An Airline Checklist Use as a Sociomaterial Practice

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Abstract
Checklists form the basis of procedural standardization in the airline cockpit, with the help of which safety-critical measures become a routine part of flight crew task management. In this paper, we discuss the normal checklist use and its problems as a sociomaterial practice. We show how routine problems in checklist use are resolved, and point out how procedural and interactive backups function in action, thereby securing flight safety. We also examine the nature of problems in the checklist use that occur within the performance of individual checklists, within the order between checklists, and within the order between the checklist performance and other flight task activities. The problem types include premature, absent and excessive actions. The problems within checklists reveal troubles in the cognitive ergonomics of task design and logics of checklist use. The order problems between checklists appear as cognitive misperformances, though cognitive overloading may have organizational grounds.

1. Introduction

The checklists form the basis of procedural standardization in the airline cockpit, with the help of which safety-critical measures become a standardized routine part of flight crew task management. In the Airbus 320 flown by the participant pilots, the task management during flight phases is assisted with eight normal checklists: before engine start, after engine start, taxi, takeoff, approach, final, parking and securing. In addition, there are abnormal and emergency checklists (the use of which is not studied here). The normal checklists are listed in one document that works as a procedural backup assisting the routinization of safety-critical performance of flight tasks. The routinization of safety-critical activities, however, seems to entail a paradox as the checklist performances are prone to recurring errors. In our data from simulated Airbus 320 flights, there occurred 12 documented errors during the performance of 122 normal checklists within 26.5 hours flight time. Therefore, there occurred an error for every two flight hours.

The errors in the performance of normal checklists do not largely seem to consist of verbal misunderstandings or any kinds of language problems. In other words, the checklist performance do not suffer from hearing, speaking or understanding difficulties (only 1 error), but problems of different sort. The checklist problems seem to be related to the use of an airline checklist document as a socio-material practice, in which talk, visual and material actions are interlinked in an ongoing interaction. The airline pilots’ situated understanding of the phase of flight and its tasks is maintained and updated in the document use. Therefore, the problems in the checklist use are not as such troublesome, but help to maintain and update pilots’ mutual awareness, thereby enhancing safety [1], [2] and [3]. The pilots’ repairs, remedies and reminders with the help of which they amend problems of checklist use form a second order interactive backup that helps to maintain the orderly performance of flight tasks. The checklists in use and the problems in their usage open a view to cockpit interaction in which talk, action and technologies are interwoven. We explore the document use as a multimodal action composed of talk and physical actions embedded with procedural and interactive backups intertwining in the formation of action.

In this paper, we discuss the normal checklist use and its problems as a socio-material practice [4]. We follow Suchman’s initiative, according to which humans and technologies are asymmetrically interdependent [5]. For Suchman, the asymmetrical interdependence derives from the ethnomethodological underpinnings of her original contribution [6], revised and republished in 2007 [5]. On the one hand, we show how routine problems in checklist use are resolved. We point out how procedural and interactive backups function and mutually elaborate each other in action,
thereby securing intersubjectivity and flight safety. On the other hand, we examine the nature of problems in the checklist use that occur within the performance of individual checklists, within the order between checklists, and within the order between the checklist performance and other flight task activities. We note that at least part of the problems within performance of individual checklists is related to the cognitive ergonomics of flight crew task management and to contradictory logic of checklist design. The problems in the order between checklists do not seem to be transparently interactional but more directly genuinely cognitive, though cognitive overloading may have organizational grounds in the crew task management. Finally, the problems in the relationship between the checklist performance and other flight task activities seem to be related to the momentary lack of intersubjective awareness of flight task accomplishment.

In the conclusion, we discuss the implications of findings, draw some conclusions and open further research questions.

2. Social action and materiality

Suchman’s co-worker, C. Goodwin [7] coined an ambitious view that a theory of action “must come to terms with both the details of language use and the way in which the social, cultural, material and sequential structure of the environment where action occurs, figure into its organization.” From this perspective, social action is a situated accomplishment that emerges from its practical management through language, social configuration and material resources. We follow this perspective and try to address the dynamic interplay between sets of language and material structures that frame and reframe social production of action and meaning during simulated flights. The study of the way in which talk, action and technical resources are interwoven in action leads us to focus on what the emerging material social science is called “agencements, combinations of human beings, material objects, technical systems, texts, algorithms, and so on” [8].

