

Usability of Portable Fire Extinguisher: Perspectives of Ergonomics and Intuitive Use

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Abstract. The present study aims to explore the usage of portable fire extinguisher's usability from the interaction with non-specialists in emergency context. Has been noticed an absence of Brazil's proper education regarding procedures for fires, evidencing the need for portable fire extinguishers to induce intuitive usage and to improve the usability by users. Were also explored ergonomic factors, such as effort to complete the task and user's perception of discomfort. In order to simulate the emergency context, a usability test was applied with addition stress stimuli. The study allows to conclude that the portable fire extinguisher evaluated present a low level of intuitive use induction, revealing the need to state better standards from Brazilian authorities towards the label and handles of this product. This paper presents the importance of evaluating ergonomic and intuitive factors related to products required on emergency contexts. This study conducted in Brazil is the starting point for other research that explore the theme and aim to improve these devices, assisting designers to take into account aspects of intuitive use and ergonomic principles during the configuration of industrial products.

Keywords: Fire Extinguisher, Usability, Safety.

1 Introduction

Given the absence of Brazil's proper education regarding procedures for fires and emergencies, having a fire extinguisher that allows correct and intuitive use becomes paramount. When fires occur, Brazilians tend to act on impulse in the use of fire extinguishers. As an outcome of this situation, the likelihood of misinterpretation of pictorial-verbal codes and misuse of fire extinguishers can be high. Within this context, the research question raised: is portable fire extinguishers' usability appropriated and allows intuitive use for Brazilian non-specialists in emergency settings?

This research's goal was to develop an exploratory study to test the usability of fire extinguisher in subjects without previous experience of using this product. The research involved usability tests, composed under the following approaches: investigation of intuitive use provided by fire extinguishers to non-expert users; required physical effort in usage tasks; and discomfort's perception. This research also enabled to develop another study, the learnability of fire extinguisher provided by

instructional video, that will be presented on a further paper. In order to enable both studies from the same research the test was composed by two rounds: the first, without any kind of instruction besides the fire extinguisher's label; and second, with the instructional video presentation.

The basic method applied on the study was the usability test, composed by different metrics in order to allow the different evaluation perspectives, such as: pre and post use questionnaire; success ratings to each task; time rating to each task; efficiency (with amount of physical and cognitive effort to finish the task); think aloud sessions; effort's subjective perception with modified Borg scale; and Corlett diagram. The test was applied with five volunteers, all male, without previous usage of the fire extinguisher, with different professions and educational levels.

As research's conclusions, is possible to infer the analyzed products present a low level of intuitive use induction regarding the proper extinguisher selection, the product's transportation and the positioning towards the flames. Was noticed a positive difference between the trials with and without instructions, however, it's necessary to perform deeper studies on that matter to establish significant quantitative results. So it is aimed to present in future study the learning aspects, through the comparison of both test rounds, in order to demonstrate the significant variation regards on learnability and usability evaluation in fire extinguishers, reiterating the absence of instruction in the first trial and with instruction in the second test.

2 Emergency Context and the Brazilian Fire Extinguisher

Due to its territorial location (among other factors), Brazil it's not a frequent target to natural disasters, such as earthquakes, blizzards and tornados, allowing the citizens to have low concerns on that matter, resulting on low culture of prevention and security plan to such phenomenon. However, emergency context may arise from human action, like fires, in which the population must prevent and be aware. Differently from some countries, Brazilian schools do not provide fire training, as well as many companies on private and public initiative. As an example of the need to insert the prevention culture on Brazilian people, the national government is creating a cooperation project between Brazil and Japan, a country with professional with high expertise on natural disasters. Burning is among the most serious injuries; besides physical trauma that may lead to death, it also can cause other problems of psychological and social orders. As it's pointed by Rossi et. al. [1], statistic data on many aspects on burning cases in Brazil are sparse for various reasons.

