Language Quality Based Heuristic effects in the ATC radio communication: The Linate 2001 and Tenerife 1977 H-LQB erroneous validation effect, and the Lexington 2006 H-LQB erroneous falsification effect.

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Summary
The aim of the present paper is to investigate the occurrences of a supposed human factor in ATC airborne communication accidents, namely a Language Quality Based Heuristic (H-LQB).
A theory on the functioning of the H-LQB is developed along with a LQB questionnaire to assess the heuristic in ATC airborne communication exchanges. A preliminary pilot study is conducted analysing the official transcriptions of three ATC misunderstanding broadcast accidents: Lexington 2006, Tenerife 1977 and Linate 2001. A sample of four Controllers responded to the questionnaire about the perceived language quality in these communications. The pilot study suggests the presence of an ATC airborne language quality frame that can turn the effectiveness of the communication into the Heuristic LQB. This happens because of the ATC communications tendency to allow a confirmative bias based on implicit expectations related to the language quality, thus avoiding the possibility to turn the proceeding acts into a cognitive conflict which is necessary to reselect the actions.

Key words: heuristic, language quality, misunderstanding, accidents

Introduction, H-LQB Theory
In a previous analysis of the transcription of the Linate 2001 Accident Cockpit Voice Recorder (CVR), a qualitative study was conducted according to Jakobson's theory of communicative functions (Jakobson 1960), and the presence of an adverse psychological mechanism, namely a Quality Based Language Heuristic (H-LQB), was suggested (Trebbi 2004).
Looking for other similar aviation communication accidents, a preliminary qualitative CVR analysis according to the Four Colours Method in the Decision Making Process (Trebbi 2006) seemed to indicate the same possible heuristic implication for the accidents of Lexington 2006 and Tenerife 1977. The term heuristic generally refers to a cognitive human simplification process by which the factual information is elaborated in order to take a decision (Tversky & Kahneman 1982). A heuristic responds under certain conditions to systematic ways of functioning, and the human perception of the quality of the environmental information can cause the heuristic function. The theory of the Language Quality Based Heuristic (H-LQB) refers to the property of the language to make cognitive simplifications of the information communicated by the language itself. This happens by the perception of the quality of the language in use between the sender and the receiver during the communication. The language quality is a direct result of the verbal interaction in air traffic control procedures and it is the framework in which the factual information exchange happened: in other word “the recipient of the articulated message” (Gazzaniga, Ivry & Magnum, 1998). The quality of a communication is itself communicated between speakers. The perception of this communicated quality is supposed to affect the process of cognitive elaboration of the information that the language conveys. More specifically, it is argued that the radio ATC communication between speakers is effective when the following two conditions are established: A) the sharing of the transmitted factual information (e.g., communicated intention, broadcasted flight date, etc.) and, B) the sharing of the expectation of the future events connected to the communicated factual information (according to Bjorklund 2000). The message about the quality of the shared expectation regarding the factual information works between the speakers as a feedback of the good understanding of the communicated broadcast. In this optimal case the airborne communication allows a safe and heedful interrelating coordination between pilots and controllers (Weick & Roberts, 1993).

It is supposed that the sharing of the expectation regarding the language can be obtained by the speakers in a continuum from more “recognized” to more “implicit” language quality. When the language quality is predominantly implicit, the sharing of the communicated language quality meaning is not able to give an effective factual information feedback (according to the heedless interrelating concept, Weick & Roberts, 1993). In that unsafe case the communicated factual information is not effective, because the radio exchange gives to the speakers an implicit sham feedback that could not match the operational reality. This false conceptualization, characterized as heedless interrelating, could find support in the prescribed communication procedures according to the level of standardization of an organization. In this case of implicit language quality meaning there is no recognized shared expectation of the future events, but only the implicit level of standardization of the organization is shared. When this happens, for example clues of evident misunderstanding are levelled off and possible conflicts are solved by relying on the heuristic LQB mechanism based on shared expectations referring to norms and standard procedures. In the H-LQB occurrences the supposed mistake can appear in two different effects: 1) a wrong information can be considered correct without stopping the running of the proceeding action (H-LQB erroneous validation effect) or, 2) a correct information can be not considered or ignored without stopping the proceeding action (H-LQB erroneous falsification effect). The H-LQB is supposed to occur due to a combination of implicit coordination and over reliance on standardization systems and it is conveyed by the broadcast communication.