We utilize the multimodal conversation analysis embedded in material social science to develop a context-sensitive research strategy that amounts to rigorous, detailed findings on social actions. We try to catch the materiality of social actions as being embodied and based on distributed cognition [7], [9], [10], [11]. Therefore we aim at empirical scrutiny of agencement, an assemblage, arrangement, configuration or lay-out that is made up of human bodies but also of prostheses, tools, equipment, technical devices, algorithms, etc. in real-time actual social practices [12].

Currently, Charles Goodwin’s multimodal conversation analysis comes closest to systematic exploration of situated social action in its socio-material context. For Goodwin [7], the interactive organization of embodied action, in which multiple parties are building courses of action together while attending to each other, and structures in a consequential environment constitutes a primordial site for the organization of human action, knowledge and cognition (see also [13], [14]).

3. Flight task performance

The airline cockpit is a complex socio-technical setting in which the pilots coordinate their talk and non-talk activities to perform the tasks necessary to fly the plane. The pilots make their reasoning and understanding accountable and observable through talk and other available modalities like gestures, gaze movements, bodily orientations and handling of objects and artifacts. The salient non-talk activities in a cockpit setting include rotating and pushing knobs, monitoring displays, moving levers, writing notes, looking out of the window, reading charts, manuals and checklists, etc. The pilots need to accomplish the tasks and talk and non-talk activities required for them in a strict sequence. The airline cockpit is a multi-task setting in which the performance of a particular task becomes relevant and appropriate only after some other tasks have been completed and certain circumstances prevail [15], [16].

The pilots’ duties and responsibilities are determined according to two formal roles [17], [18]. The first comprises their official rank or status as either Commander (CDR) or Co-pilot (COP), of which the former is usually the more experienced and trained crew member than the latter. Since an individual pilot’s rank corresponds with a particular level of qualification and skill, it cannot change from flight to flight. The second role is to be either Pilot-flying (PF) or Pilot-not-flying (PNF). The PF controls the aircraft, making the immediate inputs to control the performance of the plane and taking responsible for routine planning and decisions for the flight. The PNF typically assists the PF by setting up instruments, reading charts, communicating with the air traffic control (ATC), and monitoring the PF’s performance. An individual pilot may be PF and PNF on separate flights made during a day, because these roles are not dependent on the rank of the crew member.

3.1. Standard operating procedures

The airline pilots are required to follow the ‘scripts’ provided by the flight operating manuals and standard
operating procedures. This is to ensure that the flight tasks will be carried out in a logical, efficient and error resistant manner and to promote crew coordination via standardization. An individual flight can be broken down into the phases of pre-flight and engine start, taxi and takeoff, climb, cruise, descent, approach, landing, and taxi and engine shutdown. The standard operating procedures prescribe in detail how the aircraft is to be operated at each phase of the flight, who needs to do what and in what order. The procedures list the sequence of actions the pilots must take in setting each switch and control and checking the status of the aircraft systems. The pilots normally set the aircraft systems by heart and then check that the most critical items have been completed by reading the appropriate checklist [19], [20].

The checklists are fundamental for the procedural standardization in the airline cockpit. In the Airbus type aircrafts, for example, the checklist procedures can be categorized by the kind of device used – paper or electronic–, and by the context of use – normal, abnormal and emergency [21]. The procedures for the normal situations assume that all aircraft systems are functioning well and are being used correctly by the pilots. The main function of the normal checklist procedure is to assure that the crew will configure the airplane appropriately for any given flight phase segment. The transition between flight phase segments is sanctioned by reading the normal checklist in a paper form. A paper checklist has a list of items written on a card that is usually held in the pilot’s hand during the reading. The checklist procedures are completed by coordinated actions and communication between the Commander and Co-pilot [20].

