VALIDATION AND EXTENSION OF THE USABILITY HEURISTICS FOR MOBILE MAP APPLICATIONS

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Abstract
Heuristic usability evaluation is light but efficient method for finding usability problems. In this paper, we report the process of validation and further development of the previously introduced usability heuristics for mobile map applications. The validation began by testing the heuristics by 58 evaluators who used them for usability evaluation of four different map applications. The evaluators also filled a questionnaire about the understandability of the heuristics. The amount, severity and quality of the problems found with the heuristics were reviewed and the heuristics' understandability analyzed. As a result, it was shown that the heuristics were efficient for finding usability problems from mobile map applications. The analysis of the understandability pointed out the need to clarify the heuristics. On the basis of the findings, the heuristics were further developed. The usability heuristics introduced in this paper are supposed to be widely usable in the development of mobile map applications.

Keywords: *mobile map applications, map application development, usability heuristics, heuristic evaluation, domain-specific heuristics, usability evaluation, cartography, usability*

INTRODUCTION

The mobile map applications have become widely used in various situations. As the use cases of them are typically critical concerning for example safety (e.g. traffic and avoid getting lost) and timetables (being in time), it is also important that the usability of the mobile map applications is in a decent level. Heuristic evaluation is light but efficient way for finding usability problems in different applications (Nielsen, 1992). The another advantage of the method is that it is suitable to be used also by the evaluators that are non-professionals with usability (Nielsen, 1992).

Several usability heuristics for various different domains have been introduced earlier. The domains that are close to mobile map applications and that are having their own heuristics, include mobile computing (Bertini, Gabrielli, & Kimani, 2006), information visualization (Forsell & Johansson, 2010; Zuk, Schlesier, Neumann, Hancock, & Carpendale, 2006), Web-based GIS (Komarkova, Visek, & Novak, 2007) and mobile devices (Machado Neto & Pimentel, 2013). The most known and the most used heuristics are though the Nielsen heuristics introduced in (1994).

Kuparinen et al. (2013) introduced the first usability heuristics for mobile map applications. Since publishing the heuristics in the International Cartographic Conference 2013, they have also been presented for cartographers in the meeting of Finland's cartographic association in 2013. The received feedback in these occasions indicated high interest towards development of the usability heuristics for map area. The heuristics have also been noticed in various scientific publications since 2013. The development process has continued and is further discussed as follows.

Hermawati and Lawson (2016) have done a wide comparison of the development processes of usability heuristics for various domains. They summarized that 34 % of the 70 inspected heuristic development processes did not report any validation. To prove the effectiveness of heuristics, Hermawati and Lawson also suggest that establishing heuristics should not stop on the proposal of them. Although the Kuparinen et al. heuristics were tested by four usability specialists (Kuparinen et al., 2013) by using the heuristics in comparison to Nielsen heuristics, a validation with higher amount of data was still needed. This validation is presented in this paper.

The validation of the previously introduced heuristics began by testing the heuristics by 58 evaluators. The evaluators used the heuristics for the usability evaluation of three different mobile map applications and, as a point of reference, also for one map application used with a computer and a web browser. The test reports were collated and the amount, severity and quality of the problems found with each of the heuristics were reviewed. After the evaluation, 41

evaluators filled a questionnaire about the understandability of each of the heuristics. After analyzing these data sets, the heuristics were further developed on the basis of the findings.

The rest of the paper is organized as follows. First, we discuss the background of the topic, including the previously indicated usability problems. Second, we describe our research method; the used heuristics and the validation process. Third, we report the analysis of testing the heuristics and the analysis of the questionnaire answers of the heuristics' understandability. Finally, we present the overall results and the validated and extended heuristics. The conclusion and discussion come as last.

RESEARCH METHOD

The research method consisted of three phases. At first, the heuristics were used to evaluate map applications and the amount and severity of the findings were analyzed. At second, the evaluators filled a questionnaire about the understandability of each of the heuristics and this data was analyzed. At third, the heuristics were further developed on the basis of the findings. This process is described in this section in more detail.

Used Heuristics

The following heuristics by Kuparinen et al. (2013) were used in the evaluation. A Finnish translation of the heuristics was given to the evaluators as they were all Finnish speakers.

