

# The Use of Eye Tracking in the Study of Airline Cabin Safety Communication

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**Abstract .** The purpose of this study is intended to address the current state of comprehensibility of airline safety briefing cards by adopting the eye-tracking experimental method and comprehension test to solve the relationship between comprehensibility and fixations of airline safety briefing cards. The Land Evacuation Section of a safety card was selected to measure respondents' eye movements together with a survey to test the comprehension of pictorials/pictograms. 51 subjects participated with this study. The results indicate that the universal situation that safety information is not well transferred to passengers and potential passengers. The result of study also shows that the pictograms related to "how to operate emergency door" took the longest fixation time and fixation counts, yet with the highest comprehension score. Meanwhile, other pictorials also showed the positive correlation between their comprehensibility and fixation time and fixation counts. The implications from these results were discussed. It is hoped that the present work will generate interest in the designer and user for providing guidance in the development of cabin safety briefing card.

**Keywords:** Cabin Safety Communication, Safety Briefing Card, Briefing card comprehension, Eye Tracking.

## 1 Introduction

It is generally agreed by aviation authorities that an alert, informed, knowledgeable person has a much better chance of surviving any life or injury-threatening situation which could occur during passenger-carrying operations in civil aviation [1-2]. Therefore, to minimize aircraft occupants' risks, the regulations require airlines to provide safety communication, i.e. safety briefings to inform passengers of routine and emergency safety procedures on board transport airplanes in accordance with the applicable standards before take-off. The briefing should include restriction on smoking, the

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location of the emergency exits, the use of safety belts and when to use them, and the location and use of any required flotation means. In addition, each passenger-carrying operator must provide a safety card in a convenient location for use by each passenger. This card should supplement the oral briefing and should contain diagrams of, and methods of operating, the emergency exits, and other instructions necessary for the use of emergency equipment [3].

Research of cabin safety communication has established the importance of the provision of passenger safety information, and the importance of passenger attention being paid to such communications, such as NTSB's study showed that passengers who did not read the safety card suffered 3 times the number of injuries as passengers who did read the card [4]. However, many of the survivors indicated that their evacuation was not influenced by the passenger safety information which had been presented [5]. NTSB pointed out that many air carrier safety briefing cards do not clearly communicate safety information to passengers, because the majority of the experiment subjects failed to understand the meaning of most of the images presented on the cards [6]. ATSB's report also reveal the majority of passengers reported not having read the safety card, results suggest that the safety card is generally ineffective as a means of delivering safety information [7].

Safety information on briefing cards is typically presented graphically, using symbols, pictorials, and pictograms, while some cards employ text as well. Few researchers have done research regarding pictorials comprehension test and communication design of passenger briefing card. Fennell and Muir [8] found that the depictions of multiple brace positions on the card were confusing and forty-six percent of participants had trouble locating and removing the life vests from the packages. Over fifty percent of participants were wrong or unable to provide the information about the oxygen mask usage. Silver and Perlotto [9] stated that pictorials such as "stow away tables, no smoking in aisles, exit in a sitting position, brace against seat in front of you, and move away from the aircraft" receive less comprehension rate. Caird, Wheat, McIntosh, and Dewar [10] found that comprehension for most of the pictorial information was uniformly low, and specific comprehension difficulties are related to emergency floor lighting and do not use electronics during take-off and landing. Corbett, McLean and Cospoer [11] found comprehension of pictorials/pictograms was related to the familiarity that cabin safety professionals and high flight-time passengers have with safety briefings and briefing cards, and they concluded that safety briefing card pictorials/pictograms need to be designed and implemented with respect to novice passengers who do not have a prepotent understanding of the design, emergency equipment, and/or aircraft emergency procedures. Hsu[12] conducted a A330 safety card comprehension test by using Taiwanese respondents and reconfirms the universal situation that safety information is not well transferred to passengers and potential passengers. The improvement area of safety card comprehension should focus on the pictorials/pictograms related to Evacuation (both water ditching& land), Brace Position, Life vest used in the water/night, and Fasten seat belt sign. Hsu and Hsu [13] also tested and compared the comprehension of pictorials/pictograms on Boeing 747-400 safety cards of two national Taiwanese carriers. The findings show

that both carriers' safety information are not well transferred to passengers and potential passengers, especially the pictorial/pictograms related to Land and Water Evacuation, Fasten-seat-belt sign compliance and Brace Position. Horizontal layout of pictogram is likely to have higher comprehension level compared to vertical layout for Taiwanese participants. It is also suggested to add textual clarification and serial numbers to serial pictograms so that safety information will be easier to understand.