A ‘challenge-response’ is the most common method of conducting the normal checklist procedure: one crew member (when the aircraft is on the ground, it is the Co-pilot; when the aircraft is airborne, it is the PNF) calls an item on the list to be checked (e.g., ‘flight controls’). The other crew member (when the aircraft is on the ground, it is the Commander; when the aircraft is airborne, it is the PF) responds to the call (‘checked’) after having checked the status of the item. The normal checklist procedure is embedded with the principle of backup and redundancy [20]: the pilots first configure the aircraft from memory and only then use the relevant checklist procedure to verify that all items have been completed properly. As our data analysis reveals, the crew members also monitor one another to ensure that the aircraft will be configured correctly.

4. Data and methods

The analysis of problems in normal checklist use bases on the videotaped data collected in the Airbus 320 –flight simulator in Finnair Flight training Center, Vantaa, Finland in 2003-2004 [1]. In the simulated flights, the already experienced, licensed pilots practice a training technique called Line-Oriented Flight Training (LOFT), in which they must handle a variety of scripted real-time scenarios including routine, abnormal and emergency situations (fire in a cabin, technical malfunctions, etc.).

There are three participants in the training sessions: the Commander, the Co-pilot and the Instructor who does not have a teacher role in the traditional sense of the word. He instead controls and manipulates the environmental and physical conditions of the scenario and maintains appropriate communication with the pilots by role-playing the air traffic controller, mechanic, cabin crew member, etc.

In total twenty-five flight crews agreed to participate in the recordings. As each crew conducted two flight segments (a flight segment is a flight from point A to point B), the overall amount of data increased to over sixty hours of recorded materials. The data analysis was limited to the examination of twelve crews which amounts to 26, 5 hours of recordings. The videotaped data of twelve crews includes in total 122 normal checklist performances and 43 emergency checklist performances. The normal checklist procedure of the participant pilots consists of one document including eight checklists: before engine start, after engine start, taxi, takeoff, approach, final, parking and securing.

The instances of the problematic uses of the normal checklist document are transcribed in detail. The transcriptions describe the talk, embodied conduct, and their sequential relationship in an evolving interaction. The descriptions of talk illuminate the dynamics of turn-taking (i.e., the details about the turn initiations, turn closings, overlapping turns, and the gaps/pauses between turns) and the characteristics of speech delivery (i.e., the essential features of stress, intonation, pitch, loudness and speed [22]).

The visual actions accomplished simultaneously with talk are marked with the interlocking left brackets. Those actions performed during the periods of non-talk are described, for example, as ((Cop starts writing the notes; (1.8))). This indicates that the Co-pilot initiates his writing activity at some point within the period of (1.8)-seconds. The transcriptions also include still pictures taken from the video-recordings and marked by the symbol £. The transcription conventions are shown before References.

5. Checklist use

The uses of normal checklist document are analyzed within two problem dimensions [1], [23]. The first
dimension is called ‘talk-in-interaction’ which concerns the sequence structure or, the relationship between turns in checklist talk. The particular problem types within this dimension are hearing problems (e.g., the pilot does not hear the checklist item), understanding problems (e.g., the pilot does not understand the checklist item) and speaking problems (e.g., the pilot delivers the checklist item unclearly). The frequencies of these problems in the performances of 122 normal checklists are shown in Table 1.

Table 1. Problem type frequencies in checklist talk-in-interaction

<table>
<thead>
<tr>
<th>Problem type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing problem</td>
<td>0</td>
</tr>
<tr>
<td>Understanding problem</td>
<td>0</td>
</tr>
<tr>
<td>Speaking problem</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
</tr>
</tbody>
</table>

The problems of talk-in-interaction are very rare in the sample. In the uses of 122 normal checklists, there exists no hearing or understanding problems and only one speaking problem. In that case, the Commander responded to the ‘briefing’ item on the taxi checklist with ‘checked’ and then repaired his talk by saying ‘confirmed, I mean’.

The second problem dimension is called ‘talk-and-action-in-interaction’ which covers the sequential order or, the relative positioning of talk or action in normal checklist performance. The particular problem types within this dimension include premature actions (e.g., the pilot skipping one checklist or checklist item and proceeding prematurely to the execution of next checklist or item), absent actions (i.e., the pilot failing to do the action under his or her responsibility in the execution of the checklist) and excessive actions (i.e., the pilot initiating a checklist that has already been performed). The frequencies of these problems in the performances of 122 normal checklists are shown in Table 2.

