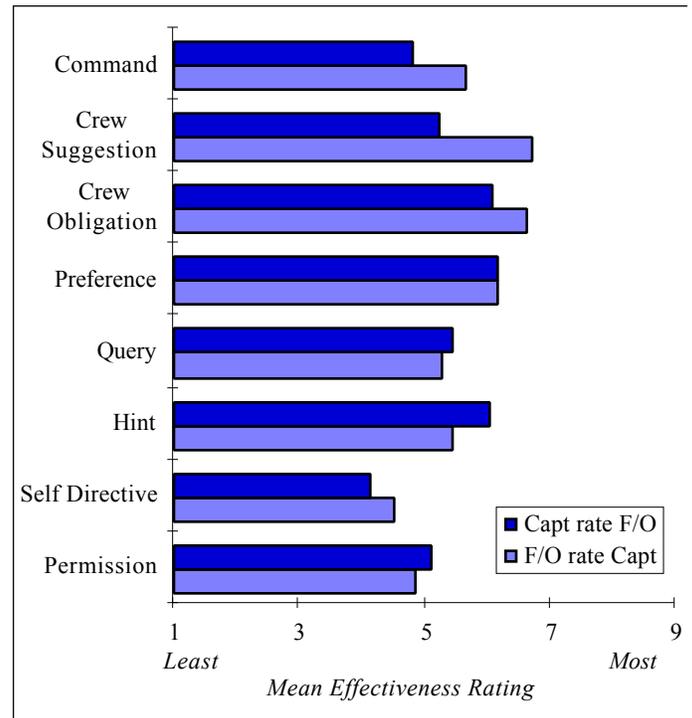


Figure 1. Captains' and First Officers' Mean Effectiveness Ratings of Different Communication Types (Aligned from Most to Least Direct)

affected by justifications, pilots from US Carrier-1 tended to judge communications that were supported by a problem or goal statement to be more effective than unsupported communications. The reverse result was obtained for pilots from US Carrier-2. (4) Captains' judgments of effective first officer strategies corresponded moderately well to the frequencies with which first officers in Study 1 used the various request strategies. A medium strong rank order correlation between captains' effectiveness ratings and observed frequency of first officers' strategies was observed ( $\rho = .51$ ). In contrast, first officers' effectiveness ratings of captains' strategies did not correlate as strongly with captains' strategy use in Study 1 ( $\rho = .34$ ). The low correlation coefficient indicates a mismatch between first officers' opinions about effective captain strategies and captains' actual responses. Crew obligation statements, crew suggestions and preference statements, the top three captain strategies according to first officers, were rarely used by captains (4%, 17% and 6% of all captain requests, respectively). On the other hand, the captains' dominant request strategy, commands, received a considerably lower effectiveness rating.

#### GENERAL DISCUSSION AND CONCLUSION

Together, studies 1 and 2 suggest that the strategies pilots indicated they would use to correct another pilot's errors may not be the most effective ones. While striking differences were found in captains' and first officers' communication strategies, there was

considerable agreement between crew positions on what constitutes effective communication. When asked to rate the effectiveness of various strategies, both captains and first officers favored communications that appealed to the crew concept rather than to any particular status-based model. Both pilot groups gave high effectiveness ratings to crew obligation statements and preference statements; they consistently rated commands, the most direct communication strategy, as less effective. Common to these strategies is that they address a problem without disrupting the team context. Like commands they explicitly state what should be done. But unlike commands they do not rely on status differences to assure compliance. While crew obligation statements seek compliance by appeal to a shared obligation, preference statements do so by referring to the solidarity between speaker and hearer.

