# Effects of Packages' Color as a Cue for Hazard-Related Perceptions: A Study Using Virtual Reality

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**Abstract.** Color is often used to communicate the level of hazard. The present study sought to determine the effect of packages' color on hazard-related perceptions in a Virtual Environment. There were two conditions: achromatic (grayscale) and chromatic (red, yellow, blue, green). A sample of 40 design students rated their hazard-related perceptions (e.g., level of hazardousness and awareness of consequences) of eight 3D packages, which differed in contents' hazardousness and familiarity, on hazard related perceptions. The results indicated that color does affect hazard-related perceptions. Compared to the achromatic versions, red and yellow produced different effects, when applied to hazardous packages which are both familiar and unfamiliar. Red increased hazard perception but did not affect awareness of consequences, and yellow did not affect the first, but decreased the latter. Blue decreased both dimensions, whereas green did not affect the first but decreased the latter. The results draw attention to the importance of color and familiarity on hazard-related perceptions.

**Keywords:** Package design · Colors · Safety · Hazard perception · Virtual environment

## 1 Introduction

Every year many users are injured while using products at home, including chemical household products. Since it is not always possible to design-out hazards in consumer products, one way to increase users' safety is to inform them of potential hazards, i.e., how to avoid being injured and the consequences of non-compliance. The packages' labels are normally used to convey warning and risk information to the users. However, such warnings are not always effective since they might not be noticed, read, understood or complied by users [1].

Such warnings fail to capture users' attention [2] due to several factors (e.g., an incorrect perception of the product's level of hazardousness and/or risk). The more


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hazardous the product is perceived to be the more likely is the user to act in a cautious manner (e.g., [3–6]). However, previous research reveals systematic bias in risk perception (e.g., [7]). If users judge the situation (i.e., using the product in a given context with a specific objective) as involving no- or low-risk level, then they tend to not actively look for the safety information in the product and, therefore, do not read the warnings in the labels [1, 2]. Consequently, aiding users to adequately assess the risk involved in a given situation, in a quick and accurate manner, can be one of the most important measures to help promote safety.

One approach can be through the use of deliberate signifiers/perceived affordances [8] in order to convey strong cues that prompt safe behaviors [9] because affordances have some meaning to guide the observer's behavior [10]. In this sense, the packages' features (e.g., shape, color) can affect users' expectations regarding the products and, consequently, the warnings effectiveness. Previous studies found that the package's shape, or configuration, [11], and color [12] can evoke different levels of hazard perception. However, similar packages can mislead the users regarding the correct perception of the content's hazardousness (e.g., [13]).

In a previous study, we assessed the extent to which participants could perceive the content hazardousness from shape of liquid household packages' [14]. Additionally, we also assessed how the familiarity affected such perception since it has been found to decrease participants' likelihood to look for, notice and/or read warnings [15–17]. The present study extends the previous one by exploring the impact of packages' color on hazard-level perceptions (i.e., hazardousness, awareness of consequences) and familiarity. The aim is to determine if color could augment the perception of hazard. In this context, participants judged eight 3D household packages in two experimental conditions (i.e., chromatic and achromatic) which were displayed in a Virtual Environment (VE).

Literature assesses color's influence on attention, perception, and behavior. The role of color in enhancing hazard perception is also well documented [18–21]. It is well known that using color directly or indirectly influences perception and that, through color, people can distinguish between hazard and safe [22]. Moreover, as an effort to improve safety, color schemes are widely used to convey information and therefore frequently studied in visual working memory [23]. In general, warning-related research suggests that red should be used to indicate a greater level of hazard, than that of yellow and/or orange [24]. And, some inconsistent results have been found for ordering other colors such as orange and yellow [25]. Colors such as blue, green and black are generally connoted with less or no hazard [26].

In this study, it is expected that packages that connote higher level of hazard through colors (red and yellow) will increase hazard-related perceptions when compared to the achromatic (grayscale) counterparts, and the opposite for those colors which are connoted with lower hazard levels (blue and green). In addition, it is hypothesized that the color effect will be greater for unfamiliar packages than for familiar ones.

While 2D images (e.g., drawings, pictures) are the method usually adopted for conducting this type of study (e.g., [11, 12]), this research, following our previous studies (e.g., [14, 27]), also adopts a 3D simulator-based methodology. Virtual Reality (VR) has been suggested as a promising methodological tool for research on safety-related topics (e.g., [28, 29]) and User Experience studies (e.g., [30]).

