Design Patterns to Support Personal Data Transparency Visualization in Mobile Applications

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Abstract. This paper presents a study to select and evaluate Mobile Design Patterns to support Personal Data Transparency. This research was considered as important for the Human-Computer Interaction analysis since Mobile Devices are the main resource used by subjects to interact and thus, produce personal data. Providing Transparency can require a lot of information and the Personal Transparency is being requiring by regulations of the GDPR (General Data Protection Regulation). Thus, we assumed that it could be complex to provide a mobile interface to support these issues. We selected some mobile patterns which were assumed that can support Personal Transparency Visualization and developed prototypes using the Android technology. These prototypes were evaluated providing data to conclude that the studied patterns were quite appropriated, but they required improvements related to navigation capacity.

Keywords: Personal data · Transparency · Human-data interaction · Mobile Design Patterns

1 Introduction

Transparency is the ability to provide information about the tasks involved in the collecting, processing, disclosing and use of personal data by any kind of organization or people that aim to obtain some advantage [1]. Among several concerns related to the use of personal data, provide information that allow subjects[1] to understand which events are conducted in their data and who is working with it is the more meaningful [1].

[1] In this paper, the word subject refers to people who produce personal data.

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In this sense, Transparency can be considered as a new requirement for all software that intend to use personal data in order to ensure knowledge [2], privacy [3], security [4], anonymity [5] and that subjects rights are met [6].

Several tools usually request access permissions to personal data at the beginning of the installation that may be poorly written and/or follow a *black box* strategy which application just presents texts such as: *To use software, you need to allow us to access your contacts*. However, details about which specific data are collected or which process are performed are not showed avoiding subjects to understand, monitoring and/or acting in the use of data [7].

Government agencies, researchers and software development teams that work with personal data are increasing their concerns on providing Personal Data Transparency using specifics software known as Transparency Enhancing Tools (TETs) [6], users' interfaces [3] and regulations as General Data Protection Regulation (GDPR) [8].

Although necessary, providing Transparency is not a simple tasks, mainly in mobile devices [2] since it can be influenced by:

1. The amount of information can be large making it difficult to visualize;
2. A Transparency's requirement is related to show the processes conducted with the personal data and, according to Mortier [1] and Haddad [2], convert the processing in a visual strategy can be really complex; and
3. Most of the personal data production is done using mobile devices and it has small screen with considerable restrictions on the adequacy of information in the screen [9].

Thus, we had as research question: is it possible to provide Transparency for subjects in mobile devices even though it's a small screen? To answer this question, the following tasks were conducted: (1) We analyzed the GDPR regulation to understand how Transparency should be presented; (2) Based on the GDPR and using Android development tool, interfaces prototypes were created to simulate the Personal Data Transparency information; and (3) To validate the design, heuristic evaluation were conducted by HCI and Computing experts that inspected the prototypes according mobile heuristic criteria.

Next section presents succinct background areas that support this research.

2 Background

This section presents background about Transparency, GDPR and Mobile Design Patterns.

2.1 Transparency

Personal Data Transparency, according to GDPR in Recital 58 requires that software must provide information for subjects about activities realized in personal data such as collecting, processing, disseminating and sharing. Since 2010

the concerns about Transparency became more meaningful due to the expansion of personal data usage for several commercial and non-commercial reasons. However, tasks performed in personal data are opaque for subjects and have a strong relationship with people's privacy, security and agency [1].

Transparency can support personal data privacy and understanding through two properties:

- **Visibility** is a property discussed by Turilli [10] and Mortier [1]. Turilli presents that it refers as the form to provide information and the possibility of accessing intentions, behaviors and processes performed by controllers. Mortier [1] discuss that personal data can guide several and critical decisions took by companies and organization that can interfere in subjects' life, for example, government can use data about foreign in social networks and e-commerce for ranking people and allow (or not) he/she visit some country; and
- The **Trust** property is discussed by Murmann and Fischer-Hubner [6], by Cuppens-Boulahia [5], by Patrick [11] and by Froehlich [12] as a mean to provide real information about the use of personal data avoiding the predominance of black box strategy which subject has enough knowledge about events related to their data. Authors present that the user can have more confidence in using a software whether he/she know how his/her data are used and also known how to act case the controller/processor conduct any illegal tasks.

