



Comprehension and hazard communication of three pictorial symbols designed for flight manual warnings

Oguzhan Erdinc *

Department of Industrial Engineering, Turkish Air Force Academy, Yeşilyurt, Istanbul, Turkey

ARTICLE INFO

Article history:

Received 5 December 2008

Received in revised form 12 October 2009

Accepted 21 December 2009

Keywords:

Flight manual

Warning

Pictorial symbol

Hazard perception

ABSTRACT

Military flight manuals contain three types of warnings; WARNING, CAUTION and NOTE messages convey personal injury or loss of life hazards, material damage hazards and essential information respectively. Effectiveness of these warning messages is crucial for flight safety. A way to enhance warning effectiveness is pairing warning messages with compatible symbols. However, no symbol was used with warning messages in current flight manuals. In this study, three pictorial symbols were designed for flight manual warnings. Comprehension and hazard perception of designed symbols were tested through matching test and psychometric rating, respectively, by Turkish military pilots. Results showed that comprehension and hazard perception of the symbols were sufficient and compatible with content of warning messages in flight manuals. It was concluded that accompanying warning messages with these symbols could contribute to effectiveness of flight manual warnings.

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1. Introduction

In military aviation, flight manuals are principal technical documents that contain all necessary information for safe and efficient operation of the aircraft. Characteristics, specifications and limitations of aircraft, normal and emergency operation procedures, and safety information are included in flight manuals. Without highest command of information given in the manuals, military pilots are under risk of inability to react as fast and accurate as they are required during flight (Hawkins, 1993). In order to gain absolute command of operational and safety information about their aircraft, military pilots have to study and review flight manuals continuously not only in flight training but all along their professional life. Thus, design of flight manuals should facilitate comprehension, memory and recall of information presented (Hawkins, 1993).

Especially for military jet pilots who have to operate high-speed aircraft under high mental stress, comprehension and memory of safety information given in the manuals assume particular importance. Critical safety information in flight manuals are presented within warning messages. There are three types of warning messages in US originated military flight manuals which are also used by Turkish Air Forces. Each type of warning messages are titled differently depending on the information they contain. Warning messages titled WARNING introduce operating procedures and

techniques which could result in personal injury or loss of life if not carefully followed. Warning messages titled CAUTION introduce operating procedures and techniques which could result in damage to material if not carefully followed. Warning messages titled NOTE introduce an operating procedure or technique which is considered essential to emphasize. The comprehension and the hazard perception of the warning messages in the flight manuals are of utmost importance for basically two reasons. Firstly, the pilots have to be aware of the conditions presented in the warning messages to avoid any erroneous operation or technique during flight. Secondly, the pilots have to react to emergencies during the flight in a very short time, even in seconds, and having the command of the information provided in the warning messages facilitates decision making process, which leads to reduced reaction time and thus, enhanced flight safety. Furthermore, the pilots should be able to discriminate the level of hazard correctly when they encounter the conditions presented in warning messages. For example, the pilot should be able to determine if an operation could lead to loss of life to material damage. Moreover, the flight manuals are not available to pilots in cockpit and reviewing the information in the flight manuals is not possible during flight, which makes effectiveness of the flight manual warnings is a particular concern for flight safety. Therefore, the design of the flight manual warnings should enable pilots notice, comprehend and recall safety information in congruence with the contents and hazard levels of the warning messages and any improvement in effectiveness of flight manual warnings can significantly enhance flight safety.

One potential way to enhance effectiveness of verbal warnings is to pair warning messages with symbols. As Rogers et al. (2000)

* Address: Hava Harp Okulu Endüstri Mühendisliği Bölümü Başkanlığı, 34149 Yeşilyurt, İstanbul, Turkey. Tel.: +90 212 6632490/4356 (office), +90 505 849 2420 (mobile); fax: +90 212 6632838.

E-mail address: o.erdinc@hho.edu.tr

elaborated; symbols in warning literature refer to all imagery representations of verbal concepts such as pictorials, graphics or pictograms. Contribution of symbols to noticing, comprehension and memory of verbal warnings has long been recognized (Clement, 1987; Laughery, 2006; Rogers et al., 2000; Wogalter et al., 2002; Young and Wogalter, 1990). As Paivio's Dual Coding Theory postulated, use of symbols with verbal messages augments memory and learning of information in that imagery could cue the message it is paired with effectively (Paivio, 1991; Young and Wogalter, 1990). Most recognized study about use of pictorial symbols in manual warnings was performed by Young and Wogalter (1990). They found that noticing, comprehension and memory of instruction manual warnings are facilitated when text messages are paired with pictorial icons.