As stated by Tullis & Albert [2] "usability can sometimes mean the difference between life and death". The authors exemplify that statement through a fatal accident involving a high-occupancy vehicle (HOV) and poorly designed signing. On emergency situations, such as fires, people tend to rely on product's intuitive use, due to hurry and low concentration on the task, increasing the importance of good usability. Essential products to the emergency situation's solution have a greater need to provide intuitive use and good usability, such as fire extinguishers. Those products are meant to be used by any kind of person that's in an emergency situation, requiring use of universal design principles on the project and development of efficient strategies to communicate to the user important information, such as: type of fire extinguishers

content; appropriate material that can be in touch with the fire extinguishers content; and general procedures of use. That approach is sustained by Moura & Banzato [3] that classifies packaging functions on four purposes: containing, protecting, communicating and utility. Klohn & Pereira [4] developed a research on pictograms on packages of dangerous products, stressing the need of good usability on products related to emergency or danger situations.

In order to collect information about Brazilian fire extinguishers requirements, it was performed a research on normalized Brazilian standards, allowing to identify few indications on communicational aspects on these products. Neither both of the main standards on the field "ABNT NBR 12693 – Protection systems by fire extinguisher" [5] and "ABNT NBR 15808 – Portable Fire Extinguishers" [6] doesn't approach proper pictorial procedural sequences (PPSs). These standards refer to capacities and contents, which, though necessary approaches, are incomplete through the holistic perspectives of those products. The national standards leave room to diversity of graphic representations and code labels among manufacturers. The label's standardization brings several benefits to the user, such as content's correct identification, types of fire where it should be used and instructions of the correct procedures of use.

Naumann et. al. [7] and Hurtienne [8] discuss the increasing need of intuitive use on product design. Blackler et. al. [9] defines intuition as a type of cognitive processing that applies previous knowledge in an unconscious level on most of times [10]. Hurtienne defines intuitive use as: "the extent to which a product can be used by subconsciously applying prior knowledge, resulting in an effective and satisfying interaction using a minimum of cognitive resources" [8, p.29]. That definition is congruent to the usability definition by ISO 9241-11 [11], so if a product allows intuitive use by lay users, it can be inferred that the same product has good usability. On this sense, monitoring the intuitive use is a form to investigate the product's usability. As showed by Krippendorff [12], in products that are strictly related to utility, other user experience factors, such as emotions and pleasure of use, are placed on second plane. Fire extinguishers are an example of products that the most important factor is utility.

The ways to identify and evaluate intuitive use are still solidifying on User Experience field. However, Blackler et. al. formulate "intuitive use heuristics", in order to guide professionals to identify characteristics of intuitive use. The proposed heuristics are evidence of conscious reasoning, expectation, subjective certainty of correctness, latency, relevant past experience, and correctness of use. The authors state that the lowest the user's previous experience with the product or similar, the better intuitive use will be identified. On the experiments performed by the authors, the most important metrics used are time to complete task related to familiarity or expertise, and mistakes made during the performance.

Given the stated, intuitive use, usability and measurement of user experience during the activity of extinguishing fire, are the basic factors to be considered in studies to evaluate the usage of a portable fire extinguisher, providing improvement in product design. In this sense, from this research and the simulated tests in Brazil, it is considered that ergonomic principles applied to fire extinguishers can improve task "extinguish fire" by users and facilitate the use of the product in the context of emergency.

3 Methods

Since the research on portable fire extinguishers used in emergency is still on its beginning, this experiment did not have the intent to perform statistical comparisons, but to provide an exploratory view on the theme, investigating and detecting aspects that should be more extensive in future researches. The research demanded observation of usage by non-expert users. For that, researchers chose developing a controlled fire situation. To perform a test with an actual fire on constructed environment, such as a house, many juridical complications emerged. Given the timing to develop the research and low budget available, the researchers simulated the emergency context in the University installations. At the pilot test, the fire started in a metal barrel, outdoors, but there were complaints about the smoke emitted. Therefore, the actual tests had the fire in a barbecue grill, enabling the smoke's direction and allowing fire control.

