Applied Ergonomics 58 (2017) 156–166

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Safety signs on agricultural machinery: Pictorials do not always successfully convey their messages to target users

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ARTICLE INFO

Article history:
Received 14 July 2015
Received in revised form
10 June 2016
Accepted 13 June 2016

Keywords:
Agriculture
Pictorial comprehension
Safety

ABSTRACT

This study investigated the extent to which a sample of Italian users comprehended safety pictorials used on agricultural machinery. A questionnaire with 12 safety pictorials was administered to 248 users of agricultural machinery. For each of the pictorials, the participants were asked to select the most appropriate description of four written choices. The investigated safety pictorials were, in general, not well comprehended. Two different classes of participants were identified, each with a different level of comprehension. The participants with better comprehension were characterized by the regular use of agricultural machinery and frequent previous exposure to pictorials. The need for training courses focusing on safety pictorials and their meanings, as well as the need for improvement to the pictorials themselves to make them more easily comprehended, is discussed.

1. Introduction

The term 'pictorial' in the present context refers to graphical forms that are increasingly used to convey information regarding safety issues in a broad range of circumstances. They serve a variety of objectives with the overall aim of reducing accidents and injuries, and the adoption and use of uniform and effective pictorials for safety communication is recommended in many international standards (e.g., ANSI Z535.3-2011). In an attempt to change potentially dangerous behaviors, pictorials provide information about hazards and their consequences in a way that, it is assumed, will increase the awareness of risks. Furthermore, they serve as reminders by raising awareness of information that may be latent (Laughery, 2006). Pictorials offer a number of advantages over written language (Edworthy and Adams, 1996): they can capture attention more quickly; they can be more quickly comprehended and can be better remembered than words (Young and Wogalter, 1988); and they can quickly communicate concepts and instructions due to the large amount of information they can represent (Wogalter et al., 2006). Pictorials are particularly useful when the target audience has limited reading skills (e.g., children, the elderly, illiterate individuals) or are unfamiliar with the language that would be used in a written message (Lesch, 2003; Wogalter et al., 1997, 2002; Wogalter and Laughery, 1996; Young and Wogalter, 2000). Boelhouwer et al. (2013) reported that pictorials may improve the communication for both naïve and expert users of safety information on safety data sheets and product labels. Dowse and Ehlers (2005) showed that the incorporation of pictorials on medicinal labels contributes positively to the comprehension of and adherence to safety requirements. Regarding pharmaceutical labels, Kalsher et al. (1996) report that labels with pictorials are preferred by both undergraduate students and older adults.

Many authors (Davies et al., 1998; Duarte and Rebelo, 2005; Liu et al., 2005; Rubbiani, 2010), however, have reported that the pictorials they have investigated have been poorly understood. For example, the Dowse and Ehlers (2001) study on the interpretation of pharmaceutical pictorials by a group of low-literate participants indicated a low comprehension rate for most of the pictorials they studied. Similarly, poor comprehension is reported both in Rother's (2008) investigation on the interpretation of pesticide label pictorials among farm workers and in a study by Chan and Ng (2010a) on the comprehension of industrial safety pictorials. Different characteristics of the intended target audience and the audience's previous experience with the pictorials have been investigated in relation to pictorial comprehension (for a review, see Rogers et al., 2000). However, inconsistent results are reported in the literature on the role played by variables such as age and education (Lesch, 2003; Ng and Chan, 2008), familiarity with the pictorials (i.e.,

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http://dx.doi.org/10.1016/j.apergo.2016.06.003
0003-6870/

prior experience with pictorials; Hancock et al., 2004; Ng and Chan, 2011) and training received (Brahm and Singer, 2013) in enhancing the comprehension of safety pictorials.

Given their particular relevance in communicating safety information, the use of pictorials has been investigated in many different domains, such as pharmaceuticals, heavy industry, transport and consumer goods (Barros et al., 2014; Boelhouwer et al., 2013; Davies et al., 1998; Lesch, 2003; Ng and Chan, 2008; Rother, 2008; Wogalter et al., 1997). However, few studies have investigated the use and effectiveness of pictorials as safety tools in the agricultural industry.

Agriculture, together with mining and construction, is one of the most hazardous sectors in both developing and industrialized countries (International Labor Organization [ILO], 2014). Approximately 170,000 out of some 335,000 fatal workplace accidents worldwide occur among agricultural workers (ILO, 2014), and the rate of fatal accidents in agriculture in several European countries and in the United States is double the average for all other industries (Molari et al., 2014; Mongin et al., 2007; Rautiainen et al., 2010). Farmers and farm workers are particularly at risk because they generally handle potentially dangerous machinery, vehicles and chemicals, all of which dramatically increase the risks of fatal and non-fatal injuries.

