Inputs to optimize risk communication: testing preferences in icons for emergencies

Contribuições para aperfeiçoar a comunicação de riscos: teste de preferências em ícones para emergências

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Disaster Risk Management (DRM) introduces a paradigm change from mitigating impacts to preparedness. Communication becomes fundamental for a safe experience. Designing information has a decisive role in optimizing the experience. Following their principles, messages can be optimized for emergencies. Everyday information tools appear to be less effective during and after an emergency. Icons constitute a paradigm of visual communication, however, usually these are not evidenced in their performance. This paper presents the testing process of an open-access icon set for emergencies, specifically the preferences test. 283 responses evidence how participants associate representations with given concepts. Communication based on icons contributes to establishing preferences, constituting a support for the communication of risk. Integrating communication to DRM contributes to an effective articulation of risks. Results are discussed as three insights: (1) Familiarity, (2) Performance, (3) Knowledge for reducing risks. Information design contributes to facilitating such a process.

A Gestão de Riscos e Desastres (GRD) introduz uma mudança de paradigma da mitigação dos impactos para a preparação. A comunicação se torna fundamental para uma experiência segura. O design da informação tem um papel decisivo no aperfeiçoamento da experiência. Seguindo seus princípios, as mensagens podem ser aprimoradas para emergências. As ferramentas de informação cotidianas parecem ser menos eficazes durante e após uma emergência. Os ícones constituem um paradigma da comunicação visual, porém, geralmente eles não são evidenciados em seu desempenho. Este artigo apresenta o processo de teste de um conjunto de ícones de acesso aberto para emergências, especificamente o teste de preferências. 283 respostas evidenciam como os participantes associam representações a determinados conceitos. A comunicação baseada em ícones contribui para o estabelecimento de preferências, constituindo um suporte para a comunicação do risco. Integrar a comunicação ao GRD contribui para uma articulação eficaz dos riscos. Os resultados são discutidos como três insights: (1) Familiaridade, (2) Desempenho, (3) Conhecimento para reduzir riscos. O design da informação contribui para facilitar esse processo.
1 Introduction

An emergency can be considered a complex scenario with large demands for information. In the context of large-scale disasters, international organizations such as the United Nations Office for Disaster Risk Reduction (UNDRR, 2015, 2023) state that in a disruptive human experience, a situation can turn into a disaster when the impact surpasses the reactive capacity of individuals or communities. Principles such as Disaster Risk Reduction (DRR) and Disaster Risk Management (DRM) promote a multi-dimensional approach (Twigg, 2015; UNDRR, 2023), defining a cycle with stages – before, during, and after an event. DRM introduces a paradigm shift, from mitigating disaster impacts to articulating anticipatory experiences, a change where communication becomes fundamental.

This paper introduces Disaster Risk Management and information design principles, presents a case study on the design and testing of a set of symbols for emergencies, and discusses their reach so far. Tests consist of asking participants to choose preferences from concepts. Results present findings and insights to discuss approaches for communication, moving from mitigating disaster impacts to transforming the emergency experience through information.

2 Risks: from reaction to management

Organizations such as the World Economic Forum (WEF, 2022) state that risk management has emerged as one of the largest challenges for development. The United Nations Office for Disaster Risk Reduction, UNDRR (2015, 2023), promotes DRM as “the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.” This is an evolution from an emphasis on reaction, mitigation, and relief, towards a reduction of disaster impacts, managing hazards, and preparedness. As Table 1 resumes, communication constitutes a fundamental instance for DRM definitions; critical definitions are presented.

Instruments such as the Sendai Framework (UNDRR, 2015) prioritize the organization and management of resources and responsibilities addressing particularly “preparedness, response and initial recovery steps.” Additionally, it provides definitions such as the need for communication and presents definitions. DRM resources can facilitate the identification of risks and contribute to learning how to deal with hazards, an opportunity to develop visible, understandable, and usable information.
As Doyle et al. (2022) state, developing a shared understanding of the causes and effects of risk has been claimed as “crucial for individuals to collaboratively manage disaster consequences.” As Bui and Sebastian (2011) suggest, information constitutes a structural support to facilitate interactions in critical contexts such as an emergency. However, as Jaenichen (2011, 2019) states, processing information can be altered in critical conditions. In parallel, an effective understanding of risk in everyday life is an ongoing challenge, and observing contextual variables may require specific considerations (UNDRR, 2015, 2023).