It is important that symbols should be comprehended correctly by the audience and they should be compatible with hazards conveyed in verbal messages they are paired with. As several authors emphasized, symbols should be tested before use (Lehto, 1992a; Wogalter et al., 2002; Wogalter and Sojourner, 1997). One of the methods to test symbol comprehension is matching test in which subjects are asked to select most applicable meaning of a symbol from a list (Lehto, 1992a). Two standards; ANSI Z535 of American National Standard Institute and ISO 3864 of Organization for International Standardization established correct comprehension criteria for symbols (Lehto, 1992a; Liu et al., 2005; Wolff and Wogalter, 1998). While according to ANSI Z535, a symbol should be correctly comprehended by 85% of a representative target audience of at least 50 people in order to be acceptable (Lehto, 1992a), in ISO 3864, minimum correct comprehension limit is 67% for acceptance of a safety related symbol (Liu et al., 2005; Wolff and Wogalter, 1998). Lehto (1992a) also propounded that various properties of symbols such as hazard perception could be tested using rating scales.

In currently used military flight manuals, warning messages are not paired with symbols. Furthermore, no study was found in literature pertaining with the use of symbols in flight manual warnings. However, it was considered that pairing warning messages with compatible pictorial symbols could facilitate noticing, comprehension and memory of flight manual warnings, which could lead to significant improvement in warning effectiveness and flight safety.

In this respect, objectives of present study are twofold: to design three pictorial symbols for flight manual warnings and to test comprehension and hazard perception of these symbols with a target audience of Turkish military pilots. Design of pictorial symbols was explained. Comprehension and hazard perception of the symbols were tested via matching test and psychometric rating, respectively. Results of the study indicated that designed symbols can be useful in enhancing effectiveness of flight manual warnings.

2. Method

2.1. Pictorial symbols

Three pictorial symbols were designed for the study. Design objective was to prepare symbols that are compatible with type of information and hazard intended to be communicated in the flight manual warnings. The pictorial symbols were designed based upon personal flight training experience of the author, communications with military pilots in immediate environment of the author and previous research findings.

WARNING messages involved two types of hazards; personal injury or loss of life. Given that personal injury could also lead to loss of life and communicating higher hazards was deemed safer than underrating hazards, a pictorial symbol which conveyed fatal-

ity was considered suitable for WARNING messages. Hence, skull and cross bones which was found to have strong potential for conveying fatality to a Turkish audience (Erdinc, 2004) and to associate with loss of life was selected for WARNING messages. A skull and cross bones was found on the internet and arranged for the study. CAUTION messages involved material damage hazards. Thus, a new pictorial symbol depicting an aircraft with a broken wing was prepared using Microsoft Paint program. As for NOTE messages which contained safety information considered essential to emphasize, an exclamation mark was prepared with Microsoft Word program. Since flight manuals are printed and used in black and white, pictorial symbols were prepared in achromatic form. Designed pictorial symbols had different shapes. In order to standardize their presentation, all three pictorials were prepared to be 2 cm in height. Designed pictorial symbols were presented in Fig. 1.

2.2. Participants

Fifty-four F-16 pilots participated in the study. All participants were Turkish and participation was voluntary. Demographics of participants were presented in Table 1.

2.3. Material and procedure

Comprehension and hazard perception of designed pictorial symbols were tested via matching test and psychometric rating respectively. Test material was a four-page booklet. The first page included demographic questions. Each of the following three pages included one of the symbols, matching test and rating scale. Participants were given one of the three versions of booklets in each of which pictorial symbols were arranged in different order for randomization. They were told that there was no right or wrong answer. Given that designed pictorials were considered to be used only with warning messages, matching test included four anchors; "loss of life", "personal injury", "damage to material" and "essential information" which cover contents of flight manual warnings and "none of them" anchor for other responses. Participants were asked to choose the anchor that the symbol shown on the page matched. In order not to limit range of potential responses, an open-ended answer part was provided under the anchors and



Fig. 1. Pictorial symbols designed for flight manual warnings.

Table 1
Demographics of participants.

| Demographics of participants | | |
|------------------------------|-----------|-------------------|
| Gender | Males | 98.1% (n = 53) |
| | Females | 1.9% (n = 1) |
| Age | Range | 24–38 |
| | Mean (SD) | 29.91 (3.620) |
| Flight hours | Range | 200–3550 |
| | Mean (SD) | 1194.81 (811.251) |

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