Haddad [2] presents that Transparency is strongly related to HCI because the visibility property requires information design in order to provide the understanding by subjects that can be traditional users (without advance knowledge about computing) and due to this reason the designer must concern about appropriate User Experience (UX). However, definitions about Transparency can be subjective and all actions involved in the use of data can lead to a complex environment to be designed [13]. In this sense, the GDPR can be used as a guideline to design Transparency information because it presents a list of items required for Transparency and considered as a right for subject.

Transparency also provides challenges related to human behavior once the interaction with data and the data-driven life is uncommon and unknown. Oliver [14] presents the passive posture and lack of custom to deal with data. Passive posture is related to the fact that systems can provide good Transparency, but to access it, subjects must choose, have time, means and/or skills to do it. Also, people use smart phones, Internet and other services and automatically interact with personal data, but they usually do not know how to use, act, analyze or lead with personal data.

Next section we present information about the GDPR and Transparency Requirements.

2.2 GDPR

GDPR is a regulation that provides criteria and rules for the use of personal data created by the Europe Union to ensure the subject's privacy and freedom rights. GDPR started in 2016 and are definitively in force since April 2018 when several companies in Europe Union and all the world should suit it processes to be conform to GDPR [8]

This regulation provides a list of requirements that must be considered to ensure Transparency for subjects [15]. This list is composed by three main articles focused on guiding controllers in the aspect as visibility, control and understanding of the personal data use by subjects [16]. In short, the GDPR requires that information about the follow items must be presented as Transparency:

- Controllers, Processors and Protection Office contact details;
- Information about purpose of use, legal basis and subjects' rights;
- Information about collecting process, period of use and the processes performed; and
- Information about disclose and sharing procedures.

Somehow, we can conclude that GDPR is a regulation that should be followed to provide Transparency even for countries that do not belong to the European Union. The guidelines well-defined and few subjective that can support the development of clear components for Transparency's interface.

Next section presents information about the Mobile Design Patterns.

2.3 Mobile Design Patterns

Design patterns have become a widely used concept in the Human-Computer Interaction field, as well as in Software Engineering. Design patterns in Computing stem from the works of Alexander [17], who develops the concept of the recurrency of solutions in architecture and the nature of order. Tidwell [18] says that "patterns are structural and behavioral features that improve the 'habitability' of something - a user interface, a website, an object-oriented program or a building." Patterns are thus valid representations of commonsense in a given field and a useful tool for designing applications for that field. Libraries of patterns have been built in several areas to help designers in finding reusable solutions to common situations in design and implementation of user interfaces (UI), in different abstraction levels [19].

Mobile devices is one of the most used computational resource. Since smartphones is working many models and types of this devices aroused and all of them has a similar features: it work as a small computer and some devices have more processing powerful than a traditional computer [20].

In fact, smartphones change several ways of software development and users can work with mobile devices for several activities and due to this reason some people does not have computers anymore [9,21].

In HCI field some challenges aroused because the design of interfaces had to be improved. Mobile screens are smaller than traditional computers, the icons

and visual components are also small and the interaction is usually based on touch-screen. Other different features from traditional computer is that users are not working totally focused on the task, but it may be using the cell phone in parallel with another task creating a sharing of attention and interaction [22].

All these features require new approaches to develop mobile interfaces in a way that all components, UX and information organization must be created specially for small interfaces and mobile interaction [23]. The amount of information in screen should be carefully designed because a prioritization of resources and components must be considered in order to avoid a high density information and an unusable interface [24].