In the last few years, the interest of cabin safety communication brought the emergence of studies on the comprehension level of safety briefing card by using comprehension surveys. Nevertheless, with the disadvantages and limits of survey technique, employing diverse methods of comprehension evaluation on the safety card is needed. Eye-tracking technique is a popular methodological approach in the area of HCI. Tracking people's eye movements can provide an insight into problem solving, reasoning, mental imagery, and search strategies which help researchers understand visual and display-based information processing and the factors that may impact upon the usability of system interfaces[14]. Because eye movements provide a window onto so many aspects of cognition, there are also rich opportunities for the application of eye-movement analysis as a usability research tool in HCI and related disciplines such as human factors and cognitive ergonomics s[14].

The present study is therefore intended to address the current state of airline safety briefing cards by adopting the briefing card comprehension test together with eye-tracking experimental method to gather behavioral data and explore the relationship between comprehensibility and fixations. The findings enable to generate some suggestions to improve usability in airline safety briefing card.

## **2 Method**

### **2.1 Participants**

Given no previous study ever conducted for safety card comprehension test by using eye-tracking technique, this research is served as a preliminary study. To this end, age variable was controlled. The sample participants are required to be aged between 18-30 years old, as safety card pictorials and pictograms need to be designed and implemented for those passengers who do not have a prepotent understanding of transport aircraft related knowledge. Meanwhile there is a growing trend of young travelers, who have better learning ability and not so many travel experiences. Sixty-eight participants volunteered for the study. All participants were undergraduates and postgraduates, and ranged in age from 18-30 years old. Due to the invalid data recorded by the eye-tracking system, there are fifty-one valid data for this research.

### **2.2 Stimulus Materials**

According to Hsu [12] and Hsu and Hsu[13], one of the specific comprehension difficulties are associated with the pictograms of Emergency Evacuation, which should be the first improvement area. The pictograms related to Land Evacuation on the

A330 safety card of a Taiwanese carrier have therefore been selected as the stimulus material in this research. The popularity of A330 in worldwide airline industry will facilitate further comparison research too.

### 2.3 Procedures and Data Analysis

The eye-tracking test was conducted with ASL Mobile Eye wearable eye tracking system, which contains eye camera, scene camera, and PC with monitor. After each participant had worn the eyeglasses and made the best adjustment, the section of Land Evacuation on the safety card was shown to participants. The participants can take as long as they like to read the diagrams, just like passengers on board the airplane. The data gathered from the eye-tracking system was classified into five categories, i.e Area of Interests (AOI) in the stimulus material (see Figure 1), and then analyzed by a software named “Gaze Map”.

Once the participants completed the reading, they were asked to conduct the comprehension test of these diagrams. The comprehension survey was adopted from the study of Hsu [12], which is an open-end questionnaire. Instructions were given to ask the participants to describe the meaning of the pictorials/pictograms. There was no time limit to complete the survey either. The comprehension test result was then scored according to the method used by Corbett, McLean and Cosper [11].

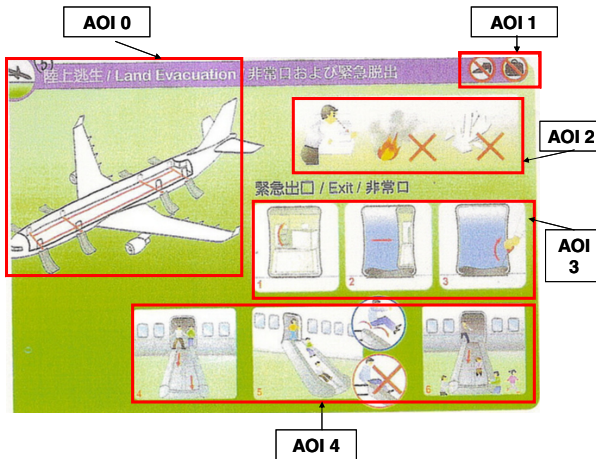


Fig. 1. Five Area of Interests (AOI) in the stimulus material

### 3 Results and Discussions

The respondents’ demographic data are presented as follows (see Table 1):

**Table 1.** Respondents' Demographic Data

		<b>Number</b>	<b>Percentage</b>
<b>Gender</b>	Female	14	27.45
	Male	37	72.55
<b>Age</b>	21-30	36	70.59
	under 20	15	29.41
<b>Flying Frequency</b>	7-8 time	1	1.96
	5-6	2	3.92
	3-4	3	5.88
	1-2	20	39.22
	0	25	49.02
<b>Flying Experience</b>	Yes	42	82.35
	No	9	17.65
<b>Purpose</b>	VFR	1	1.96
	Study	2	3.92
	Travel	35	68.63
	Business	2	3.92
<b>Attribute</b>	Group	30	58.82
	Individual	10	19.60
<b>Missing</b>	System	11	21.57

### 3.1 Comprehension Scores

A matrix of the comprehension scores of each AOI is displayed in Table 2. Comprehension scores based on the item for each AOI ranged from 17.16 % to 66.67 %, with a mean score of 40.19%. No items met the more stringent American National Standards Institute (ANSI) suggested comprehension standard of 85%. One of AOI pictorial/pictogram (AOI3) almost met the International Organization of Standards (ISO) suggested comprehension criterion of 67%. Others were understood accurately below the 50% level (see Table 2).