# 2 Method

## 2.1 Experimental Design

Two experimental conditions were used to examine the effect of color on hazard-related dimensions. In the first condition, participants were exposed to achromatic packages. In the second condition, participants were presented with chromatic packages. A mixed design was used, with the two experimental conditions as the between-subjects factor and the type of package (with four levels: HF - Hazardous Familiar, NHF - Non-hazardous Familiar, HUF - Hazardous Unfamiliar and NHUF - Non-hazardous Unfamiliar) as the within-subjects factor. The dependent variables are hazard related perceptions (i.e., the level of hazardousness and awareness of consequences). Familiarity was used as a control variable.

## 2.2 Stimuli

The VE and the eight packages used were the same as the ones tested in a previous study by Ayanoğlu and colleagues [14]. The packages were presented either in achromatic (i.e., grayscale) or chromatic versions (i.e., red, yellow, blue and green) according to the experimental condition (see Fig. 1). The four colors were selected according to their connoted level of hazard, as defined in the literature (e.g., [19]). The RGB values, i.e. red (165, 32, 25), yellow (229, 190, 1), blue (30, 45, 110) and green (49, 127, 67), from ISO 3864-4 [31] were used to define the colors' properties.

*Note. Package A and B are unfamiliar packages with hazardous content (yellow); Package C and F are familiar packages with hazardous content (red), Package D and H are unfamiliar packages with non-hazardous content (green); Package E and G are familiar packages with non-hazardous content (blue).*

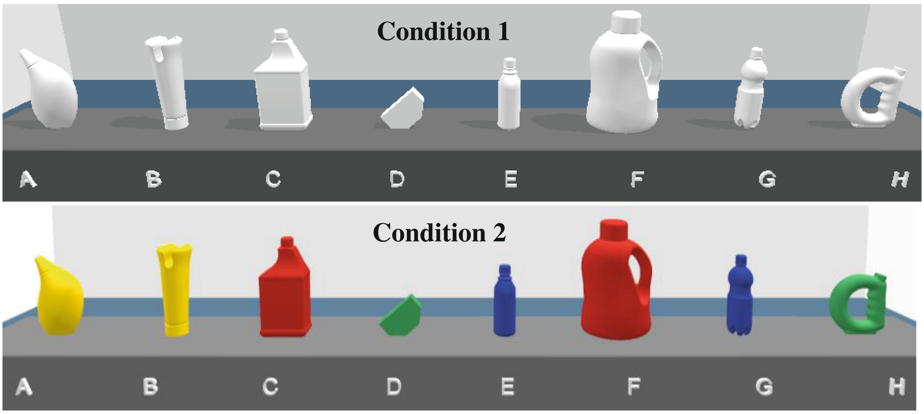


**Fig. 1.** Experimental conditions (Condition 1 – achromatic; Condition 2 – chromatic packages) (Color figure online)

The colors were then assigned to the packages according to their content's level of hazardousness and package's familiarity as defined in the previous study. Thus, warm colors were assigned to packages with hazardous contents (red for familiar and yellow for unfamiliar packages) and cool colors for non-hazardous contents (blue for familiar and green for unfamiliar packages).

### 2.3 Sample

A total of 40 undergraduate design students (M = 20.73 years, SD = 2.05) participated in this study. Twenty participants, equally distributed by gender, were randomly assigned to each condition (Condition 1: M = 20.45 years, SD = 1.72, Condition 2: M = 21.0 years, SD = 2.32). All participants had normal sight (or used corrective lenses) and had no color vision deficiencies.

### 2.4 Experimental Settings and Virtual Environment

The experiment was conducted at the IADE-UX.Lab, in a dark room. The same experimental settings and VE were used for both conditions. It included a video projector (to display the VE), a computer workstation and a mouse (to navigate in the VE). Participants were seated at a table, in front of the projected image. The image's size was 1.72 m (horizontal) by 0.95 m (vertical), with an aspect ratio of 16:9. The observation distance between the screen and the participant was 1.50 m, resulting in a 35.2° of vertical field-of-view (FOV) and 59.7° horizontal FOV.

The VE was a closed room, measuring 6.6 m by 6.6 m, containing a table (260 cm in length, 30 cm in width and 90 cm in height) positioned in the middle of the room. The packages were placed on top of the table, evenly spaced from each other (i.e., 20 cm). In order to identify the packages easily, each one was associated to a letter from A to H.

### 2.5 Procedure

Upon arrival, each participant received a brief explanation about the study. An informed consent form was signed before starting the experiment. Participants were subjected to a color vision test [32] only for Condition 2. Participants were then seated and presented to the equipment. After that they performed a training session in which they explored a VE which was created specifically to get them familiarized with the environment and the equipment. Once they were able to accomplish the task and declared to be ready to perform the test, they were presented with a cover story and a task as follows:

*Cover Story*. Imagine that your friend is moving to a new house and he/she asks you to help unpack and to organize a group of liquid household products' packages according to their level of hazard (e.g., how poisonous can the content be when drunk, how toxic can it be when inhaled, or how irritant/harmful can it be if it comes into contact with skin).