Interestingly, hints were both produced frequently by first officers and were judged by captains to be a highly effective first officer strategy for requesting action of them. Yet, accident analyses suggest that first officers had little success in changing the captain's behavior when they used hints. This discrepancy in findings may be reconciled if we bear in mind that there are different types of hints. Weak hints merely insinuate rather than define a problem, and thus require the listener first to infer that there is a problem. In contrast, many of the hints that the first officers produced in Study 1 and that captains rated in Study 2 were strong hints. They were problem or goal statements that strongly implied what action should be taken, for example, "Clearance was to 9000!" Or "I show us 15 kts slow." In each of these examples what the first officer wants the captain to do is clear. Moreover, once the addressee acknowledges the problem, he is also committed to the appropriate action. Thus, without explicitly doing so, speakers demand listener action and compliance. By using strong hints, first officers at most question the captain's understanding of the situation. They minimally challenge his status since the decision about how best to respond to the problem is left to the captain. This characteristic of strong hints may also explain why captains considered them a particularly effective strategy to correct highly embarrassing mistakes. In using strong hints, speakers protect their addressee's face since control over any corrective action is left with the person who committed the mistake.

We suspect that it was first officers' reliance on weak hints that contributed to many of the plan continuation errors observed in accident analyses. As illustrated by the Air Florida case, when first officers use weak hints, their interventions may be too indirect to get the captain's attention or to change his behavior. In contrast, our research suggests that plan continuation errors could be prevented if crew members' communications were more explicit about the nature of the problem and possible alternative courses of action. At the same time, they should appeal to the crew's shared responsibility for coping with a problem.

If we assume that pilots' effectiveness ratings reflect a valid model of crew discourse, then it is surprising that their communications in Study 1 did not follow this model more closely. Our research shows that while pilots upheld a crew-oriented discourse model in their effectiveness judgments, a status-based discourse model drove their productions. This discrepancy may indicate that crew members find it difficult to overcome ingrained norms for interacting with superiors and subordinates and to translate an abstract notion like "crew concept" into specific communication strategies. Consequently, crews may benefit from

training initiatives that facilitate this translation process. Training approaches that provide examples of crew-oriented communication strategies and that coach individual members in these strategies may be essential in order to bring about change in well-established behavioral patterns.

## REFERENCES

- Blum-Kulka, S., House, J. & Kasper, G. (Eds.). 1989. *Cross-cultural pragmatics: Requests and apologies*. (Advances in Discourse Processes: Vol. 31). Norwood, NJ: Ablex Publishing.
- Brown, P., & Levinson, S. C. (1987). *Politeness: Some universals in language usage*. Cambridge: Cambridge University Press.
- Herrmann, T., & Grabowski, J. (1994). *Sprechen: Psychologie der Sprachproduktion*. Heidelberg: Spektrum Akademischer Verlag GmbH.
- Jentsch, F., Martin, L. & Bowers, C. (1997). *Identifying critical training needs for junior first officers*. Special Technical Report submitted to Naval Air Warfare Center Training Systems Division. May 12, 1997.
- Linde, C. (1988). The quantitative study of communicative success: Politeness and accidents in aviation discourse. *Language in Society*, 17, 375-399.
- National Transportation Safety Board (1982). *Aircraft Accident Report: Air Florida, Inc., Boeing 737-222, N62AF, Collision with 14th Street Bridge, Near Washington National Airport, Washington, D. C., January 13, 1982* (NTSB-AAR-82-8). Washington, DC: Author.
- National Transportation Safety Board (NTSB) (1994). *Safety study: A review of flightcrew-involved, major accidents of U.S. air carriers, 1978 through 1990* (NTSB/SS-94/01). Washington DC: National Technical Information Service.
- Orasanu, J. (1994). Shared problem models and flight crew performance. In N. Johnston, N. McDonald, & R. Fuller (Eds.), *Aviation psychology in practice*. (pp. 255-285). Avebury Technical.
- Orasanu, J., & Fischer, U. (1992). Distributed cognition in the cockpit: Linguistic control of shared problem solving. In *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society* (pp. 189-194). Hillsdale, NJ: Erlbaum.
- Orasanu, J., Martin, L., & Davison, J. (In press). Cognitive and contextual factors in aviation accidents. In G. Klein and E. Salas (Eds.) *Applications of Naturalistic Decision Making*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Searle, J. R. (1969). *Speech acts: An essay in the philosophy of language*. Cambridge: Cambridge University Press.