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Distributed Cognition at Cockpit: A Preliminary Study

Selma Leal de Oliveira Ribeiro

DISTRIBUTED COGNITION AT COCKPIT: A PRELIMINARY STUDY

Selma Leal de Oliveira Ribeiro
Civil Aviation Ergonomics Studies Management / Brazilian Civil Aviation Agency (ANAC)
International Civil Aviation Organization / Technical Cooperation Mission (ICAO/TCM)
Rio de Janeiro – RJ - Brazil

Distributed Cognition is a theoretical structure, derived of cognitive science, which considers that the human knowledge and the cognition are not confined to the individual. In contrast, it is distributed to memories, facts or knowledge on the objects, individuals and environmental tools. The insertion of automated devices in different work stations had aimed at to reduce the operator workload and to minimize human error incidence. However, such initiative brought other questions, which demands great knowledge and abilities from the operator in the cognitive field. The main objective of this article is to present a preliminary cockpit analysis from Hutchins and his collaborators' point of view to the Distributed Cognition approach in order to better understand the relations between the human activities and the environment that surrounds them. Since aviation is a system which has the main characteristic that the task occurs inside a highly dynamic environment, this approach presents a structure that seeks to analyze the complex activities of work, socially distributed, in which the diversity of technological artifacts and other tools are necessary parties. The analysis presented will be based on observations performed at EMBRAER 120 - "Brasilia" simulator during data collection of the study developed by Ribeiro (2003) about pilot workload in tasks of approach for landing using Flight Director (FD) device. The FD is an automation device shown in the artificial horizon of the pilot (indicator attitude), located in the main pilots' visual field, in the central panel, and can be seen by both pilots. The results showed that tasks performed at the cockpit are well defined in each pilots' workstation. Actually, each one has attributions predefined and tries to behave in order to attend their requirements. The notions of "**horizon of observation**", "**distributed nature of information and representation",** "**shared task knowledge**", and so on, which characterize the distribute cognition approach are described. Although the functions performed in a cockpit have an individual character, they happen in a synchronized way within the cockpit group, characterizing this work space as socially distributed. The Hutchins and collaborators' structure offers a different perspective which can contribute to better understand cognitive phenomena which involves tasks developed at cockpit. Other studies are in development in order to deep the knowledge on how the cognitive process involved in the pilots' activity of flying an aircraft occurs.

Introduction

In the way of the society has been modified, the production ways have also suffered alterations. The mechanization and the division of work had been the topics underlined during the period of the industrial revolution. In it, the work was done in manual way and the requirement was predominantly physical. But, the nature of the work evolved, leading the worker to more complex responsibilities and requiring of him more than physical force.

The recent step was the insertion of automated devices in different work stations aimed at to reduce the operator workload and to minimize human error incidence. However, such initiative brought other questions, for example, the migration of the work requirements from psychomotor focus (or physical) to an intellectual one (or mental), which demands great knowledge and abilities from the operator in the cognitive field.

So, we can note a gradual change on the demands at work, directed to communication, cooperation and problem solving areas, increasing, as a consequence, the prudence and the variability in the worker action.

The main objective of this article is to present a preliminary cockpit analysis from Hutchins and his collaborators' point of view to the Distributed Cognition approach in order to better understand the cognitive relations between the pilots' activities and the environment that surrounds them.

The cockpit: a complex system?

Aviation is a system that involves a series of segments, such as: the air traffic control, the airport structure, the aeronautical telecommunications, the company operational support and so on.

At cockpit, to perform the task of "flying the airplane", the pilot needs to keep a harmonious relation with his/her aircraft, his/her flight assistant (copilot and flight engineer, in some cases), and the different segments of the aviation system.

At a simplified way, until sometimes ago, the pilot tasks were: to fly (to control the aircraft), to navigate (to direct the aircraft from its origin to its destination) and to communicate (to give data, to make requests, to receive instructions and information). More

recently, taking into account the great amount of available resources, one another task was added to his/her work: the management.

The main characteristic of this task is related to the development occurred inside a highly dynamic environment. The perceptual requirements are considerable and the cognitive demands are enormous, many of the necessary information to the pilot must be synthesized from a great amount of data, some of them very ambiguous in certain circumstances.

In this direction, the aviation area, in an ample way, and the cockpit, at a more restricted point of view, can be called as complex systems.

In order to better understand the complex relation between the operator and the machine, in the case of aviation, between the pilot and the airplane, considering the technological advances of this last one, it was decided to study the cognitive issue related.