To support the mobile interface development several Mobile Design Patterns were created and/or selected based on scientific researches or practical software development experience. The patterns aim to provide means to create interface to be suitable for mobile devices in size, working and interaction [24]. Without the patterns it was not difficult to identify the process of miniaturization which desktop components had it sized reduced on canvas creating a terrible interface and UX [23]. Some examples for Mobile Design Patterns are:

- Springboards: provide a group of buttons in a main interface that allow users to access any kind of information from this interface;
- Headerless Table: is a concept of table special design for mobile interface and is considered appropriate for quick visualization and actions. In this pattern, column's title are hidden to improve the data visualization through the organization of a items collection per row. The rows can display several different components as images, charts, colors and text;
- User Guide: require an information organization by topics that allow the user to conduct a systematic search (also supported by search fields);
- Maps and markers: present information using maps services as Google Maps and use markers to point to a specific information or present more content;
- Time-lines and charts: is an interface component that provides a line with interactive resources to manipulate and visualize information; and
- Thresholds: present information based on a range with markers to indicate how many items of the context were done

Patterns presented by Neil [24] were created for Android and IoS operational systems and are being improved according to new mobile interfaces needs to provide increasingly UX.

The next section presents the selection of Mobile Design Patterns for Personal Data Transparency.

3 Patterns for Transparency in Mobile Devices

This section presents the process conducted to select Mobile Design Patterns to support Personal Data Transparency visualization in mobile devices. Highlighting that the main challenge was to look for interfaces' components to provide a good experience in the visualization of Transparency. Also, GDPR Transparency

guideline was used to establish which information must be presented. Thus, the follow tasks were performed:

- analyzing GDPR to identify which information must be presented to provide Transparency;
- search and analyze Mobile Design Patterns that could support the development of interfaces for Transparency visualization. Important to highlight that in this stage we did not create new patterns, but selected existed patterns, mainly those proposed by Neil [24] and Nuldemann [23];
- prototyping interfaces using the selected patterns in Android Platform; and
- evaluating the prototypes using Mobile Heuristic evaluation.

3.1 Transparency Requirements

In this stage we analyzed the GDPR's articles number thirteen, fourteen and fifteen in order to identify which elements should be presented to provide Transparency. The Transparency items were classified according to type of information required by each one as followed:

1. **Contact Data Information**: Several companies/people can be involved in the use of some personal data and due to this reason GDPR requires that information to allow subject to contact any organization or people that are working with the data must be presented. Also, GDPR classified companies and people in: controllers, processors, protection office and recipients;
2. **Purposes and Legal basis, Rights of subjects**: One of the main objectives of GDPR is provide information to avoid the "black box" strategy. In this sense, Transparency can be achieved presenting information about the purpose of use, whether the purpose is legal and how subjects can exercise his/her rights;
3. **Location**: Besides data for contact, GDPR requires that the location must be clearly presented in order to allow subjects to know where his/her data is being used in the world since Internet and Cloud Computing allow that computational tasks can be performed using a distributed strategy and different places. Location is also required to support to identify companies which data are sharing or disclosed;
4. **Processing information**: Using interface's components to explaining the execution of an algorithm is complex, but according to GDPR, show minimum information about the data processing which allow subject to understand how data is used must be done;
5. **Data Source**: The data can be collected by the users' device or obtained from third parties and in this case, the subject must to know the datasource; and
6. **Period of use**: Subjects must know about the period of use (processing/storage) the data.

Based on these Transparency's needs, we started to analyzed which patterns could be used to present these information in mobile devices.

3.2 Mobile Design Patterns

The interface for Transparency was developed considering the limitations of small mobile screens which does not have area for large amount of components and because of this it requires an better analysis to ensure that all the resources presented are really necessary to avoid the waste of resources. An approach named Mobile First [21] that was developed for Web-Mobile was considered to support this project because it purpose is to input in the interface just components that are really important for context beside to consider the development for mobile before development for desktop.

Two interaction properties were concerned for Transparency delivery: (1) Navigation: Subjects can have different needs of Transparency and intentions of use and due to this reason the interface must allow he/she to navigate among different information; and (2) Information Display: provide an appropriate design that allow user to visualize and understand the information presented.

We started developing and prototyping the Navigation strategy that were classified, according to Neil [24] in Primary and Secondary.