In order to see whether the five AOIs differed across demographics, T test were conducted for each item across gender, age, flying experience and passenger attribute. One-way Analysis of Variance (ANOVA) was conducted across flying frequency, and purpose of the flight. When the effects are significant, the means must be then examined in order to determine the nature of the effects, by employing the post hoc multiple comparison- LSD. The results indicate that:

**Table 2.** Comprehension score of AOI 1-5

Item		Comprehension Scores (%)
<b>AOI 3</b>	How to open the door	66.67
<b>AOI 4</b>	How to use slide	63.73
<b>AOI 2</b>	Watch outside circumstances before open the door	27.94
<b>AOI 0</b>	Emergency exit and evacuation route	25.49
<b>AOI 1</b>	No baggage and high heel when evacuation	17.16
<b>Average</b>		40.19

- (1) **Gender-** the significant differences between male and female were found on **AOI 0 -Emergency Exit and evacuation route**, ( $T=2.52^*$ , male>female).
- (2) **Flying experience-** the significant differences between yes and no were found on **AOI 3- How to open the door** ( $T=-2.21^*$ , no>yes), **AOI 4- How to use slide** ( $T=-2.20^*$ , no>yes).
- (3) **Flying frequency-** The item with significant difference is **AOI 1- No baggage and high heel when evacuation** ( $F=3.88$ ,  $p<0.05$ ). LSD indicated that the variability may come from the difference between 3-4 times and 1-2 times (3-4times> 1-2 times).

### 3.2 Eye Movement Analysis

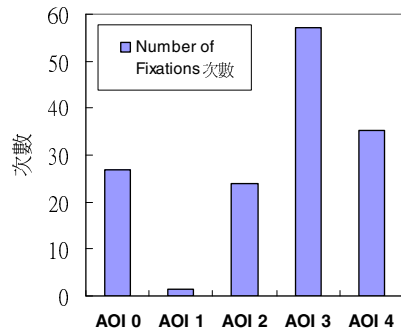
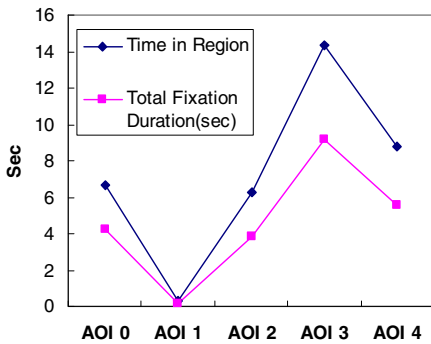
Table 3 shows the results of Eye Movement Index for AOI 1-AOI 5, including “Time in region”, “Number of Fixations”, “Total Fixation Duration” , and “Time to First Fixation”.

**Table 3.** Eye Movement Index and Data

Eye Movement Index	AOI 0	AOI 1	AOI 2	AOI 3	AOI 4
Time in Region(sec)	6.65	0.34	6.28	14.39	8.79
Total Fixation Duration(sec)	4.2	0.19	3.81	9.18	5.54
Number of Fixations(frequency)	26.94	1.31	23.94	57.13	35.21
Time to First Fixation(sec)	2.99	27.58	7.3	9.62	19.83

As shown in Figure 2, in terms of “Time in Region” and “Total Fixation Duration”, **AOI 3 (How to open the door)** has the highest ranking, then AOI 4(How to use slide)> AOI 0 (Emergency Exit and evacuation route)>AOI 2 (Watch outside circumstances before open the door) >AOI 1 (No baggage and high heel when evacuation). For the index of “Number of Fixations”, the results remain the same (see Figure 3).

AOI 3 (How to open the door) takes more time to read and renders the highest Number of Fixations. It shows that there are more messages/details in this area, or it is more difficult to read within the context, which cause the readers desire or need to spend more time in dealing with the message in this area. In particular, according to T test, the significant differences of flying experience between yes and no were found on Time in Region( $T=-2.04^*$ , no>yes), Total Fixation Duration( $T=-2.26^*$ , no>yes) and Number of Fixations( $T=-2.20^*$ , no>yes). In other word, those who have no flying experiences may need more observation time to deal with messages contained in AOI 3 (How to open the door).