Table 2. Problem type frequencies in checklist talk-and-action-in-interaction

<table>
<thead>
<tr>
<th>Problem type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature action</td>
<td>6</td>
</tr>
<tr>
<td>Absent action</td>
<td>4</td>
</tr>
<tr>
<td>Excessive action</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
</tr>
</tbody>
</table>

The pilots are dealing with the problems of talk-and-action-in-interaction in 11 out of 122 normal checklist performances. Though relatively infrequent, the positioning problems are still more common than the linguistic problems in the execution of the normal checklist procedure.

It is important to notice that the quantitative data shown in Tables 1 and 2 describe the checklist uses the pilots themselves treat as problematic. As shown in Chapter 5.1., the problems are brought to the conversational surface by the crew members using repairs and reminders in the execution of the normal checklists. There are also some cases, in which the pilot, for example, does not complete the checklist procedure appropriately. In these cases, however, the pilots do not orient to the situations as problematic. The non-corrections of errors threaten potentially flight-safety, but would require separate analysis. We should be able to distinguish deliberate departures from standard procedures from genuine errors. We should be capable of making a distinction between unproblematic cases and cases just appearing unproblematic.

5.1. Document use as a socio-material practice

The qualitative analysis centers on three data examples of the problematic uses of normal checklist document. The examples illuminate premature actions (cases 1 and 3) and absent action (case 2) in checklist talk-and-action-in-interaction. The data analysis shows how the pilots use the practices of repair, remedy and reminder in locating and resolving these problems in the execution of a normal checklist procedure. The analysis aims to reveal how the conversational practices of repairs, remedies and reminders function as an
interactive backup in the uses of normal checklist document. In the three data examples, consequently, the interactive and procedural backups become closely intertwined in action.

The pilots studied use English and Finnish for their flight tasks and activities. When they speak Finnish, the transcriptions follow a two-line format including, firstly, an original Finnish version and secondly, an idiomatic or vernacular English translation. Prior to each transcription, we specify the situation of action, the problem under discussion and the formal roles of participant pilots. In our focus lines, marked in bold on transcriptions, there occurs problematic (i.e., premature or absent) actions as well as repairs and reminders in the courses of interactions. The still pictures taken from the video-recordings are used to visualize and highlight the aspects of interaction relevant for the analysis.

The crew is going through the before engine start checklist at Stockholm-Arlanda Airport in case 1. As the aircraft is on the ground, it is the Co-pilot’s duty to read the checklist items aloud while the Commander responds to them. At line 6, the Co-pilot breaks down the procedural order of the checklist performance by skipping the altimeters item and producing the takeoff data item prematurely. At lines 8 and 10-11, the Commander activates an interactive backup with the repair initiation; the Co-pilot continues using the interactive backup at line 12, in which he corrects his talk and returns the procedural order of checklist execution.

Case 1 (CDR = PNF, COP = PF)

01 COP: ö fjuuli, h=    uh fuel, h=    
02 CDR: =viis yhdeksän kuusikymmentä, h =five nine sixty, h    
03 (£) (£)    
04 COP: ↑viis yhdeksän kuusikymmentä.  
↑five nine sixty.    
05 (.) (.)    
06 COP: take off deitta,? take off data,?    
07 (.) (.)    
08 CDR: e- is-    
09 (1.1)    
10 CDR: °eiks se altimeter° °isn’t it the altimeter°    
11 °tu [le ]°, °com[ing]°,    
£    
12 COP: [al]timeter↓ sori( ),= sorry( ),=    
2) £ ((COP takes the normal checklist document into his hands))    
13 CDR: =a- a- tuhatkolmeto:ista↓ =a- a- one thousand and thirte:en↓    
14 satakymmene,= one hundred and ten,=    
15 COP: =tuhat kolmeto:ista =one thousand and thirte:en    
16 satakymmenen<, one hundred and ten<,    
17 ja (and) take off deitta, and (and) take off data,    