*Task.* Observe the packages and reply to the questions.

They were asked to observe the packages and to fill a questionnaire regarding their hazard-related perceptions. The same questionnaire [14], which was adapted from Wogalter and colleagues [11, 33], was used to evaluate the perceptions. A 9-point Likert type scale was used, from 0 to 8, where 0 indicated the minimum and 8 indicates the maximum. The 12 questions were organized according to three categories: hazard perception (consisting of 8 questions which rate the of the content's level of hazardousness; the hazardousness of the package's shape; whether the package is hazardous to children; the content's flammability; the level of hazardousness if drunk; the level of hazardousness if inhaled, the level of hazardousness if contacted with skin; and the content's hazardousness in closed spaces), awareness of consequences (consisting of 3 questions which rate the cautious intent; likelihood of injury; and severity of injury related with the packages) and familiarity (which consisted of 1 question to rate the participants' familiarity with the packages). Only in for Condition 2 did the participants complete a follow-up questionnaire which intended to assess how they connoted the different colors regarding the level of hazard.

# 3 Result

## 3.1 Familiarity

Regarding familiarity (i.e., control variable), the participants' ratings (see Fig. 2) confirmed the previous classification of the packages as familiar and unfamiliar.

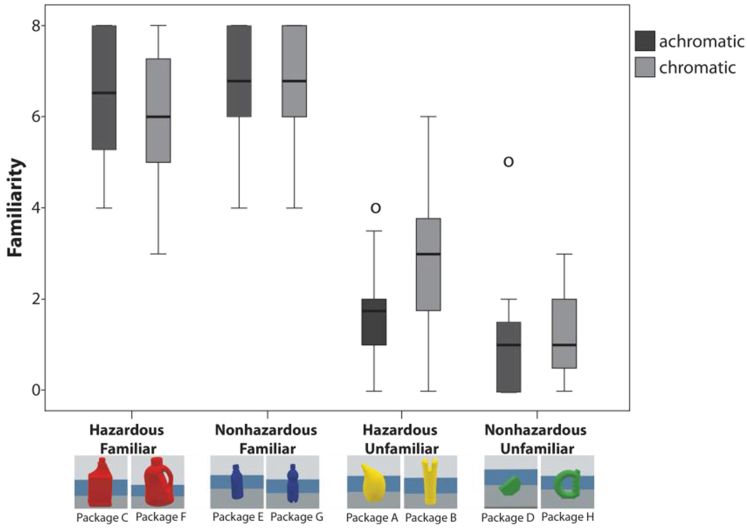


**Fig. 2.** Box-plots of familiarity scores by package

### 3.2 Hazard-Related Perceptions

The statistical analysis was performed with the software IBM SPSS Statistics, version 22, and a significance level of 5 % was considered.

The type of package (four levels: HF, NHF, HUF, and NHUF), the experimental conditions' (two levels: achromatic and chromatic) effects and their interaction on hazard perception and awareness of consequences were analyzed using two-way mixed-design ANOVAs, with the type of package as the within-subjects factor and the experimental condition as the between–subjects factor. Regarding the mixed ANOVA assumptions, no significant deviations from normality, homogeneity of variance and sphericity were found.

**Hazard Perception.** The interaction between the type of package and the experimental condition ($F(3,114) = 8.899$, $p < .001$; partial $\eta^2 = .190$, medium effect), and type package ($F(3,114) = 29.758$, $p < .001$; partial $\eta^2 = .439$, high effect) have significant effects on the hazard perception's mean scores. The mean (*SD*) of the hazard perception scores are shown in Fig. 3.

The effect of the experimental condition was not the same for all types of packages: in HF packages, color enhances the hazard perception scores (achromatic: $M = 3.87$, $SD = 1.15$; chromatic: $M = 5.07$, $SD = 1.09$) whereas in the NHF, there is a decrease (achromatic: $M = 2.73$, $SD = 1.56$; chromatic: $M = 1.01$, $SD = 0.99$); in the HUF (achromatic: $M = 3.39$, $SD = 1.46$; chromatic: $M = 3.37$, $SD = 1.20$) and NHUF (achromatic: $M = 3.78$, $SD = 1.54$; chromatic: $M = 3.68$, $SD = 1.44$) packages there is no color effect.