For primary navigation we chose the Springboard pattern. As we classified Transparency's information in six main topics presented in previous subsection, we assumed that a springboard could be a simple and clear way to guide the subjects to navigate among the topics. Also, due to the reduced amount of information classes, springboard provide a clear interface and the buttons can have a size and position that did not overlap and also it were well defined areas avoiding uncorrected selections.

For secondary navigation that could be used to support a direct navigation (without use the springboard) among topics we decided to use the a pattern named Toggle Menu that is an interaction component that is showed as an overlay always the user select another component as a button or a label. This navigation should not interfere in the data visualization and due to this reason a Transient pattern were select, i.e, the navigation is hidden until the user active the option thought an interface component.

In Fig. 1 is presented a prototype for primary navigation with Springboard and the secondary navigation with Toggle Menu with few options once more options could be defined later.

After, we chose a design pattern to present the items for Transparency required by GDPR. First item designed was to display **Contact Data Information**. To select the patterns for this requirement, the follow aspects were considered: (1) GDPR requires that the identification and contact details of entities must be presented, but it does not point out specific data, so the follow data were considered for identification: the name and a picture with the company's logo (or people's face image) and contact details (e-mail address, website address and full phone number); (2) these data were select considered as minimum information needed to identify a organization/person; and (3) the data select should occupy little space in the screen;

Thus, the design pattern selected for this information was the Headerless Table because it can presents several controllers, processors or protection offices

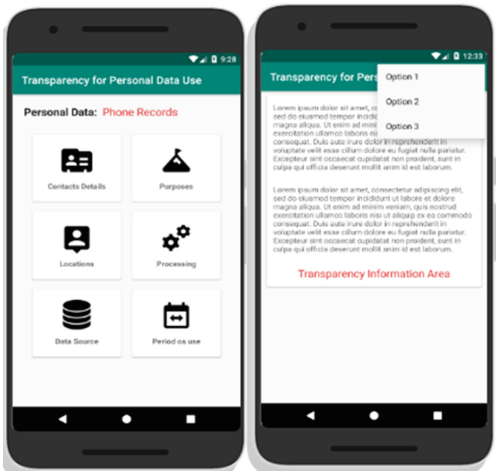

Fig. 1. Springboard and Toggle Menu prototype for transparency main menu

in a kind of list. For each contact a row should be provided with a image, identification with highlight letters and contact details in normal format letters. In Fig. 2 an example of list of contacts is displayed.

Provide information about **Purposes and Legal basis, Rights of subjects** is a concern of GDPR since most of users produce personal data without know about the controller's purpose of use and whether is legal or not.

This Transparency item can be one of more complex to be designed for mobile interfaces because it usually present a large amount of texts which can be uncomfortable and visually inefficient once size of fonts could be small and the user must read all the text in mobile.

To support it, we considered the use of a pattern named User Guide/Help System. The topics (Purpose, Legal basis and Rights) are organized in a main interface (similiar to Springboard) and according to user needs, he/she can navigate using a drill-down strategy. Also, each topic can guide to textual interface where user can read the text or search a specific word.

Thus, we proposed the use of User Guide/Help System pattern using at least three levels: (1) First level were organized as a Springboard with the options: (a) Purpose; (b) Legal Basis; and (c) Rights of Subjects; (2) Secondary level could present the subgroups of information, for example, for Legal Basis information, this level can present items such as: Number of Law, Date of Beginning, Responsible. Also for Right of Subjects some suggestion can be: How to cancel the use or How to obtain a copy; (3) This level presents textual information with a search field to make easy to find a word.

In Fig. 3 is presented an example of proposed pattern with explained level exemplified by Rights for Subject information.