As stated by Twigg (2015) and Robinson (2017), tools for effective communication and advances in information technologies appear to be efficient and have dramatically improved scientific risk information. However, the same tools usually appear to be less effective during a critical scenario. Twigg (2015) suggests that communication for Disaster Risk Reduction (DRR) “should aim to shift the balance of power towards communities by enabling people to investigate, define and explain their own problems.” Robinson (2017) states “People face different risks, access information differently and take action on different issues.” She suggests the importance of social interactions arguing that effective communication is “critical for people to understand the different types of risk they face, discuss what can be done and take action to manage those risks.”

Observations from Aitsi-Selmi et al. (2016) analyzing the role of science in Disaster Risk Management (DRM), pose challenging ideas for the communication of emergencies:
- Once an event has started, human responses become mainly instinctive (i.e., run away), not rational, as communication models suggest.
- Large events such as earthquakes might be focused on preparedness, hazard identification, and mitigation actions.
- Learning is a primary and fundamental action for preparedness. This can be optimized by integrating instructional information (i.e., procedures, do’s, don’ts).
- Interaction may involve sharing knowledge; this is an opportunity to foster participatory practice and settle common approaches.

Information embraces a key role in conducting the experience of risk and emergency, for example presenting appropriate messages to identify hazards or integrate preparedness. Figure 1 presents a conceptual diagram as a sequence (before, during, and after an event), connecting the experience with information.

**Figure 1** A synthesis of risk and emergency: Experience + DRM + Actions. Source: Author.
of disaster risk, including hazards, exposure, or vulnerability is a focus of risk management. Such focus may consider the identification of contents, typologies, moments, and originators of information, making visible, for example, who (i.e., originator), what (i.e., actions – options), or how (i.e., procedures). Communication is an articulator to manage the experience, facilitating, for example preparing, preventing, and transferring messages into actions. For effective communication, it is necessary also to integrate context (where) and the nature of users (who), presenting “meaningful information that leads into specific action” (Robinson, 2017); which is discussed in the next section.

4 Designing information

As mentioned, visual information is a central part of everyday experiences and can facilitate interactions in critical scenarios. Information design, a multidisciplinary field, has been defined as a practice focused on preparing content that is visible, understandable, and usable for people, combining both art and science (Horn, 1999). According to Frascara (2011, 2015), information design draws on visual outcomes such as legible typography, meaningful symbols, normalized images and sequential instructions, among other supports, aimed at being a natural way to visualize requirements and allow them to be understood and interacted with. It consists of applied tools that can be systematically managed in multiple and even simultaneous supports and contexts in everyday life. Applying information design as a step-based method might contribute to articulating needs, optimizing communication, and measuring the performance of messages using multiple instruments such as perceptual or cognitive instruments. For the International Institute for Information Design (IIID), one core competency is “[…] testing of use and usability, evaluate the test results and refine the information accordingly.” (iX Group, 2007). Graphic elements such as symbols and typography appear as ubiquitous solutions that deliver visible and legible information, and in critical contexts, such resources might be a simple, effective approach to visualizing content.

Robinson (2017) poses critical questions addressing to reflect on the importance of developing communication tools for emergencies: How to develop visible and understandable information, facilitating seeing, understanding, and taking action. To communicate in emergencies it is fundamental to detect factors that optimize information for being visible, understandable, and able to be transferred into action. Therefore, managing the experience of an emergency is an opportunity to implement effective messages, by integrating information design principles. Specifically, visual tools can aid in the understanding of risk and hazardous scenarios, from identification, prevention and preparation (Before) to reaction (During) and active recovery (After) (Ramírez, 2022). The case study introduces icons as functional, measurable units of information.
5 Case study: icons for emergencies

Based on definitions from Abdullah and Hubner (2006), pictograms, symbols or icons constitute normalized images designed to condense a concrete meaning (i.e., a subject or action), functional tools that reduce linguistic barriers, usually conceptualized as a “universal” language.

Icons are components of the everyday processing of visual information, displaying messages to be conveyed via different media or information technologies (Easterby & Zwaga, 1984; Boersema & Adams, 2017). As graphic tools, constitute seemingly optimal instruments for conveying efficient messages and handling barriers in communication (i.e., accessibility, multi-modal displaying). As a visual system, icons share attributes in order to present messages in a consistent manner.

As different authors mention (Easterby & Zwaga, 1984; Dewar, 1999; Frascara, 2011; Boersema & Adams, 2017), different symbol systems have been developed for various contexts such as tourism (WTO), public spaces (AIGA) or work safety (ANSI), aimed at serving as functional communication tools. As Frascara (2015) states, an icon development project involves a cycle of interviews, meetings and tests, with a considerable amount of time spent on consultation and refinement of their visual design. The general public needs to recognize an evident meaning, ideally with no learning required.