After the COP has red ‘fuel’ aloud from the before engine start checklist, the CDR responds with the aircraft’s fuel quantity of 5,960 kilos (lines 1-2). Next, the COP confirms the fuel quantity, simultaneously checking it out from the Secondary Engine Display (lines 3-4; Still 1). The item the COP reads aloud from the checklist next is takeoff data (line 6). Instead of responding to the item, the CDR marks the COP’s move as problematic by initiating a repair at lines 8 and 10-11: ‘is-…isn’t it the altimeter coming,’. The COP repairs his previous talk in partial overlap with the CDR’s turn by replacing takeoff data with altimeters (lines 11-12; Still 2). He also displays an orientation to professional responsibility by being sorry for his mistake in checklist performance. The CDR
responds to the altimeters by announcing the standard atmospheric pressure of 1013 hectopascals and the height above sea level, 110 feet (lines 13-14). After confirming the CDR’s response with the repetition, the COP delivers the item of takeoff data in procedurally appropriate place at line 17.

The flight crew in case 2 is going through the taxi checklist before taking off at Helsinki-Vantaa Airport. At line 1, the Co-pilot reads aloud ‘briefing’ on the checklist, referring to the short confirmation of the through takeoff briefing done earlier during the preparatory phase of the flight. The normal procedure is that it is the Pilot-flying’s (i.e., the Co-pilot’s) duty to deliver the takeoff briefing in the performance of the taxi checklist. This procedural order of checklist execution momentarily breaks down, as the Co-pilot fails to produce the briefing at line 2. The Commander registers that the Co-pilot does not act according to his responsibility as a Pilot-flying. At line 4, the Commander launches an interactive backup by reminding the Co-pilot about the task allocation in the checklist execution.

Case 2 (CDR = PNF, COP = PF)

01 COP: br:iefing,?
02 (1.5)
03 COP: [hh ]
04 CDR: [se ]oli sun  he[niä ],
[that] was your ba[by ],
05 COP: [ru:nen]
06 four delta four thousand blue
07 no changes. hh[hh ]
08 CDR: ^[con]firmed,

3) £ ((CDR points towards COP with thumb; COP points towards his Navigation Display))

After COP’s reading of ‘briefing’ on the taxi checklist, there is (1.5)-second pause in talk at line 2. The COP may be taking the floor by inhaling deeply at line 3. In overlap with the COP’s in-breath, the CDR reminds the COP about his responsibility to deliver the briefing by saying ‘that was your baby’ and pointing towards the COP (lines 3-4; Still 3). The CDR’s turn focuses on the COP’s previous move of not delivering the takeoff briefing at line 2. It functions as an interactive backup restoring the procedural order of checklist execution.

The COP follows the procedural order by delivering the actual briefing at lines 5-7. The briefing consists of the departure route ‘runen four delta’ and the altitude of ‘four thousand’ feet engaged in the aircraft automatics. The COP’s utterance of ‘no changes’ indicates that the current briefing is consistent with the clearance delivery. The CDR confirms the takeoff briefing in overlap with the COP’s strong exhalation at lines 7-8.

In case 3, the crew is at Helsinki-Vantaa Airport before take-off. As the aircraft is still on the ground, it is the Commander’s duty to initiate the appropriate checklist by calling its name. At line 6, the Commander is skipping the taxi checklist and prematurely initiating the takeoff checklist, therefore breaking down the procedural order of checklist execution. With his repair at lines 8-10, the Co-pilot mobilizes an interactive backup by correcting the Commander’s talk and restoring the procedural order of the checklist performance.

Case 3 (CDR = PF, COP = PNF)

01 COP: zulu kilo (.) runway zero
02 ↑four (.) cleared for take
03 off, Finnair six five one
04 Romeo,
05 ((Cop starts writing the notes; (1.8)))
06 CDR: j[.] takeoff tsekki.
[and takeoff check.
07 ((Cop is writing the notes; (0.7)))
08 COP: zuluº kilo ja täs tulee
zuluº kilo and here is
09 ((Cop stops writing after saying ‘kilo’))
10 COP: taxi [k],
the taxi che[ck],
11 CDR: x[n ]
[ya]
12 taxi[ng tsekki ] anteeks joo,
taxi[ng check ] sorry yeah,
13 COP: [ensin ],
[first ],
14 (0.2) £ (0.5)

1595
The COP displays his understanding of and compliance with the ATC take-off clearance by reading it back at lines 1-4. The CDR initiates the performance of the takeoff checklist after the COP has read back the ATC take-off clearance and started to write notes on it (lines 1-6). After completing the writing activity and talk related to it ('zulu kilo' refers to the holding point via which the tower controller cleared the crew to taxi), the COP marks the course of action previously launched by the CDR as problematic. With his repair at lines 8-10, the COP replaces takeoff checklist with taxi checklist.