Method, LQB Questionnaire

To better study the occurrences of this H-LQB, a preliminary pilot research is hereby conducted. The official CVR transcription of three ATC communication accidents, (Lexington 2006, Tenerife 1977, Linate 2001) are taken together forming a list of 16 airborne ATC communications. Every communication has an odd or even number of radio exchanges between pilot and controller. This list of 16 airborne communications represents the material that the research sample of four controllers has to rate. According to the H-LQB theory, a questionnaire is build with 3 questions subdivided into 11 items to detect the perceived language quality for each of the 16 ATC communications (full questionnaire for an ATC communication is in appendix A).
According to H-LQB theory, question 1 tested the following 7 scale items:

<u>Items supposed to be positively correlated with the H-LQB occurrences</u>:
a) The communication uses the expectation to receive wait information.
b) The performed communication is standard.
i) The communication employs the implicit knowledge of the communicated meaning.

<u>Items supposed inversely correlated with the H-LQB occurrences:</u>
c) The communication produces a conflict to understand how to resolve the situation.
e) The communication has the aim to clarify an ambiguous information and doubt of the speaker.
h) The communication supports the recognition of the communicated meaning.

<u>Items free to vary with the H-LQB occurrences:</u>
d) The communication is made to speed up the radio exchange.
f) The communication tends to arouse the impression of a certain emotion of the listener.
g) The communication produces a good communicational contact between pilot and controller.

<u>Question 2 was developed to validate the 9 subitems of question 1:</u>
2) The communication is effective for the share of the meaning by the radio.

<u>Question 3 was developed to validate the 9 subitems of question 1, too:</u>
3) The communication contribute to guarantee the operational safety

<u>Data sample</u>: Four male Air Traffic Controllers: ATC 1, age 27, experience 1 month; ATC 2, age 32, experience 5 years; ATC 3, age 36 experience 10 years; ATC 4, age 41, experience 20 years.

Results:

Correlations per controllers

The following tables report the correlations between the 11 items for *N*=16 ATC communications separately for each rater (controller). In the following, only the significant correlations are reported.

**Correlation is significant at a level 0.01 (bilateral)
* Correlation is significant at a level 0.05 (bilateral)
(note: e.g. "i1a" stands for "item a question one")

Item b: the performed communication is standard.

Item b	i1a	i1c	i1d	i1e	i1g	i1h	i2	i3
CTA 1		-,789(**)		,545(*)	,631(**)		,838(**)	,828(**)
CTA 2		-,656(**)			,527(*)	,558(*)	,755(**)	,667(**)
CTA 3	,753(**)	-,787(**)			,602(*)	,585(*)	,690(**)	,540(*)
CTA 4			-,836(**)					,773(**)

Note: the standard communication is negatively correlated with a conflict to understand (item c) and positively correlated with the effective communication (item 2) and operational safety (item 3).

Item c: the communication produce a conflict to understand to resolve the situation.

Item c	i1a	i1b	i1e	i1f	i1g	i1h	i2	i3
CTA 1		-,789(**)	-,633(**)		-,538(*)	-,556(*)	-,933(**)	-,859(**)
CTA 2		-,656(**)		,748(**)	-,875(**)	-,775(**)	-,835(**)	-,685(**)
CTA 3	-,641(**)	-,787(**)			-,552(*)		-,726(**)	-,625(*)
CTA 4			-,693(**)			-,841(**)		

Note: the conflict to understand is negatively correlated with the most items, particularly with the effective communication (item 2). A single case positive correlation with arousing emotion (item f).

Item h**:** the communication support the recognition of the communicated meaning.

