Chapter 7
Pilot Error and Error Recovery

Xiaoyan Zhang and Hongjun Xue

Abstract Three pilot error mechanisms have been presented from the analysis of aviation accidents and the limit of pilot performance. The three mechanisms are speed limited, learned carelessness, and cognitive locked which is all validated through experiments. The essential causes for the three errors are the capability limit, human cognitive inertia, and the limited cognitive resource. The recovery suggestions have already been presented from the cockpit design and pilot training. For the cockpit HCI design, the persistent time for the information should be 500 ms at least to give pilot enough time to react; if the pilot has to execute multitasks at the same time, the information should be designed in ladder to avoid unreasonable attention resource allocation; for the pilot training, the responsibility of the job should be enhanced and the study of rules and procedures should be stricter to avoid carelessness learned.

Keywords Pilot error · Error recovery · Speed limited · Learned carelessness · Cognitive locked · Cockpit design · Pilot training

7.1 Introduction

The statistic results of aviation accidents in recent years are shown in Fig. 7.1, which shows nearly 70 % causes of all aviation accidents is the crew. According to the survey conclusion of the aviation accidents, the major causes of the accidents are cognition and environment. The environment factors includes mainly the rough

X. Zhang (✉) · H. Xue
School of Aeronautics, Northwestern Polytechnical University, Xi'an 710072 Shanxi, China
e-mail: zxyliuyan@163.com

H. Xue
e-mail: xuehj@nwpu.edu

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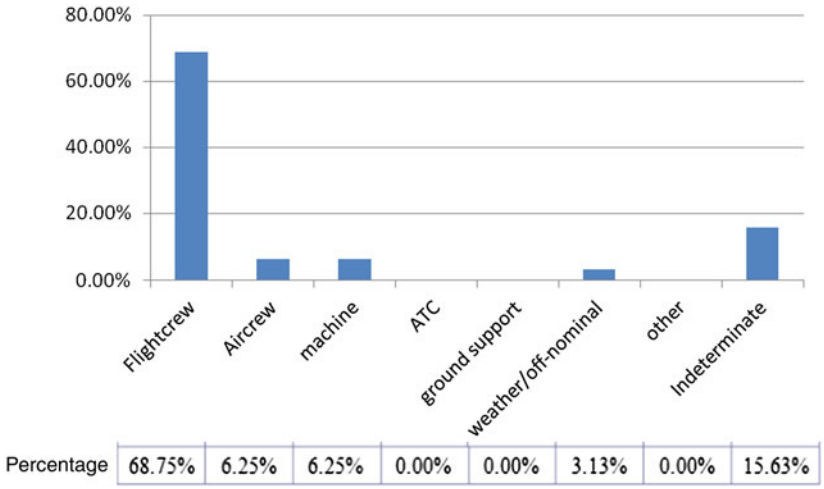

Fig. 7.1 Statistic analysis of commercial aviation accidents during 1999–2008

HCI design [1], automatic operation hard to understand [2] and adverse weather conditions [3] while the cognition factors includes poor situation awareness [4], disobeying operation procedures [5], and coordination and communication of crew [6], mainly related with the pilot. Foreign scholars established some cognition models of pilots [7], including ACT-R, AIR-MIDAS, and A-SA to simulate the decision error of pilots. The models can make simulation on the mistakes in selecting the taxi track for landing, obtaining ideal results. Such teams established the cognition capacity models of pilots; however, they were devoted to improving the simulation capacity of the people [8] and failed to connect the mechanism of error and actual aviation accidents; thus, such models had no significant guidance for the aviation security. The thesis, on the basis of survey and study on the present aviation accidents, presents three mechanisms of the pilot error, namely speed limited, learned carelessness, and cognitive locked. The experiments have been made to verify such three mechanisms. Then, the thesis makes suggestions on recovering such three errors in the cockpit HCI design, operation program design, and trainings on pilots.