For **Location** Transparency information the decision was relatively simple since people are accustomed to using maps because of the popularity of

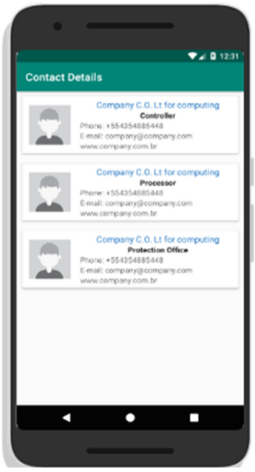

Fig. 2. Prototype for contact details interface

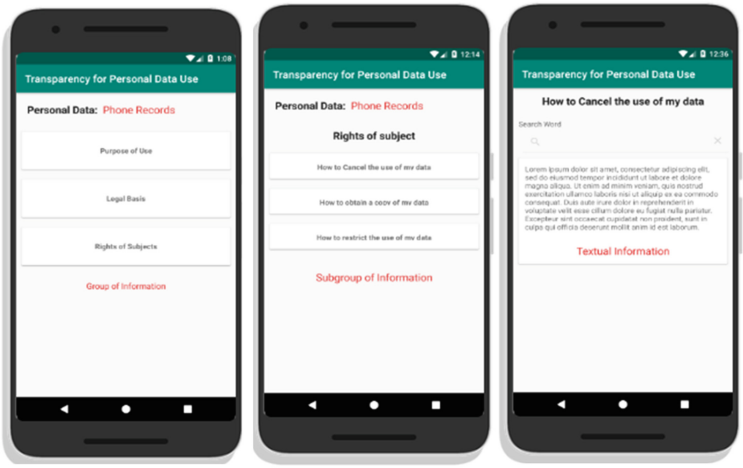

Fig. 3. Prototype for purpose, legal basis and rights of subjects

applications as Google Maps and Waze. Thus, to provide information about location of organizations, people or any entity that require the identification we propose the use of Maps that is a usual resource in mobile tools. To support the details visualization we suggest the use of markers to provide, at least, the name, phone, e-mail, address or any information that can help user to understand the location.

In Fig. 4 an example is presented, which a marker displays information about a hypothetical Data Processor located in Sao Paulo Brazil. Data as phone, e-mail address helps to identify the actor.

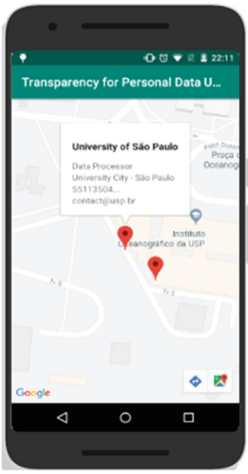

Fig. 4. Prototype for location information using maps and markers

Providing details of data **Processing** is considered one of biggest challenge for Transparency information as discussed by Mortier [1] and Haddad [2] . It is not simple create a visual demonstration about how data and algorithms works. However, GDPR requires that subjects have access to minimum information that allow him/her understand the processing tasks mainly whether a computer-based decision is performed using personal data.

What the word "minimum" means is not detailed presented leading us to assume that the user should understand at least: which stages (name), the sequence when it happens and a brief and lay description. Details about the operation of algorithm can be hidden since the vast majority of people could not desire (and need) to know execution low level details.

Thus, we propose the use of a timelime concept based on the pattern named Interactive Timelime. The time-lime could be presented in vertical orientation with markers in a reasonable distance that can present the number of sequence, the name of task and a single description. In certain way, it can be similar to road map or to a subway map that can be find in the stations. In Fig. 5 an example of timelime pattern is presented containing three stages and the third marker is selected and presenting the information.

The next Transparency item is the **Data Sources**. It is common for people receive e-mail, phone calls or be surprised by information of your interest without information about the source of data. In this sense, GDPR proposes that data source information must be presented mainly if data is obtained from 3rd sources and not directly by subjects' device.

We assumed that information must be classified in two types as presented in Fig. 6: Data collected directly from subject; and Data obtained from 3rd. For first type, we suggest an approach where data is presented using an image to represent the data source and a panel with three other data:

Fig. 5. Prototype for processing minimum details

- Source: description of the data source, for example, smart phone, subway service or credit card machine;
- Resource: component that performs the data collecting such as camera, surveillance camera, payments in the credit card machine; and
- Collection period: the interval for data collecting.