Item h	i1a	i1b	i1c	i1d	i1e	i1f	i1g	i1i	i2	i3
CTA 1			-,556(*)	,738(**)	,706(**)	-,595(*)	,790(**)	,774(**)	,503(*)	
CTA 2		,558(*)	-,775(**)	-,526(*)		-,584(*)	,864(**)		,900(**)	,853(**)
CTA 3	,497(*)	,585(*)								
CTA 4			-,841(**)		,720(**)				,548(*)	

Note: the recognition of the meaning is negatively correlated with the conflict to understand (item c) and positively correlated with the effective communication (item 2)

Question 2: the communication is effective for the share of the communicated meaning by radio

Item 2	i1a	i1b	i1c	i1e	i1f	i1g	i1h	i3
CTA 1		838(**)	-,933(**)	,708(**)		,498(*)	,503(*)	,837(**)
CTA 2		,755(**)	-,835(**)		-,567(*)	,773(**)	,900(**)	,866(**)
CTA 3	,568(*)	,690(**)	-,726(**)					,792(**)
CTA 4							,548(*)	

Note: the effective sharing of the communicated meaning is negatively correlated with the conflict to understand (item c). It is positively correlated with standard communication (item b), and the recognition of communicated meaning (item h).

Statistic description per communications

The following tables report the statistic description of the quality language perceived from the 4 raters (controllers) to some significant critical misunderstanding communications in the accidents.

Communication 3: from CVR official transcription of Lexington 2006 accident, as follow:

06:02:01.3 RDO: Comair one ninety one is ready to taxi we have ALPHA.
06:02:03.8 GND: Comair one ninety one, taxi to runway two two. altimeter three zero zero zero and the winds are two zero zero at eight.
06:02:08.9 RDO: three triple zero and taxi two two, Comair one ninety one.

The following table reports the descriptive statistics for each item taking together the ratings of all four raters with respect to communication 3.

Com.3	i1a	i1b	i1c	i1d	i1e	i1f	i1g	i1h	i1i	i2	i3
mean	6,25	3,25	2,25	5,25	3,50	1,75	3,50	4,75	6,33	4,50	3,50
median	7,00	3,00	2,50	5,00	4,00	1,50	3,50	4,50	6,00	4,50	3,50
standard deviation	1,500	2,630	,957	1,500	1,000	,957	1,291	,957	,577	1,732	1,732
Min	4	1	1	4	2	1	2	4	6	3	2
Max	7	6	3	7	4	3	5	6	7	6	5

Note: this communication has a high level of expectation to receive wait information (item a), high level to employ implicit meaning (item i) and a low level to produce a conflict to understand (item c)

Communication 10: from CVR official transcription of Tenerife 1977 accident, as follow:

1705:44.8	KLM RT	Uh, the KLM ... four eight zero five is now ready for take-off ... uh and we're waiting for our ATC clearance.
1705:53.4	APP	KLM eight seven zero five uh you are cleared to the Papa Beacon climb to and maintain flight level nine zero right turn after take-off proceed with heading zero four zero until intercepting the three two five radial from Las Palmas VOR.
1706:09.6	KLM RT	Ah roger, sir, we're cleared to the Papa Beacon flight level nine zero, right turn out zero four zero until intercepting the three two five and we're now at take-off.
1706:18.19	APP	OK.
1706:19.3	PA RT	No .. eh.
1706:20.08	APP	Stand by for take-off, I will call you.

The following table reports the descriptive statistics for each item taking together the ratings of all four raters with respect to communication 10.

Com. 10	i1a	i1b	i1c	i1d	i1e	i1f	i1g	i1h	i1i	i2	i3
mean	5,25	1,25	6,75	4,00	2,25	5,50	1,50	1,50	4,00	1,75	1,25
median	5,00	1,00	7,00	4,00	2,00	5,50	1,00	1,00	3,50	1,50	1,00
standard deviation	1,500	,500	,500	2,582	1,500	,577	1,000	1,000	1,414	,957	,500
Min	4	1	6	1	1	5	1	1	3	1	1
Maxi	7	2	7	7	4	6	3	3	6	3	2

Note: this communication has a very a high level of conflict to understand (item c), a high level of expectation to receive wait information (item a), a high level of arouse emotion (item f). It have also low level of standard communication (item b), low level of good contact (item g), low level of recognition of the meaning (item h), low effective share meaning (item 2) and a low safety (item 3)

Communication 15: from CVR official transcription of Linate 2001 accident, as follow:

06 09 19 GROUND: DeltaVictorXray continue your taxi on the main apron, follow the Alfa Line.