Were added several stress stimuli to the user (e.g. smoke, restricted time and visual stimuli for the context of fire), in order to cause specific physiological factors, such as the release of adrenaline in the body, increasing heart rate and body temperature. The odor presence and visual obstruction caused by smoke from burning materials are some other aggravating factors to the task execution. The procedures of usability testing with users were not invasive, so ethical aspects were assist with the implementation of the Consent Form Free and Clarification [13].

Were applied additional tasks with the goal to stimulate mental and physical users' aspects. Mental aspects: (1) displayed video containing fire scenes and people with burns and injuries. (2) The user was asked to perform a logic game with restricted timing. Physical aspects: (3) after the game task, the user ran a circuit to the local where the fire extinguishers were placed. (4) Another running, carrying the extinguisher, to the location of the fire, followed by the procedure of fire's extinguishment.

The experiment was performed on two trials with five users for each, all with timing. The users on the first and second trials were the same. At first, users proceed without instructions. In the second trial, oral information and a fire department's instructional video were present, teaching how to proper handle a fire extinguisher. Both trials were monitored by the researchers and video recorded. The selected users were all male without previous experience in fires, with different education levels. All users were volunteers and were willing to perform tasks that required running and lifting of weight, which added difficulties to user recruiting. Since the research was part of the Federal University of Paraná (UFPR) activities, many UFPR employees were invite to participate the experiment, but only male employees attended, justifying the users' gender of the experiment.

After each trial, users answered a semi-open structured interview. The questions addressed intuitive use, physical effort, perceived discomfort during equipment use, and learnability. Since the perspective of intuitive use address to investigate how inexperienced users proceed the tasks without any kind of instructions, the evaluation of intuitive use applied only on the first trial. The perspectives of physical effort and perceived discomforts during equipment use evaluated both trials, and the issues addressed to learnability emerged from the comparison between both trials' results. However, the results discussed on this paper present the evaluation of the intuitive use and perception of effort and discomfort on the delimited task. The evaluation of users learning ability on the same task is approached on a specific study on that matter, thorough cognitive inspection, presented in detail in a future study.

The contents of fire extinguishers used on the tests were: water (type A), indicated for extinguishing fires produced from wood, paper, rubber and fabric; and dry chemical (type BC), proper to extinguish fires from inflammable liquids and electrical equipment. Still there are also fires classified as Type D, ignited from metals and type K, ignited from kitchen oil. The choice of fire extinguishers was related to its availability. In the experiment, users were requested to distinguish and choose the correct extinguisher to extinguish the fire caused from electrical equipment, so the correct fire extinguisher was the Dry Chemical.

4 Results

Relating to the main task, “extinguish fire”, on the first trial, all the users were able to conclude the task, but four of the five users had some kind of difficulty to complete the task, performing multiple triggering (Figure 1). Three users had a wrong distance towards the flame, and only one user had a correct posture towards the fire (Figure X).

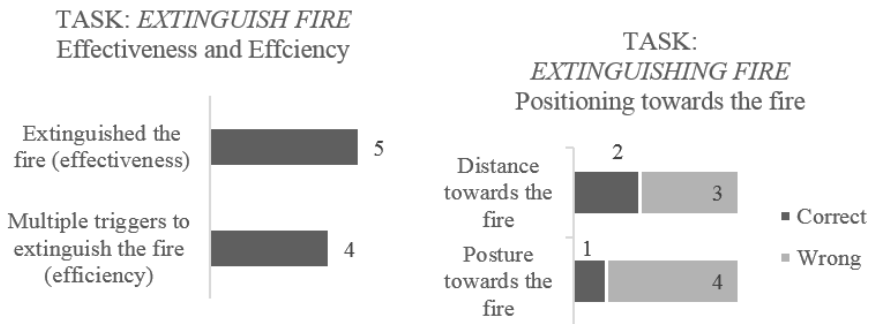


Fig. 1. Graphics regarded to the main task "Extinguishing fire"

Were evaluated the following main sub-tasks, towards the “Intuitive User” perspective on the first trial: portable fire extinguisher transporting, seal breaking, valve triggering and label checking. Four of the five users presented difficulties on removing and carrying the product to the fire’s placement, the same number repeated on the valve triggering, in which four users triggered the valve several times, instead only one, as appropriate. All users showed difficulties on breaking the seal, performing that sub-task only when facing the flames, instead breaking the seal at the product’s removal from original placement. Four users checked the label before the product’s removal (Figure 2).