For data obtained from three controllers, we assume that it can be complex to detail which resources or devices were used to collect the data because the controller that is providing Transparency could not have this information. Therefore, display information about who is the responsible for data collecting is possible. Also, details about the moment which data were transferred from the source to the actual controller and data explaining whether the source is public or private is also needed since it is required by GDPR.

Thus, we propose to use the same Pattern used for **Location** presented in Fig. 4. A map with markers to set the data-source location and for each marker, data about the controller or processor could be presented. Besides the data already discussed in location requirement, the date of acquisition must be presented.

Period of use is the last Transparency item identified and is considered important since users must know about the time the data will be used. This is a subjects' right because it can interfere in privacy, freedom and security. Also, the use of data can be expired according to the context of use, so the subjects need to know if his/her data is not being used incorrectly.

For this requirement we propose the use of a calendar adapted by a pattern named Thresholds. For example, a personal data is collected to be used by one year and the rate is composed from the collect date until the end date. The marker must be positioned to indicate how much of a period has elapsed since the beginning of use of the data. Thus, we propose a pattern adaptation to be

Fig. 6. Prototype for data source information

used to indicate the period of use of the data. As presented in Fig. 7 this pattern must have at least two information: Start date of data usage; and End data of data usage.

This section presented the proposition of Mobile Design Patterns for Personal Data Transparency's visualization based on GDPR. The concern in create this kind of interaction is justified because Transparency can required a large amount of information conflicting with mobile screen features such as size and interaction ways.

With the proposed patterns we assumed that Transparency information could be visualized in mobile devices in a way that would allow subject to identify some events related to their personal data.

Next section presents the validation of the proposed patterns.

4 Validation

The validation was performed using Heuristic Evaluation strategy that is a systematic inspection of the user interface's design to identify ergonomic problems [25]. The prototypes (developed using Android technology) were organized in cards and presented for 7 evaluators with advanced knowledge in HCI or Computer Science. The number of evaluators is according to Nilsen [25] proposition that required at least 5 evaluators-specialists.

The evaluators received the cards with: (1) the instructions to understand the heuristics and the criteria to be evaluated; and (2) the prototype images with the description. We suggested that evaluators focused on verify whether the patterns selected, and levels organization (if applicable) were appropriate in order to provide Transparency information visualization in Mobile Device.

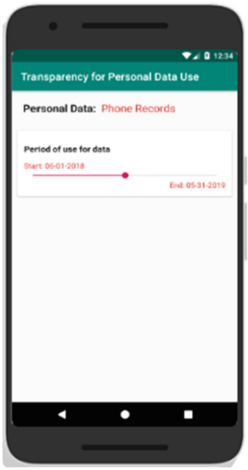

Fig. 7. Prototype for period of use

The heuristics selected are based on the research of Rocha [26] that used eleven criteria for mobile interface evaluation. However, the evaluation were conduct in cards using the prototypes based on Android user interface, but without computational interactions and due to this reason we selected six heuristics (Table 1) that could better answer questions about data visualization, design, organization and user experience in prototype/static images.

Table 1. Mobile Heuristics select for evaluation

Heuristic	Name
HM1	Good use of screen space
HM2	Visibility and easy access to all information existing
HM3	Suitability between the component and its functionality
HM4	Message matching to functionality and user
HM5	Ease access to features
HM6	User memory load minimization

Each heuristic were evaluated based on the criteria presented in Table 2. Next section presents the results and discussions.

5 Results and Discussions

The results were described in a way similar to [26], in three tables that classified the results as followed:

Table 2. Criteria to evaluate the heuristics

Severity	Problem description
0 - No relevant	Does not severely affect the interface and does not cover all users which excludes the need for adjustments
1 - Design	No relevant, but can be improved as possible
2 - Simple	Can be repaired but has low priority
3 - Serious	Must be repaired as soon as possible
4 - Catastrophic	Must be repaired immediately because it affects/prevents the use of the interface

1. Total of problems and severity average (Table 3);
2. Amount of problems and severity average per Interface (Table 4);
3. Amount of problems and severity average per Heuristics (Table 5).