06 09 28 D-IEVX: Roger continue the taxi in main apron, Alfa Line the.. DeltaVictorXray.

06 09 33 GROUND: That is correct and please call me back entering the main taxiway.

06 09 38 D-IEVX: I'll call you on the main taxiway.

The following table reports the descriptive statistics for each item taking together the ratings of all four raters with respect to communication 15.

Com. 15	i1a	i1b	i1c	i1d	i1e	i1f	i1g	i1h	i1i	i2	i3
mean	5,25	3,50	4,25	5,00	3,75	3,50	4,25	3,50	5,25	2,75	3,50
median	6,00	3,50	4,50	5,00	3,50	3,00	4,50	3,00	6,00	2,50	3,50
standard deviation	1,500	,577	1,708	,816	,957	1,732	1,708	1,915	2,217	,957	,577
Min	3	3	2	4	3	2	2	2	2	2	3
Maxi	6	4	6	6	5	6	6	6	7	4	4

Note: This communication has a high level of expectation to receive wait information (item a), high level to speed up the radio exchange (item d) and a high level to employ the implicit meaning (item i). It have also a low level of recognition of the meaning (item h), low effective share meaning (item 2) and a low safety (item 3)

Conclusion

This preliminary pilot study to investigate the occurrence of the supposed H-LQB in ATC accident communications seems to give support of the formulated theory. The perceived language quality assessment carried out with the LQB questionnaire on the 16 airborne ATC communications, gives a first indication of the nature of the ATC broadcast communication. Its aim is to implement a standard communication, in order to support the recognition of a communicated meaning, but the safety function of the language in producing a cognitive conflict to recover possible procedural ATC mistake seems to be invalidated by a confirmative bias when over trusting implicit language expectations. A further desirable study with a bigger experimental sample (pilots and controllers) can gives a better understanding of the H-LQB occurrences.

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Appendix A

LQB QUESTIONNAIRE MODULE

1) Indicate your agreement on the following 7 point scale referring to the communication A
Put a cross on the scales from 1 to 7 according your judgment.

a) The communication uses the expectation to receive wait information.

Low expectation	1	2	3	4	5	6	7	High expectation

b) The performed communication is standard.

No standard	1	2	3	4	5	6	7	Standard

c) The communication produces a conflict to understand how to resolve the situation.

No conflict	1	2	3	4	5	6	7	High conflict

d) The communication is made to speed up the radio exchange.

Slow exchange	1	2	3	4	5	6	7	Speed up exchange

e) The communication has the aim to clarify an ambiguous information and doubt of the speaker.

No clarification	1	2	3	4	5	6	7	Obtained clarification

f) The communication tends to arouse the impression of a certain emotion of the listener.

No emotion	1	2	3	4	5	6	7	Big emotion

g) The communication produces a good communicational contact between pilot and controller.

Bad contact	1	2	3	4	5	6	7	God contact

h) The communication supports the recognition of the communicated meaning.

Not recognized	1	2	3	4	5	6	7	Recognized meaning

i) The communication employs the implicit knowledge of the communicated meaning.

Not implicit	1	2	3	4	5	6	7	Implicit meaning

2) The communication A is effective for the sharing of the meaning by the radio.
Put a cross on the scales from 1 to 7 according your judgment.

Not effective	1	2	3	4	5	6	7	effective

3) The communication A contributes to guarantee the operational safety.
Put a cross on the scales from 1 to 7 according your judgment.

Worsen safety	1	2	3	4	5	6	7	Improve safety