The seconds taken to choose between both fire extinguishers varied from five (5) to twenty three (23) seconds, only by the four users who checked the label before the choice. The users did not perform “think aloud”, even when asked to do so. At the post-session interview, when asked about the difficulties on use, only one user stated to have some trouble, as all the others said to have no difficulties to perform portable fire extinguishers use.

SUB-TASK:
TRANSPORT
Difficulties on removing and carrying the portable fire extinguisher



■ No difficulty
■ Some difficulty

SUB-TASK:
BREAK THE SEAL
Difficulties on breaking the seal



■ No difficulty
■ Some difficulty

SUB-TASK:
VALVE TRIGGERING



■ Correct ■ Wrong

SUB-TASK:
LABEL CHECKING
Checked the product's label before the selection



■ Checked
■ Did not checked

Fig. 2. Graphics regarded to the sub tasks

To measure subjective perception of discomfort was applied a questionnaire to users post-use scenario. In this survey the users identified in Diagram Corlett and Manenica [14], the perception of some kind of pain or discomfort in body parts as the Figure 3.

A protocol, illustrated by Figure 4, was also applied post-usage scenario for evaluation of subjective perception of painful areas in the upper limbs, which is commonly used for evaluation of hand tools [15]. This checklist identify any pain or discomfort in the upper right and left upper limbs.

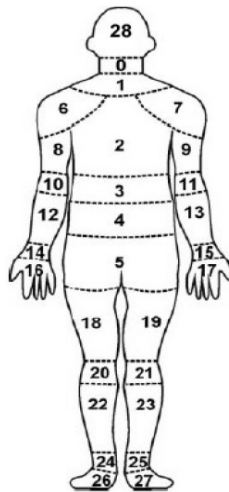


Fig. 3. Diagram of Subjective Perception of Pain or Discomfort (Source: Corlett and Manenica, 1980)

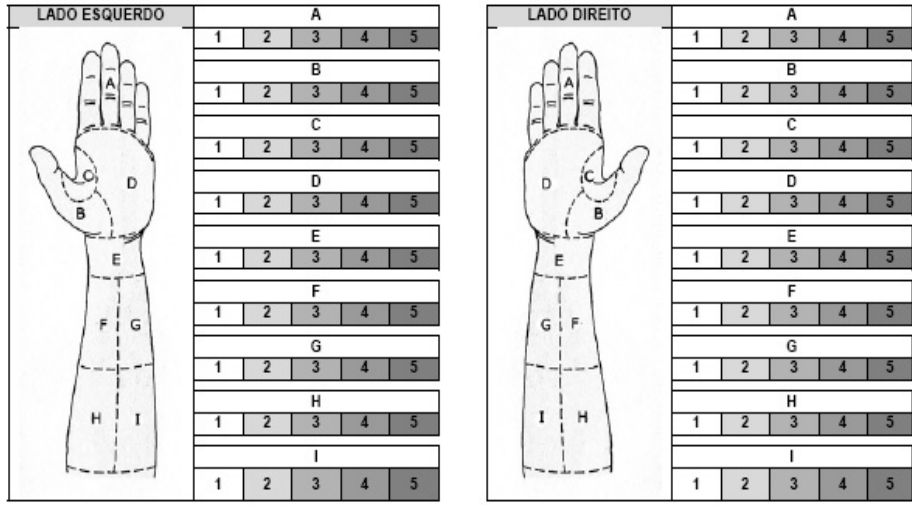


Fig. 4. Diagram of the subjective perception of pain or discomfort in the upper body (Source: Kadeffors et al, 1993)