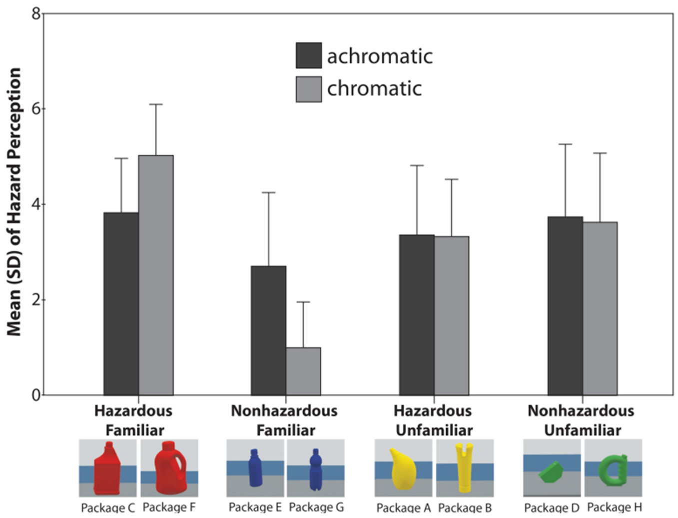


**Fig. 3.** Bar charts representing the mean (SD) of Hazard Perception scores by type of package for the two conditions.

**Awareness of Consequence.** The interaction between the type of package and experimental condition ($F(3,114) = 4.065$, $p = .009$; partial $\eta^2 = .097$, low effect) have significant effects on the awareness of consequences mean scores. The mean (*SD*) of the hazard perception scores are shown in Fig. 4.

The effect of the experimental conditional was not the same for all types of packages: the effect of color in NHF (achromatic: $M = 2.43$, $SD = 1.34$; chromatic: $M = 0.73$, $SD = 0.81$), HUF (achromatic: $M = 3.06$, $SD = 1.73$; chromatic: $M = 2.08$, $SD = 1.25$) and NHUF (achromatic: $M = 4.65$, $SD = 1.80$; chromatic: $M = 3.25$, $SD = 1.58$) packages decreases the awareness of consequence mean of scores; and in the HF packages (achromatic: $M = 3.88$, $SD = 1.34$; chromatic: $M = 4.09$, $SD = 1.25$) there is no color effect.

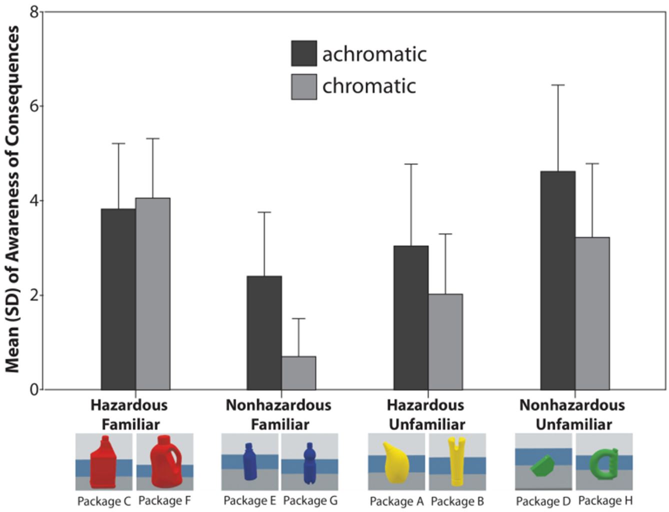


**Fig. 4.** Bar charts representing the mean (SD) of Awareness of Consequences scores by type of package for the two conditions.

### 3.3 Connoted Level of Hazard by Color

A follow-up questionnaire was given to the 20 participants on Condition 2 in order to assess how they ranked the four colors regarding the connoted level of hazard, from the least hazardous (rank of 1) to the most hazardous (rank of 4). The results showed that red attained the highest level of hazard perceived followed by yellow, blue and green (see in Fig. 5).

The Page's trend test [34] was used to evaluate the ranking of these colors with respect to the connoted level of hazard. The existence of a previous ordinal position of the colors' effects (more precisely, from the least to the most hazardous: green, blue, yellow and red), available on the literature [35–37] supported the option of performing an ordered test of alternative hypothesis using a within-subjects design.