7.2 Mechanism of Pilot Error

The pilot error means an action or omission of the pilot, resulting in disobedience of the will of crew or requirements of actual situation, including the regulations, rules, and standard operation procedures [9]. The pilot error mainly results from awareness of situation, fatigue, work load, HCI design level, organizational culture, and external environment, etc. In the thesis, the discussion is made on the

three mechanisms of the pilot error from the limit of the performance, namely speed limited, learned carelessness, and cognitive locked.

1. Speed limited

According to the speed limited, people have the inherent limit in the performance and cannot make correct reaction in a certain speed limited. Especially in adverse and emergent operation situations, the aircraft is in particular condition. It is difficult to leave enough time for the pilot to make cognition and reaction, thus, resulting in the error.

2. Learned carelessness

If the pilot failing to operate according to the procedures in a certain mission does not result in the accident or any accident sign, he will have the tendency to simply the procedures in the future, causing the accident finally.

3. Cognitive locked

According to cognitive locked, the cognitive source of the pilot is limited [9]. Therefore, the pilot will make unreasonable attention resource allocation, even given enough time in executing multitasks, thus, causing the error.

In the following part of the thesis, the experiment is made to verify the three mechanisms of the pilot error. The discussion is made on the speed limited in the operation, the tendency to simply the operation procedures and limited cognition resources.

7.3 Error Mechanism Verification Experiment and Analysis

7.3.1 Speed Limited Experiment

1. Subjects

12 students on school, including 3 girl students. Their right hands are dominant. The cognition level is restricted to be the faster the better on the basis of correctness. The subjects are in normal spirit without any abnormal conditions as fatigue in the experiment.

2. Experiment design

The experiment is designed as one with a single variable of the appearing time of the stimulus, 800, 500, 400, 350, 300, 275, 250, and 200 ms, each of which the subject is required to be tested for 20 times. In the experiment, on the screen will appear red and green warning lights to indicate different warning levels. The subjects are required to click different buttons according to the warning light of

different colors. The computer will make warning sound and record the reaction time and accuracy rate of the subjects. The subjects are required to participate in the formal experiment after being skilled at the experiment.

3. Experiment result and analysis

The experiment results show that the error rate of the subjects increases in nearly linear mode as the present time decreases. In the present time of the warning information of 200 ms, the error rate reaches 90 %. No reaction errors are 195 in the total 216 errors, covering 90.3 %. In the present time of the warning information of 800 ms, the error rate reduces to 2.9 %, of which only one no reaction error. It is a complete cognition control process for the subject to make judgment on the information and corresponding reaction. If the present time is not enough for the process, the subject will make errors of no reaction or the subconscious error.

Besides, the experiment results show that the reaction time of the subjects decreases in a nearly linear mode with the shortening present time. In the stimulus present time of 200 ms, the correct reaction time is only 163.5 ms. However, the studies of anthropologists show that the limit of the reaction time is 0.2 s. It shows that the time pressure will inspire the potential to make reaction beyond the capacity limit. However, such state beyond the capacity limit will not last for a long period. The people will feel frustration and tend to give up in case of the reaction frequency failing catching up with that of the present stimulus (Figs. 7.2 and 7.3).

The experiment of speed limited is made when the subjects are quite familiar with the operation procedures. The results show that the people have capacity limit in cognition or operation. In case of the reaction time less than 400 ms, the error rate will be more than 30 %. In case of the reaction time more than 800 ms, the error rate of the subjects tends to zero.

7.3.2 Learned Carelessness Experiment

1. Subjects

Same with the above-mentioned experiment.

2. Experiment design

Besides the judgment on the warning information, the subjects are required to check the flight altimeter beside the warning information and to press different buttons in case of abnormal conditions on the altimeter. In the experiment, the altimeter is designed to be normal altitude range, interspersed with abnormal altitude range. The record is made on the reaction time and accuracy rate of the subjects. The whole experiment is required to be made for 20 times. The subjects are required to participate in the formal experiment after being skilled at the experiment.