The results of the perception of pain or discomfort in the body regions demonstrate that the majority do not exhibit levels of discomfort. However, compared with the sample of five individuals, two responded that they felt some discomfort in the palmar region and during the task of carrying the extinguisher, but a moderate discomfort. At the end of the test was also applied to the Borg Scale, which is a common method used to measure the degree of effort an individual, during the performance of some activity. It is a subjective checklist, easy, but with a significant degree of efficiency compared their results with changes in heart rate. This is the estimate of the intensity of effort reported by the individual [16]. In Borg Scale, the individual assigns a score for intensity of discomfort, the scale goes from 0 (none) to 10 (maximum).

As results of perception of effort during the first round of testing, four users have given a mark of 0 on the scale, ie, no level of effort. And only one user reported having a degree of effort extremely lightweight.



Fig. 5. Examples of users during the task "Extinguish Fire"

5 Discussion

Since the users did not have prior experience with the researched product or similar, the intuitive use was perceived through the main task efficiency and the specialist observations of difficulties imposed by the product to lay users.

From the first trial, it was observed that all users were able to complete the task “extinguish fire”, but most users triggered the extinguisher many times, an action not indicated by specialists. It is possible to perceive that non-expert users do not position themselves correctly towards the fire, positioning too closely and with arched posture. The positioning can be prejudicial if the flames are too high, which was not the experiment’s case because the flame was controlled. It was also noticed that most users did not carry the portable fire extinguisher in a proper manner; the product must be carried on a vertical positioning with only one hand at the body’s side, and users tend to transport the product horizontally, with both hands. That observation may be related to the product’s weight. The “seal breaking” sub-task was performed wrongly by all users, indicating a review of that attribute on the portable fire extinguisher. Most of the users checked the product’s label before the choice for, at least, five seconds, evidencing the importance of a clear and self-explicative label to provide a proper product selection. The results on discomfort’s perception in the hands and upper body members pointed there is a higher incidence of pains on the palm region and difficulty on breaking the extinguisher’s seal. There is also occurrence of user’s difficulty on pushing the valve trigger quickly.

With respect to the perception of discomfort, there was a significant report by users in relation to the palmar region during the task and the manipulation of the seal. There were no significant perceptions of effort by users, unless two people diagnosed with a light degree of effort performing the task.

Has been stated that the learnability analysis will be further presented on a specific study, however, it’s been considered important to already present some results found, in a synthetic way. It was observed a strong performance difference between the tests with and without instructions. Without use indications, users did not read the labels to search the proper proceedings, performing the tasks intuitively, and, sometimes, wrongly. On the proper extinguisher’s selection, was observed the need of better strategies to distinguish extinguisher’s types, since the choice process is fast and lack of attention. The instructional video efficacy was evidenced by the change of user’s behavior between the two test rounds. The tasks “transporting the extinguisher” and “positioning towards the fire” were performed correctly after the video presentation.

6 Conclusions

The research had the goal to explore many perspectives addressed to portable fire extinguisher use. Since this product is required on emergency context, the study had to simulate different variables to allow the user to feel in a stressed context, approaching the actual context of product’s use. The researchers faced several difficulties to simulate the emergency context, such as proper environment to execute experiments

with fire, recruiting volunteers willing to participate stressful and physical activities, and collect solid background references to base the study.

From the experiment, is possible to identify that most users, although reached effectiveness, presented some kind of difficulty to perform the task without instruction. The main difficulties involved the positioning towards the flame, the seal breaking moment and the seal breaking itself, the product's transporting and the valve triggering. That indicates gaps to be studied more extensively, maybe through the label improvement or better product's shape design.

This study also show us that is required a deeper research to verify if only the label adjustment is enough for the user to perform proper use, or if it's necessary to be made larger changes in the product's design. We suggest for future works researches on developing a Brazilian technical standard for portable fire extinguishers' labels, and further study about the ergonomic aspects that influence activity with manual trigger, taking into account the ergonomics of the palm region and the upper body.

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