The few studies investigating safety pictorials in the agricultural industries have examined messages regarding chemicals. Some studies that assessed the understanding of pictorials used in pesticide exposure risk communication reported low comprehension rates (for a review, see Emery et al., 2015). With regard to the factors affecting the comprehension levels of safety pictorials adopted for chemicals, contrasting results are reported in the literature. Indeed, considering the sociodemographic variables, gender appeared to enhance comprehensibility (Rother, 2008), whereas age and education did not report any significant effects (Rubbiani, 2010). With regard to the expertise of the participants and familiarity with the pictorials, these variables showed a significant positive effect on compliance in the study by Ortiz et al. (2000), whereas more complex and ambiguous results are reported in other studies (Boelhouwer et al., 2013; Edworthy et al., 2004). Finally, contrasting results are reported on training: the work by Rubbiani (2010) showed that the effective understanding of pictorials was facilitated by training, whereas Rother (2008) found that those who reported having been trained were less likely to have sufficient knowledge of the pictorials used on pesticide labels.

1.1. Pictorials on agricultural machinery

Many authors list farm machinery as a major source of injury in agriculture (Douphrate et al., 2009; Forastieri, 2001; Jawa et al., 2013; Narasimhan et al., 2010). In particular, the highest number of fatalities involves tractors: 9.6 tractor-related injuries/1000 persons per year are reported by Carlson et al. (2005) in the United States; Cavallo et al. (2014a) reported that tractor roll-over is the leading cause of fatal injuries among farmers and farm workers. A similar picture emerges in European Union countries (European Commission, 2009) and within the European Union, Italy is a particularly heavily affected country, accounting for nearly 24% of the 150,000 accidents reported in the agricultural, fishing and forestry sectors in 2012 (Eurostat, 2015). In 2010, more than 1.6 million holdings (13.2% of the EU-28's holdings) in Italy with an average dimension (7.9 ha) below that of the EU-28 (14.2 ha) exist, and in 2008, approximately 1.75 million tractors were in use (Cavallo et al., 2014b). In Italy, tractor accidents are the leading cause of injuries in agriculture: in 2013, 121 fatal accidents involving tractors occurred, with tractor roll-over being the main cause of fatalities (70%), followed by crushing or being run over by tractors (10%) (FederUnacoma, 2014).

In a move towards reducing this level, a number of authors (Caputo et al., 2013; Murphy and Anderson, 1992; Purschwitz, 2006) have proposed that a safety hierarchy protocol be applied in the design of machinery and equipment to ensure safe use by end users. This protocol consists of a three-step procedure: 1) the elimination of the sources of hazards by design, 2) the adoption of technical protective solutions when hazards cannot be eliminated, and 3) the provision of information to end users through the use of warnings. Warnings, which include safety indicators such as pictorials and written messages, make end users aware of the residual risks — i.e., risks that could not be removed by design or safeguards — and inform the end users about the appropriate method of using equipment or machinery to avoid these residual hazards (Fraser, 2009; ISO 14121-1:2007). Thus, warnings are not a substitute for good design or adequate safeguards; they should be used as a supplement to other safety-related approaches (Lehto and Salvendy, 1995). This 3-step process is included in the 'Principles of safety integration' adopted in the European Machine Directive (European Commission, 2006), which is in force throughout the European Union countries (Fraser, 2009).

The adoption of this 3-step approach to risk reduction is also recommended by the ISO 11684:1995 standard, which establishes the principles for the design and application of safety signs for agricultural and forestry machinery. After reporting the different steps through which the risks should be eliminated or reduced, the standard states: "Even when the appropriate design features and safety devices are incorporated into machinery, some residual risks may remain. Safety signs warn operators or other exposed persons about such residual risks." (par. 3.2, p. 1) The standard provides four different formats for safety signs based on different combinations of signal panels (containing the safety alert symbol and one of these words: *Caution, Warning,* or *Danger*), message panels (containing a text) and pictorial panels (containing graphical forms). The standard considers two types of pictorials: those that present a visual description of the hazard and the consequences of not avoiding the hazard, and those that issue visual instructions on how the hazard should be avoided.

Caffaro and Cavallo (2015) investigated the knowledge of safety pictorials used in agricultural machinery and their noticeability. The pictorials examined were poorly comprehended and were reported as being seen on the machine itself rather than in operator's manuals. In addition, familiarity with the pictorials without having received training significantly increased users' comprehension. The issue of pictorial relevance and noticeability has also been investigated in other studies that focused on safety warnings on tractor operator's manuals. These studies noted that the manuals have poor document design, which does not clarify critical information and discourages readers (Tebeaux, 2010a). Over time, manufacturers made efforts to warn operators about the risks associated with tractors (Tebeaux, 2010b), but the information given in the manuals is required to comply with laws and safety regulations rather than to inform operators (Tebeaux, 2010a).

1.2. Aims of the study

The present study is based on some considerations arising from a review of the literature.

Pictorials are relevant safety tools, especially in agriculture, which is a highly hazardous sector (ILO, 2014); however, few