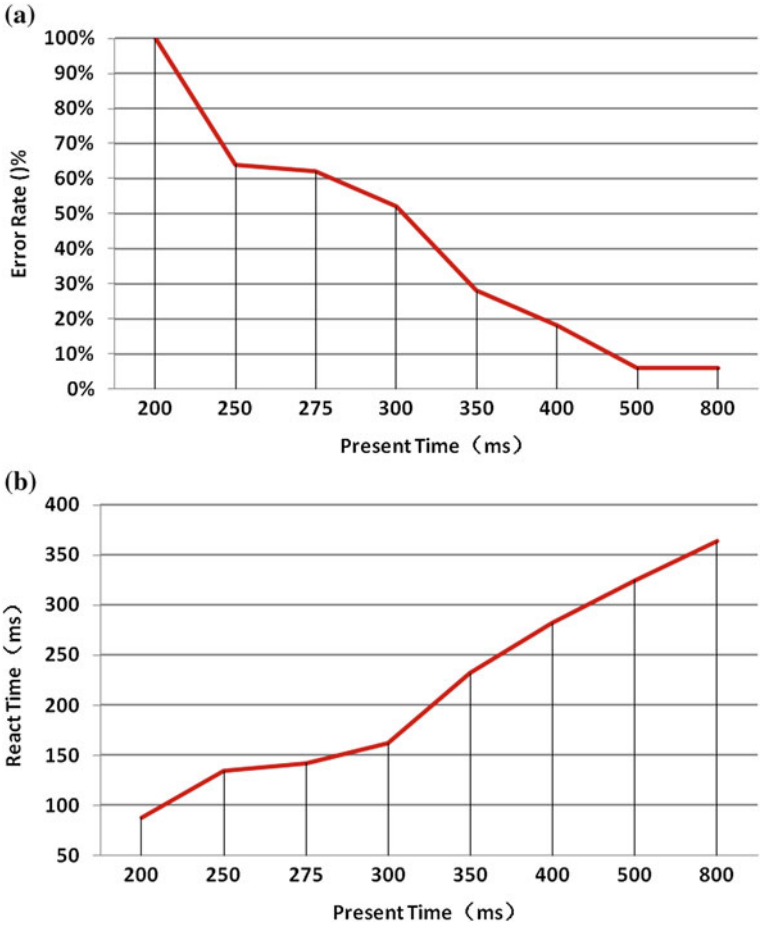

Fig. 7.2 Result of speed limited. **a** Relation between information present time and error rate. **b** Relation between information present time and reaction time

3. Experiment results and analysis

In the experiment, the flight altimeter is set up in the normal range for the first 5 times on purpose, to observe whether the subjects have the tendency to ignore examining the altimeter. The experiment results show that the reaction time of the subjects is longer at the beginning of the experiment, indicating the subjects check the altimeter according to the requirements of the procedures. However, finding the altimeter in normal condition for several times successively, the subjects will ignore the check on the altimeter and simply the operation procedures. The reaction time will be shortened to 744 ms on average and the error rate will increase to 6.25 %. In 240 experiments, nearly all errors appear in the inflection points set up in the experiment, that is, the time when the altimeter changes from normal condition to abnormal condition. It shows that the people will have the