Different icon sets are available under an open-access policy (i.e., Material Design). Also, being easily implementable in multiple platforms, icon sets are also available specifically for emergencies (i.e., UNOCHA), to represent context (i.e., tsunami hazard), messages (i.e., shelter available), or actions (i.e., evacuation), among others. In a comparison of different emergency symbols for vulnerable users, Frommberger and Waidynatha (2017) concluded that “visual language can decisively contribute to action.” Icons are normalized images that operate as codified messages that condense conventional meanings articulated in a familiar language, can be flexibly implemented on different supports, and are considered a lingua franca of the information age. However, usually driven by collaborative efforts, these sets are offered for open use with no evidence of their performance. Beyond the visual design statement, for critical applications (i.e., warnings) it is necessary to know what people see and what they interpret in a representation (Marom & Goldschmidt, 2011).

Guemil is an open-access icon set for emergencies. Conceptually, it aims to integrate the DRM phases before > during > after an event, constituting both a design and a research initiative (www.guemil.info). The design part integrates multiple representations such as risks, hazards or actions, combining analogical, anthropomorphous, or symbolic elements. In parallel, iterated icon versions were introduced (2018, v10, 2020, v15), the latter included COVID icons and improvements from previous processes (Ramírez, 2022). As shown in Figure 2, the current version includes 86 symbols.
6 Integrating performance indicators

Icons epitomize elementary principles of information design: graphic tools to be seen and understood, and to activate decisions. According to literature review (Brugger, 1999; Olygay, 2003; Frascara, 2011; Boersema & Adams, 2017; Brick & Freeman, 2021) and international practice (ANSI, 2011; ISO, 2018), evidence of icon performance is constructed by collecting qualitative data (open responses) to evaluate comprehension, usually through quantitative indicators (i.e., percentage of responses).

Representations generate interpretations, allowing a determination of whether they convey meaningful information. However, often icon systems do not evidence performance indicators. References to good practices such as the “Hablamos Juntos” project (2010, 2012) demonstrate how this evaluation process can create a more inclusive and effective implementation. Following such practice, performance is defined through choices and interpretations given by participants, as shown in the next sections.

6.1 Methodology: testing meaning and preferences

As mentioned, the case study process integrates both design and testing. Interpretations from icons become fundamental to research about the communication of emergencies. Tests explore how every representation is visualized and deciphered by individuals, making associations and using their own words.
Hypothesis: If symbols are designed for risks and emergencies, evaluating their interpretations and preferences will reveal if those are visualized and understood, contributing to the management of risks.

The testing method involves a validation experiment in three sequential steps: (1) Define tests; (2) Collect and categorize; and (3) Establish performance. Two different tests were developed: (1) Meaning and (2) Preferences, both implemented through interactive surveys, oriented to collect at least 200 anonymous responses per item. For both tests, bilingual forms were designed using Google Forms and Typeform to be completed by individual participants in 10 minutes. To ensure accessibility, printed tests were also available by demand. An onboarding dialog task provided information consent, instructions facilitated the characterization process and interaction with participants. Also, they were able to provide comments after responding. Figure 3 summarizes the methodology applied in both tests.

In this paper, the detail of the results are taken from the Preferences test (2). Visualizations of both tests are available on the project website; for further discussion on open-access icon systems and detailed responses considering the meaning test, see Ramírez (2018).

6.1.1 Meaning test

This test displays an isolated icon and the question: ‘What does this icon represent?’ asking participants to provide open responses. Each answer is matched with a list of possible denominations, categorizing the response.
according to a 6-grade scale. Such scale was based on the work of Brugger (1999), Olygay (2003), and Frascara (2011), considering an approval of 83%. Labeling was not incorporated as a variable. Table 2 presents the categorization scale.

In the Meaning test, results define a quantitative index per each icon, contributing to evidence performance. From left to right, Figure 4 illustrates a sequence of examples for icons considered optimal, to neutral or poor performance icons from their interpretations.

### Table 2  Meaning tests categorization.

<table>
<thead>
<tr>
<th>1 Correct</th>
<th>2 Almost correct</th>
<th>3 Doubtful</th>
<th>4 Incorrect</th>
<th>5 Opposite meaning</th>
<th>6 No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct understanding of the icon is certain</td>
<td>Correct understanding of the icon is likely</td>
<td>Correct understanding of the icon is marginally likely</td>
<td>The response is wrong to the intended meaning</td>
<td>Understanding is opposite as is intended</td>
<td>No answer or any answer is given</td>
</tr>
</tbody>
</table>

Based on the work of Brugger (1999), Olygay (2003), and Frascara (2011).