At the aviation context, depending on the focus, the pilot work can evolve since the social and organizational relationship with the employer, colleagues inside and outside the airplane, and so on, as soon as the tasks developed before, during and after the flight.

This article seeks to understand the interaction between the pilot and his/her aircraft, when developing the flying tasks, using Distributed Cognition aspects (ROGERS, 1997; HUTCHINS & KLAUSEN, 1998).

Human cognition

The human cognition is related to mental processes involved with thought and its use. People who are interested in cognitive issues believe that the study about the way people think leads to a broad understanding about most of the human behavior (STERNBERG, 2000).

According to Green *et al* (1993), to fly is a task which involves observations and reactions to events which happen inside the cockpit and at the external environment.

The insertion of automated artifacts at the cockpit helps the pilot to control the aircraft and give to him/her a great amount of data. So, it's very important an approach that can study persons beyond your individuality but, also, your cognition related to all these artifacts and other people who share the same work space.

Distributed cognition approach

The cognitive science has studied the human thought aiming at to understand the mental mechanism that forms the basis of the human ability to process the information, changing it into symbolic elements with a meaning.

However, the human activities, mainly the ones related to work, do not happen isolated of the environment that surrounds them. They take place and are inserted in a social and technological context, in some cases, of extreme complexity.

In order to better understand these relations, the notion of **Distributed Cognition** appears. It consists in a theoretical and methodological structure developed by Hutchins and his collaborators, at University of California, San Diego, to explain cognitive activities as personified and situated within work contexts in which they occur (ROGERS, 1997; ROGERS & ELLIS, 1994).

Distributed Cognition is a theoretical structure, derived of cognitive science, which considers that the human knowledge and the cognition are not confined to the individual (HUTCHINS, 2000). In contrast, it is distributed to memories, facts or knowledge on the objects, individuals and environmental tools.

According to Hutchins (2000), the observation of human activity can become apparent some interesting items of distributed cognitive process: "*it may be distributed across the members of a social group; it may be distributed in the sense that the operation of the cognitive system involves coordination between internal and external structure; and it may be distributed through time in such a way that the products of earlier events can transform the nature of later events*".

This approach presents a structure that seeks to analyze the complex activities of work, socially distributed, in which the diversity of technological artifacts and other tools are necessary parts. It aims at a deepened knowledge of the workplace, through the permanence of the researcher during a certain time in the environment, analyzing the problems with the existing technology and practices at work that needs to be redesigned in order to support and to increase the contribution and coordination of the work activities (ROGERS & ELLIS 1994).

Under this point of view the work activities are seen as linked, changing from the conventional conception of individual cognition to another one where the

work situations are seen in a social and shared way. According to Rogers (1997), this approach "seeks to apply the same cognitive concepts, but this time, to the interactions among a number of human actors and technological devices for a given activity, instead of focusing on human activity in terms of processes acting upon representations inside an individual actor's heads".

The **Distributed Cognition** describes the socio-technical system as functional, which comprises a collection of individuals, artifacts and their relations to each other in the environmental setting in which they are situated (DECORTIS *et al*., 2002).
Norman (1991, *apud* RIZZO & MARTI, 2003) defined the tools representing, storing and processing information as cognitive artifacts. At the cockpit, every displays and counters besides manuals, checklists and so on, which are used by the pilots in order to capture information and help them to process data in order to decided can be considered as a cognitive artifacts.

The cockpit from distributed cognition point of view

The context

In order to establish a relation between the activities developed inside the cockpit and some Distributed Cognition aspects, it is necessary a brief description of the context observed.

The analysis was based on observations performed at the simulator of the EMBRAER 120 - "Brasilia" (Figure 1) during data collection of the study developed by Ribeiro (2003) about pilot workload in tasks of approach for landing using Flight Director (FD) device (Figure 2).

The EMB 120 is a pressurized twin-turboprop featuring high cruise speed and low operating costs. The cockpit features Electronic Flight instruments. Its roomy cabin can seat up to 30 passengers (EMBRAER, 2007).

The Flight Director (FD) is an instrument in the main pilot visual field, at the central panel, where can be found the attitude indicator, known as horizon indicator. Its purpose is to guide the pilots. Basically a Flight Director gives visual cues to the pilot, so that the pilot mission is to follow the FD cues with his inputs to the aircraft's controls and therefore take the airplane to the programmed destination.