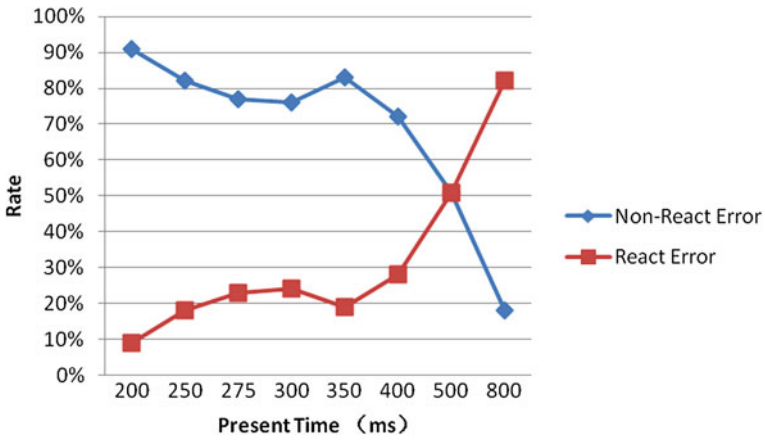

Fig. 7.3 Different errors and information present time

cognitive inertia. Finding no check on the altimeter does not result in the accident or accident signs informed in advance, the subjects will tend to ignore checking the altimeter. Such proves the existence of learned carelessness, which is the error mechanism due to the simplification of the operation procedures of the pilots.

7.3.3 Cognitive Locked Experiment

1. Subjects

   Same with above-mentioned experiment.

2. Experiment design

   Besides the judgment on the warning information, the subjects are required to check whether there is any prompt information at the lower right corner of the screen. The subjects are required to press corresponding buttons in case of any other prompt information. The recorded is made on the reaction time and accuracy rate of the subjects. The whole experiment is required to be made for 20 times. The subjects are required to participate in the formal experiment after being skilled at the experiment.

3. Experiment results and analysis

   In the experiment, the subjects are required to execute two tasks simultaneously on purpose, to make judgment on different warning information levels and to notice whether there is any abnormal condition at the lower right corner and to make corresponding reaction. The reaction time of the subjects is shorter than that of the subjects in the learned carelessness. However, the error rate increases remarkably. The average reaction time is 496 ms and the error rate is 12.9 %.

The analysis on the errors of the subjects shows that the subjects make errors on the reaction to the abnormal conditions at the lower right corner of the screen. Besides, the interview to the subjects shows that the subjects tend to focus on the judgment on the warning information level, thus, resulting in ignoring the judgment on the abnormal conditions at the lower right corner of the screen. It shows the people have limited cognition resources and will make unreasonable attention allocation in multitasks. The subjects will ignore the important information and make the error, of which the rate is higher than that of learned carelessness and which is hard to recover.

7.4 Conclusion

The results of three experiments verify three error mechanisms of pilots, namely speed limited, learned carelessness, and cognitive locked. Detailed analysis is also made on the causes of three error mechanisms in the thesis. It requires making corresponding recovery measures for the errors of pilots with the purpose of improving the aviation security. In the thesis, some suggestions are made on the recovery of three errors in the cockpit HCI design and the pilot training:

1. The speed limited shows the capacity limit is one of sources of errors. Consideration is required to make in the cockpit HCI design. The information needs being presented no less than 500 ms and more than one warning measure is made in case of any fault to avoid the pilot ignoring the warning information;
2. The learned carelessness shows the people have the thinking and operation inertia. Therefore, the pilot training will focus on the responsibility of job and mastering rules and operation procedures. In the cockpit HCI design, the reasonable warning will be made in case of any pilot failing to operate in accordance with the operation procedures;
3. The cognitive locked shows that the people have the limited cognition resources. Therefore, in the cockpit HCI design, the attention shall be paid to keeping the stimulus presented in gradient and trying not to require the pilot to execute multitasks in the same time. Otherwise, there should be warning device to interrupt the cognitive locked of the pilot. In the pilot training, the training on the capacity to execute multitasks should be strengthened because it is impossible to avoid the pilot executing multitasks simultaneously in the flight, especially in adverse and emergent conditions.

The thesis presents three error mechanisms of pilots in the capacity limit of pilots and suggests corresponding recovery measures. However, the factors are complicated to affect the aviation security and the serious accidents or disasters are generally from various factors as the environment, crew and cockpit HCI design simultaneously. Therefore, the further study will be made on the complex factors affecting the pilot errors in the adverse and emergent conditions to improve the aviation security.

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