**Fig. 2.** Time in Region and Total Fixation Duration of AOI 1-AOI 5

**Fig. 3.** Number of Fixations of AOI 1-AOI 5

In terms of the index of “Time to First Fixation”, AOI 0 (Emergency Exit and evacuation route) rendered the shortest time, then the order is AOI 2 (Watch outside circumstances before open the door)< AOI 3(How to open the door) < AOI 4(How to use slide) <AOI 1 (No baggage and high heel when evacuation)(see Figure 4). As “Time to First Fixation” means the time it takes for a participant to first fixate on a specific area or interest. It can show people across the board which AOI was drawing respondents’ attention in the context of the task they are asked to perform. Therefore, the result implies that AOI 0 (Emergency Exit and evacuation route) attracts the respondents the most, and the path of reading interest of AOIs appears like Figure 5.

The results reflect that most languages are read left-to-right, and top-to-down. Also, compared to other AOIs, the diagrams in AOI 1 (No baggage and high heel when evacuation) are much smaller, which obviously the least attractive items for the respondents.

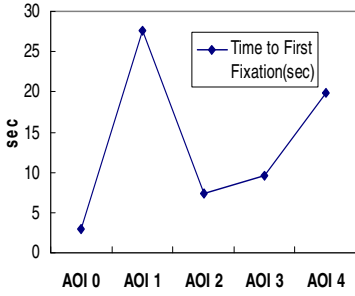


Fig. 4. Time to First Fixation of AOI 1-AOI

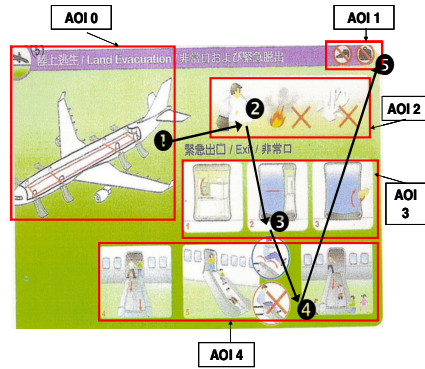


Fig. 5. The path of reading interest of AOI1-AOI 5

### 3.3 Eye Movement versus Comprehensibility

To explore the relationship between eye movement index and comprehension score of AOIs, correlation analysis was conducted. Table 4 shows the significant correlations. The comprehension score of AOI 1 (No baggage and high heel when evacuation) has significant low and positive correlation with Time in Region, Number of Fixation, as well as Fixation Duration, and low plus negative correlation with Time to First Fixation. The results show that for AOI 1(No baggage and high heel when evacuation), the shorter of observation length and longer Time to First Fixation are related to the least comprehensibility. For AOI 2 (Watch outside circumstances before open the door), its comprehension score has significant low and negative correlation with Time

Table 4. The correlation between eye movement index and comprehension score of AOIs

	Comprehensibility		
	AOI 1	AOI 2	AOI 4
AOI 1_time in region	0.30**		
AOI 1_number of fixation	0.28**		
AOI 1_fixation duration	0.28**		
AOI 1_time to first fixation	-0.06*		
AOI 2_time to first fixation		-0.28*	
AOI 4_time in region			0.38**
AOI 4_number of fixation			0.39**
AOI 4_fixation duration			0.39**

\* Correlation is significant at the 0.05 level (2-tailed).

\*\* Correlation is significant at the 0.01 level (2-tailed).



to First Fixation. The result shows that the less interest attention (longer Time to First Fixation) are associated with the lower comprehensibility. Meanwhile, the comprehension score of AOI 4(How to use slide) has significant low and positive correlation with Time in Region, Number of Fixation, and Fixation Duration. It reveals the longer of observation length are in association with better comprehensibility.

## 4 Conclusions and Suggestions

The purpose of this research was to investigate the efficacy and usability of airline safety cards through a comprehensibility test together with an eye-tracking study. Tracking people's eye movements provide an insight into mental imagery and display-based information processing of airline safety card, which enhanced the current comprehensibility test. Findings of this research led to following conclusions for the improvement of usability in the safety card:

1. Within the context of Emergency Evacuation, the diagrams relating to "How to open the door" take most time for respondents to comprehend but render in the highest comprehension scores. Also flying experiences exert an influence on the comprehensibility and cognition processing time in terms of "How to open the door". So it is crucial to make passengers spend time reading the safety card to increase the comprehensibility.
2. Diagrams relating to "No baggage and high heel when evacuation" should be as larger as better, because this is the part ought to be fulfilled by the passengers when emergency evacuation. It is better to move the diagrams to left hand side for first priority to read.
3. Diagrams relating to "Watch outside circumstances" render the most problematic answers, it is suggested to add some textual clarification to make safety information more meaningful.

**Acknowledgement.** This research is supported by the National Science Council of Taiwan, R.O.C., under Grant no. NSC 99-2221-E-424 -002

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