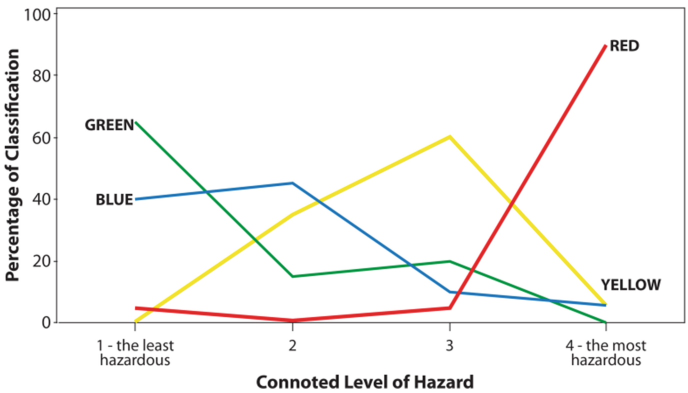


**Fig. 5.** Percentage of classification ranking of connoted level of hazard for each color (Color figure online)

The results of Page's trend test revealed a significant monotonic trend ($L$ = 569, $z$ = 26.724, $p$ < .001), where green was connoted with the least hazardous color (mean rank = 1.60), followed by blue (mean rank = 1.88), yellow (mean rank = 2.73), and then red (mean rank = 3.80), which was classified as the most hazardous color. Post hoc testing showed that: (i) green, blue and yellow have significantly lower connoted level of hazard than red ($ps$ < .001 for all comparisons); (ii) green ($p$ = .003) and blue ($p$ = .015) have significantly lower connoted level of hazard than yellow; and (iii) green does not have a significantly lower connoted level of hazard when compared with blue ($p$ = 1.0).

## 4 Discussion

This research examined the impact of packages' color on hazard-related perceptions (i.e., level hazardousness, and awareness of consequences), by addressing the question 'Does color affects hazard perception?' Participants rated eight 3D household packages, which differed in content hazardousness and familiarity, in two conditions (i.e., achromatic and chromatic), using a simulator-based methodology. After the simulation, participants ranked the four colors provided, on connoted hazard. Regarding the latter, as expected, red had a higher hazard connotation than yellow, followed by blue and green, thereby supporting the majority of the results in the findings in the literature [18, 19].

It was hypothesized that chromatic packages, which connote higher levels of hazard (red and yellow), would increase hazard-related perceptions when compared to the achromatic (grayscale) counterparts, and the opposite for those colors (blue and green) which connote lower hazard levels. Also, it was hypothesized that the color effect would be greater for unfamiliar packages than for familiar ones. However, neither of these hypotheses was fully confirmed by the data.

The results showed that color does affect hazard-related perceptions (i.e., hazard perception and awareness of consequences). However, the effect is not significant for all type of packages and do not always follow the same direction. The results from the hazard perception assessment show that for familiar-hazardous packages the color (red) increases hazard perception and the opposite for the familiar-non-hazardous (blue). For the unfamiliar hazardous (yellow) and non-hazardous (green) packages, the color did not significantly affect hazard perception.

Regarding the level of awareness of the consequences, unlike the verified results on hazard perception for familiar-hazardous packages, red did not significantly increase this perception. For the familiar-non-hazardous (blue), unfamiliar hazardous (yellow) and unfamiliar non-hazardous (green) packages, the color decreased this perception. With regard to the results found for the yellow packages (unfamiliar), the interpretation is not clear and one explanation could be that participants associated the color with edible substances (e.g., juice). Further data would be necessary to clarify this finding.

The second hypothesis, that the color effect would be greater for unfamiliar packages than for familiar ones, was not supported.

This study has some limitations; one is the sample that is constituted only by students, which compromises the generalization of the results to a larger population. Another limitation is the number of experimental conditions. In this study, the warm colors were assigned to packages with hazardous contents (red for familiar and yellow for unfamiliar packages) and cool colors for nonhazardous contents (blue for familiar and green for unfamiliar packages). Other conjugations should be carried out in the future.

Despite the above limitations, the findings highlight the importance of color in hazard-related perceptions and raise several aspects that warrant further attention. For example, what happens with multicolored packages? How color and shape interaction, account for hazard-related perceptions is also unclear.

This study is the second phase of a larger research project which aims to explore how signifiers (i.e., package features) and hazard-related perceptions interact, and as well as to what extent they influence users to adopt safer behaviors. The project's first step was concerned with the effect of the packages' shape in which it was also suggested that Virtual Reality (VR) is adequate to be used as a tool for this type of study; while this second step was concerned with the effect of color in VR. Further research, with a larger sample, will be carried out in order to examine the effects of colors in diverse conditions and different package features (e.g., texture and material), as well as to determine the effect of other features on hazard-related perceptions. Consequently, since VR was successfully used to assess user's perceptions about packages' level of hazardousness, in future work, different contextual Virtual Environments will be used to understand the effect of diverse environments, as well as package features.

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