![Figure 4](Meaning tests performance (examples 2018–2022).)

#### 6.1.2 Preferences test

15 concepts were included in this test, oriented to collect associations related to a concept provided, depicting a particular element (i.e., icon) or integrating a whole composition (i.e., a sign). Here, the question was “Which of these icons does represent [...]?”, in order to identify which
representation participants can connect with a given concept, called a Preference. The purpose of this test was to explore particularities among concepts and representations that could share formal attributes or mark a difference. Therefore, unlike the previous test, the preferences test was not aimed at obtaining correct meanings nor a definitory index, but rather at identifying associations or relations, suggesting trends from the preferences marked. Also, sample icons from other systems are included as options (i.e., UNOCHA icons).

According to the categorization of usability testing by Chisnell and Rubin (2008), this test is considered an exploratory evaluation, where participants were asked to select from a series of representations to indicate which of them matched a defined concept or message. However, as the participant had to choose a representation from given alternatives, this test might be also considered a multiple-choice evaluation. Figure 5 introduces the concepts included.

<table>
<thead>
<tr>
<th>Emergency Exit</th>
<th>Assembly Point</th>
<th>Tsunami Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Emergency Exit Icon" /></td>
<td><img src="image" alt="Assembly Point Icon" /></td>
<td><img src="image" alt="Tsunami Alarm Icon" /></td>
</tr>
<tr>
<td>Evacuation Way</td>
<td>Tsunami Hazard</td>
<td>Shelter</td>
</tr>
<tr>
<td><img src="image" alt="Evacuation Way Icon" /></td>
<td><img src="image" alt="Tsunami Hazard Icon" /></td>
<td><img src="image" alt="Shelter Icon" /></td>
</tr>
<tr>
<td>Landslide</td>
<td>Charging</td>
<td>Vertical Evacuation Area</td>
</tr>
<tr>
<td><img src="image" alt="Landslide Icon" /></td>
<td><img src="image" alt="Charging Icon" /></td>
<td><img src="image" alt="Vertical Evacuation Area Icon" /></td>
</tr>
<tr>
<td>Volcanic Eruption</td>
<td>Safe Location</td>
<td>Connectivity</td>
</tr>
<tr>
<td><img src="image" alt="Volcanic Eruption Icon" /></td>
<td><img src="image" alt="Safe Location Icon" /></td>
<td><img src="image" alt="Connectivity Icon" /></td>
</tr>
<tr>
<td>Warning</td>
<td>Go to Shelter</td>
<td>Flooding</td>
</tr>
<tr>
<td><img src="image" alt="Warning Icon" /></td>
<td><img src="image" alt="Go to Shelter Icon" /></td>
<td><img src="image" alt="Flooding Icon" /></td>
</tr>
</tbody>
</table>

**Figure 5** Preferences testing | Concepts and icons.
Test participants were recruited by open callings (social networks, email) and during activities (workshops). 283 answers were then collected and processed for analysis ($N = 283$), distributed in Females ($n = 181$), Males ($n = 94$) and not responding ($n = 8$). Test participants were mostly in the undergraduate level of education ($n = 140$) and the largest age range group was 16–25 years ($n = 76$). Geographically, the main group came from Chile ($n = 242$), then Japan ($n = 17$) and Argentina ($n = 9$). Few came from Colombia, Cuba, Peru, Spain, and New Zealand, among others, accounting for eleven countries in total.

In the preferences test, the dimensions are open to discover more associations than specific interpretations and may constitute all ‘correct’ choices. Thus, choosing more than one option was allowed, and results may reflect more than one preference per concept (marked as [...] in results). Results are visualized in Figure 6.

7 Discussion and insights

In general terms, results from the preferences test reveal clear associations between a given concept and its graphic representation, for example in “Warning” (206 preferences in 283 responses). Other associated with common visual references or well-known icons tend to be most preferred, for example, “Tsunami hazard” (199 preferences). On the other hand, icon cases depicting less-known significant references, show clear preferences, for example in “Vertical Evacuation Area”, where one option doubles the other (182 vs 86 preferences).