Figure 1. Embraer 120 "Brasília" aircraft. (www.embraer.com.br)

Figure 2. EMB120 Brasília panel with both Flight Directors (FD) – http://www.airliners.net (authorized by L. Ten Hoppen)

Preliminary cockpit analysis according to Distribution Cognition approach

Hutchins & Klausen (1998) defined the cockpit system as composed by pilots and its informational environment, because to fly a modern aircraft is a job that can not be done by a single person, which features the cognitive work as socially distributed. It means that this workspace is characterized as a "**distributed cognitive system**" composed by two pilots - *Pilot Flying* (PF) and *Pilot Monitoring* (PM) - the artifacts inside the cockpit and the multiple interactions at the system (between pilots, between pilots and artifacts, and among pilots and outside sectors).

The tasks performed at the cockpit are well defined in each pilots' workstation (HUTCHINS, 1995). Actually, each one has attributions predefined and tries to behave in order to attend their requirements. The pilot at PF position has the main attribution to

conduct and control the aircraft, and uses FD indications in order to maintain the aircraft at the right attitude. The pilot at PM position also observes FD and PF movements in order to complement and provide necessary information to help PF to perform his/her tasks.

The artifacts at cockpit compose the informational space shared by the pilots and is called "**horizon of observation** " (DECORTIS ET AL, 2002), in which each one of the actors (pilots) can monitor everything what it is happening, including the task performed by the other, evidencing the part of the task that can be seen and be heard by each member of the team. The FD is an automation device shown in the artificial horizon of the pilot (indicator attitude), located in the main pilots' visual field, in the central panel, and can be seen by both pilots.

The information given through the FD shows the aircraft lateral and vertical deviations. The knowledge of both pilots about the right attitude that the aircraft must to have when developing an approach landing – flaps configuration, speed, altitude, heading and so on – allows them to understand the situation showed by FD and choose the best action in order to correct the aircraft attitude.

One of the activities developed for both pilots, and that is present in all other ones, at the cognitive point of view, is what they call of "monitoring" or "cross check".

On their descriptions, this activity is defined as being a "constant follow-up of the flight parameters". However, it was observed that other mental processes enclosed in the information processing cycle had been also reported, clarifying that such activity involves a series of other individual cognitive functions, like: attention, identification, memory, interpretation, reasoning, anticipation and decision making.

The interfaces that can be found in the systems will supply indications to the pilot who, in function of his/her internal state, will develop representations of them leading to a treatment of the information and the consequent decision making (RASMUSSEN & LIND, 1981), in accordance with these representations.

The "**distributed nature of information and representation",** which can be caught in the different devices, as well as in manuals, checklists, communications and the proper crew members' knowledge, reinforce this characteristic of complexity of this environment (PAVARD & DUGDALE, 2003). Each one of the crew members at the cockpit makes use of his/her individual cognitive resources to minimize the effect of this characteristic.

However, the task doesn't occur in an isolated way, where each one has his/her role defined for the positions that they occupy and perform their own activities. According to Roger & Ellis (1994), inside of this social-technical space, it also can (and must) be found a sharing of internal representations states and external communication artifacts (medias), in which the necessary knowledge is transmitted and propagated in this space.

This characteristic facilitates the "**shared task knowledge**", since the information necessary to complete successfully the activities is distributed in different parts of the environment, being able to be perceived by any one of the pilots considering the "**pathways and trajectories for information**".

Finally, both pilots, being part of a complex professional practical community, have considerable previous knowledge about how the things must operate inside of this workspace. Therefore, during the development of their activities, sometimes, they use the shared knowledge as a resource to negotiate or construct a shared understanding to solve problems that could occur (DECORTIS *et al*, 2002). This characteristic is called "**intersubjective understanding**".

Conclusion

Based on these notions, cockpit can be considered as a system in which main concepts developed at Distributed Cognition theory can be found.

Although the functions performed in a cockpit have an individual character, they happen in a synchronized way within the cockpit group, characterizing this work space as socially distributed. Therefore, it can be considered that the aeronautical activity has also the possibility of sharing the processes involved in problems resolution and consequent decision making, what classifies it as an activity in which cognitive mechanisms are also socially distributed.

The Hutchins and collaborators' structure offers a different perspective which can contribute to better understand cognitive phenomena which involve tasks developed at cockpit.

Other studies must be developed to deep the knowledge on how the cognitive process involved in the pilots' activity of flying an aircraft occurs.

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