To be considered as a problem, a heuristic must be evaluated among the rates 1 (one) and 4 (four). Each evaluator could answer about 54 problems, thus, as 7 (seven) evaluators worked in the evaluation 378 problems were possible. The severity average were calculated using traditional average mathematics technique.

Table 3. Total of problems and severity average

Total of problems	General severity average
74	1,37

Results in Table 3 present that the evaluated interfaces had few amount of problems since 15% of all possible problems were found and that the problem severity average was between 1 and 2 leading to assume that the interfaces had aesthetic and simple problems.

Also, results in Table 4 present that from the nine functions evaluated, just two functions were classified with greater severity than 2. Two interface were very well evaluated because it severity average was between zero and one. Other interfaces presented severity between 1 and 2 similar to the general evaluation severity.

Coincidentally, worst severities were found in navigation interfaces in which one were the pattern named Toggle Menu and other one was about Purposes and Legal basis, Rights of subjects that used a Guide/Help design pattern. We assume that this problems happened because provide navigation for many interfaces and information in a small screen can required that information be divided, classified or using strategies as filters and/or drill-down. In this sense, the interface can required that user conduct several clicks, tips or other commands to find/access an information making the task for finding something difficult.

Table 4. Problems by interface/functions

Interface/function	Total of problems	Severity average
Springboard	10	1,6
Navigation	19	3,1
Contact data details	1	0,16
Purpose, legal basis and rights	15	2,5
Location	6	1
Processing information	4	0,67
Data source (by subject)	0	0
Data source (by other sources)	8	1,33
Period of use	11	1,83

On the other hand, the best evaluated interfaces used simple, direct and easy visualization patterns that allowed a good components organization in a little screen space and thus, the information was in a unique interface, in a visible way and well and easy interactive allowing user to find information with few tasks.

With results presented in Table 5 we concluded that the navigation pattern was the main problem of the proposed interfaces. The heuristic HM2 related to navigation was the worsted evaluated being the unique with severity Two and eighteen errors. All the other were severity between 1 and 1.5 and the amount of errors was about 15% similar to general severity values.

Table 5. Problems identified by Heuristic

Heuristic	Total of problems	Severity average
HM1	14	1,5
HM2	18	2
HM3	11	1,2
HM4	10	1,1
HM5	9	1
HM6	12	1,2

Considering the results, we concluded that the interfaces are quite appropriate to provide Personal Data Transparency. Except navigation heuristics, all others were considered irrelevant or simple and that do not interfere or impede the views of information.

For Navigation issues, we proposed to study how to find, improve and/or create new patters that can support navigation among several Transparency information with more quality and reducing the number of tasks among the screens. For information that was visualized using navigation pattern we intend

to look for new patterns that can present the information in few (or just one) interfaces and avoid changes between multiple screens.

Next section presents the Final Considerations and Futures Works.

6 Final Considerations and Future Works

Personal Data Transparency became an important requirement to be provide for users in order to allow him/her to understand how their personal data are used and by who. The more usually resource used for subjects to do their tasks is the smartphone that has small screens leading to challenges in design interfaces for visualization of many contents such as Transparency.

The Mobile Design Patterns could support the development of interface for Transparency and due to this reason we selected, developed and evaluated a group of mobile interfaces that were based on mobile patterns and Transparency requirements from GDPR.

The evaluations were conducted using Heuristic evaluation techniques and presented that the patterns can support most of Transparency Requirements, but Navigation issues were not considered appropriated and must be improved mainly to support the navigation among all the resource and also to support navigation in a drill-down concept which is a kind of interaction that could be common in Transparency for personal data.

As future work we intend to improve the navigation capability to facilitate the interaction with big amount of information in different interfaces. The development of an usable release in order to realize usability testing and understand how the subjects interact with Transparency information and whether the patterns really support the interaction between user and interface. Also we intend to expand the patterns for other digital platforms as IoS and Web-Responsive.

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