On the other hand, no critical differences were observed across the characterization of participants and dimensions observed: the majority of concepts indicate clearly one option chosen. Following findings such as those from Brick and Freeman (2021), most preferred representations combined iconic representations with indications such as descriptive shapes, for example, “Landslide” (162 preferences), or color, for example, “Evacuation Way” (148 preferences). Nevertheless, results remark on the importance of context and familiarity in achieving accurate interpretations (i.e., representations of hazards such as “Landslide” or “Volcanic Eruption”). So far, visualizing the results challenge prevalent ideas pre-assigned to icons, such as “universal” language on the representation of emergencies, for example, familiarity with risks, iconic vs symbolic representation, and implementation.

Observations become important for identifying what is working, along with what might be misinterpreted, contributing to iterating the visual communication of emergencies. However, interpretation and preferences are just two dimensions in a complex experience for participants, and variables such as context, the complexity of emergencies and local practices may affect associations, for example in “Safe location” (160 preferences). Another focus is the frequency of combined or non-given responses marked as [...], which appears distributed along the concepts.
<table>
<thead>
<tr>
<th>Icon Category</th>
<th>Icon Elements</th>
<th>Preferences Test N=283</th>
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<tbody>
<tr>
<td>Emergency Exit</td>
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</tbody>
</table>

**Figure 6** Visualization of results, preferences test.
Results reveal significant associations on how to integrate visual resources into DRM. Additionally to the testing evidence presented, three insights allow to open discussion on the importance of the role of visual information and considering preconceptions as “universal language” for emergencies, towards the articulation of the experience:

1. Familiarity: Responses tend to validate interpretations based in analogical representations, or those that participants frequently interact, suggesting that previous experience and knowledge of hazards play a role associating concepts and representations (i.e., Emergency Exit and Warning). On the other hand, symbolic or abstract representations tend to distribute preferences (i.e., Shelter).

2. Performance indicators: Beyond a statement assuming that an icon would be comprehended just because of a defined style, it is important to provide functional evidence regarding what is naturally associated, define visible differences, present messages to bring clarity and reduce uncertainty, or matching concepts with their representations as effective information for emergencies (i.e., Volcanic Eruption). Icons can be highly interpretative, it is important to follow up their performance on a continuous basis, to evaluate if representations can improve their associations (i.e., Assembly Point). Testing is also an opportunity to collect local interpretations and recognize cultural associations to compare performance indicators.

3. Knowledge for reducing risks: As a participatory experience conducted by visual information, test results may constitute an appropriate moment to dialog on what is defined as significant information for specific groups, and what is relevant to enhance emergency management. This could activate dialogs on how to optimize the communication of risk driven by social awareness and participatory knowledge.

As the results evidence, visual information establishes preferences and generates valuable insights for designing appropriate, usable information for emergencies. Also, findings spark questions: As participants could guess, what are the differences to choose? Are labeling determining a bias in choices? What if collecting more interpretations allows visual meanings to be refined, toward a common language for emergencies? And, moreover, what other cultural or educational variables might affect specific, local interpretations of hazards or risks? A key is updated information available, via open-access media, and multi-disciplinary integration. Nowadays, tests are continuously being applied, updating results on the project website.
7.1 Limitations

Being part of an ongoing research process, tests can contribute to validating visual tools but also pose limitations. It is necessary to continuously improve testing in the following phases: The first aims to clarify interpretation and integrate resources such as text labels. So far, testing has been designed as a form-filling task, conducted in an “ideal” situation, not amid a real disruptive scenario nor in a simulation context, with a potential bias in the collected responses. A critical observation to improve the process is to attend moments that eventually may represent an emotional or cognitive barrier to new information, such as during or after an event. With data analysis, it becomes evident the convenience of expanding instruments, for example using statistical content analysis.

8 Conclusions

Emergency scenarios constitute complex experiences with large requirements for information. Such disruptive scenarios usually entail limited access to information or lack of certainty, probably one of the most difficult challenges for DRM. Integrating communication to DRM contributes to an effective articulation of risks. Clear, familiar information can make a difference in visualizing, understanding and applying communication. The management of emergencies can be optimized by delivering timely information that brings certainty and prevents an escalation to a disaster. Icons can be considered an effective resource to communicate emergencies. However, as icons may change their interpretations it is important to evaluate on a continuous basis.

Projecting in the long term, an opportunity to create common bodies of knowledge can integrate local and global platforms. This is an example of “small change” to facilitate larger transformations, contributing to enhancing DRM through the application of open access and validated visual tools. Moreover, collaborative design is an opportunity to integrate local or multicultural participants, in order to create participatory information tools. Finally, this research informs multidisciplinary approaches and is open to collaboration.

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