The CDR acknowledges the remedy of his premature action with overlapping ‘ya’ (lines 10-11); his ‘taxing check’ indicates that the pilots have a shared understanding of the checklist to be accomplished next. The COP’s temporal specification ‘first’ implies that the taxi checklist will be performed prior to takeoff checklist (lines 12-13). An apology at line 12 shows the CDR’s orientation to professional responsibility for skipping the checklist; he further acknowledges the repair with ‘yeah’ (line 12).

During the following (0.7)-second pause, the COP brings the normal checklist document into view (line 14; Still 4). He noticeably adheres to the procedural order of the checklist execution by reading out the first item on the taxi checklist: ‘flight controls’ (lines 15-17). In his response, produced after a pause, the CDR confirms that the item ‘was checked’ (lines 18-19). As in case 1, the use of a conversational repair as an interactive backup secured the procedural order of checklist execution in case 3.

6. Discussion

The linguistic problems in normal checklist use are infrequent; the checklist standardization seems to be well-designed, functional and successful in linguistic terms. The sequential ordering of action in relation to the checklist use appears to contain more problems. As shown in Table 3, from the prior eleven cases, six concern the problematic sequential order between checklist items, three of eleven concerns the problematic sequential order between various checklists and two of eleven concerns the problematic sequential order between a checklist and other flight task activities.

<table>
<thead>
<tr>
<th>Problem type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order between checklist items</td>
<td>6</td>
</tr>
<tr>
<td>Order between different checklists</td>
<td>3</td>
</tr>
<tr>
<td>Order between checklist performance and other activities</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
</tr>
</tbody>
</table>

We can clearly distinguish various problem types in the uses of normal checklists. First, there are problems concerning items in an individual checklist. The case 1 is one instance of that sort; there a checklist item of altimeters is skipped, as the Co-pilot proceeds prematurely to the next item of takeoff data. Notably, there is one other instance where exactly the same problem occurs.

The case 2 is also categorized as the problem concerning the relationship between checklist items. The Co-pilot reads the item of briefing aloud from the taxi checklist, but does not proceed to perform briefing despite its being his duty according to the task allocation. The very same problem occurs in one other instance in our data.
There happen also errors in the order between checklists (case 3). While the flight crew is preparing for takeoff, the Commander initiates the takeoff checklist and skips the taxi checklist. The errors of this type occur also at other phases of the flight.

There are also errors in the order between checklist performance and other flight task activity. In one example (not shown here), the Commander initiated the final checklist and then produced a self-repair by saying: ‘…no no, we do not perform the final checklist yet since we have to accomplish X and Y first…’. After the flight crew had performed those other activities, the Commander re-initiated the final checklist.

The checklist problems vary in terms of how transparently the source of problem can be detected. The problems in with the order between checklist items appear to originate from cognitive ergonomics of task design. In case 1, and at least in one parallel example, the checklist performance requires the checklist performing pilot to move his gaze away from the checklist to conduct the task required. The necessity to move the focus outside of checklist seems to increase the risk of misconduct of the checklist (see case 1; Still 1).

The problems in with the order between checklist items may also arise from the contradictory logic of checklist design. The use of the normal checklists is principally based on pilots talking and acting in turns. However, the (taxi) checklist practice according to which one pilot delivers both the item (briefing) and its content (runen four delta…) consecutively, without the other pilot’s response in between, contradicts with the initial logic of checklist use (case 2).

The errors in the order of performance of checklists appear less transparent. In case 3, the CDR’s situated understanding of the phase of the flight tasks seems to be based on the prior conversation between ATC and COP. The problem may have its roots in organizational dynamics. The ATC clearances are not issued in synchrony with the cockpit operations. For example, the take-off clearance can be given irrespective of whether or not the pilots have performed the taxi checklist. We would still need to deepen our analysis to explore the degree of linkage of cognitive overloading (mis-performance being its outcome) to the organizational level of flight crew task management.

Finally, the third problem type addressing the order between checklist performance and other flight task activities seem to be related to the situated awareness, in other words, maintenance of intersubjective understanding of the flight phase and task. Again further analysis would be needed to explore potential systematics of the emergence of this type of troubles.

The problems with the uses of normal checklists discussed are cases which pilots have repaired and remedied, therefore they do not pose a safety threat of any sort as such. Instead, the checklist practices including problems in their performances enable the flight crew to re-orientate and, when necessary, update their understanding on the ongoing flight phases and tasks. The checklist problems dealt with the collaborative repair practices enable the prevention of incidents and accidents before their occurrence. Consequently, checklist problems form part of the reflexive orderliness of safety-critical socio-material cockpit practices in which safety is a situated practice consisting of an assemblance of people, technologies and textual and symbolic forms as a set of material relations [24].

Following Reason’s famous Swiss cheese model, incidents and accidents emerge as holes in safety architecture of the organized system in action [2], [25]. An incident to emerge the hole must penetrate through all the layers. The safety-critical procedures, such as checklist performance, form safety layers in the organizational architecture. The agents’ interactional practices to remedy problems in the checklist performance compose another interactive backup layer on the top of the original procedure.

Checklist performance problems could become serious, if they would interact with other latent errors or failures. The pilots’ collaborative checklist performance itself contains a dual structure, where individual pilot’s misconduct will become corrected by the other. Only if the error passes unnoticeably by the flight crew, a basis of latent failure becomes evident. The emerging latent failure would subsequently need to interact with other failures and pass unnoticed for a risk to incident to emerge.

Nevertheless, the problems in the checklist performance point and make visible potential problem dimensions in the safety-critical performance of cockpit interaction. The observed trouble sources in the cognitive ergonomics of task design and incongruous logic of checklist use open an area for potential design improvements. Cognitive and crew interaction problems thus open questions for further research to pin down, describe and detail the trouble sources to open up potential design areas [26].

Methodologically, we propose to marry the multimodal conversation analysis with material social science to develop a context-sensitive research strategy that amounts to rigorous, detailed findings on social actions in their socio-material context. The marriage promises for multimodal conversation analysis a way beyond the narrow situationalism by considering performativity as a material process in which talk, action and technical resources are interwoven. For its part, multimodal conversation analysis can provide empirical tools for material social science to explore the
materiality of social action and address the dynamic interplay between sets of language and material structures that frame and reframe the social production of action and meaning. When we take into account the multimodality of social action, we can discern the ways in which social, cultural, material and sequential structures figure together in the organization of action.

7. Conclusions

The checklists are a crucial part of safety-critical procedural standardization of the flight crew task management. They are a routine procedure with the help of which transitions from a flight phase to another is orchestrated. Linguistically, the normal checklists used by participant pilots appear to be unproblematic. The talk-and-action-in-interaction in the performance of the checklists is instead prone to problems.

The problem types include premature, absent and excessive actions. In the normal checklist performance, the problems may occur between checklist items, between different checklists, or between the checklist and other flight task activities. The problems within checklists reveal troubles in the cognitive ergonomics of task design and logics of checklist use that can be translated into design challenges.

The order problems between checklists appear as cognitive mis-performances, but there seem to be underlying organizational trouble sources for them. We would still need to sharpen the analysis of the linkages between interactional and organizational orders. Further question concerns transferability of findings from simulated flights into real circumstances. High fidelity of the simulated environment and available studies on natural flight settings [18] suggest that on the whole, transferability should exist but in specific details, there may be non-transferability.

Transcription conventions

[ ] Interlocking left-brackets indicate where overlapping talk begins; interlocking right-brackets indicate where overlapping talk ends.
= Equal signs, one at the end of one line and one at the beginning of a next, indicate no “gap” between the two lines.
(1.5) Silence measured in seconds and tenths of seconds.
( . ) Silence of less than a fifth of a second, i.e., less than (0.2). He says Underscoring indicates some form of stress, via pitch and/or amplitude.
: : Colons indicate prolongation of the immediately prior sound. The length of the colon row indicates length of the prolongation.
↑ ↓ Arrows indicate shifts into higher or lower pitch.
. . ? . ? Punctuation markers are used to indicate intonation.

8. References