1. **Visibility of the contextual map functions and important locations.** The map application should always interact with the user by giving informative feedback within reasonable time. The map functions should be visible. The map view should constantly stay visible when the map application is in use.
2. **Match between the system and the physical surroundings of the user.** The map application should show clear indication of the user's location and other important locations (e.g. destinations and POIs) on the map. It is essential that the map corresponds in an understandable way with the physical surroundings of the user. The map should be up-to-date.
3. **User control over map functions.** Allow the user to take control of the map application when interruptions (from the mobile device: phone call, message, other applications' notifications, from the concrete surroundings: traffic, weather, traffic lights) happen. Allow multitasking.
4. **Consistency and standards.** Follow platform conventions in the user interface design. Be consistent within the use of interaction gestures, controls, functions, elements of user interface and map features. Use clear, intuitive, commonly known map symbols.
5. **Error prevention.** Make the map application free of errors. If errors still happen, be sure to offer the possibility to recover from them. Prevent the user from getting lost.
6. **Recognition rather than recall.** Minimize the user's memory load. Make sure that the main functions of the map application (e.g. exploring, route guidance, zooming, panning, POI selection) are easily accessible. Use short menu paths for the main functions or keep the main functions present all the time.
7. **Flexibility, scalability and efficiency of use.** Offer flexible options for the main map functions. Allow the user to save locations to be used as shortcuts (e.g. home) and support POI information. Give easy access to additional information (metadata, links, user-generated content). Make sure the user interface is scalable for different screen sizes of mobile devices.
8. **Balanced and simplistic visual design.** Harmonious overall appearance should consist of clear contrast between visual elements, balanced layout and informative colors. Visual elements should guide users gaze to important elements. Avoid visual clutter.
9. **Recognizing, diagnosing and recovering from errors.** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution. Indicate clearly the reasons for why the searched locations are not found. Save the user's previous searches for fast repetition.
10. **Offering help.** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Provide both: fast guidance focused on the user's task and more detailed documentation with search functions. Pay attention to the understandability of the help.

Validation Process

As part of the university course User-Centered Software Development 66 Finnish students performed a usability heuristic evaluation for a map application by using the heuristics introduced by Kuparinen et al. (2013). 58 of the evaluators gave their permission to use their usability analysis report in part of the research when updating the usability heuristics for mobile map applications.

The task for the evaluators was to conduct a usability analysis for a mobile map application by a smart phone, or in the case of not having a smart phone, for an internet browser based map application by a laptop or desktop computer. Depending of the smart phone's operating system, three options were offered for the analysis of a mobile map application: MapFactor Navigator Free (MapFactor, 2013) for Android, MapFactor Navigator Free (MapFactor, 2013) or Nokia Maps (Nokia, 2013) for Windows Phone and NavFree (Navmii, 2013) for iOS. Three different applications were offered because of the problem of finding one suitable mobile map application for every operation system. As there were a total of 138 students registered for the course and all of them were possible participants also to conduct the usability analysis, we were not able to arrange a smart phone with consistent operating system for all of them. Instead, the students were allowed to use their own smart phone, or one of the loanable smart phones, to complete the analysis. If a student could not use a smart phone, he was allowed to conduct the analysis by a computer. In that case, the used map application was Fonecta Maps (Fonecta, 2013).

The number of evaluators using each of the applications was following:

- MapFactor Navigator Free (Android): 17 evaluators (29 %)
- Nokia Maps (Windows Phone: 12, Symbian: 4, Meego: 1): 17 evaluators (29 %)
- NavFree (iOs): 8 evaluators (14 %)
- Fonecta Maps (Computer and web browser): 16 evaluators (28 %)

To clear it up, 28 % of the analyses were completed with computer and a browser-based map application and total of 72 % with mobile map applications.

The tasks the evaluators executed were:

1. Locate yourself on the map so that you can see your current street address.
2. Find a predefined address by using the search function of the map service.
3. Scroll the map. Try to perceive the target location in relation to your current address. Do not use navigational tools, but only scroll the map.
4. Get navigation guidance: You want to walk to your predefined target location. Get pedestrian guidance. Check the estimated travel time.
5. Find a Point-of-Interest. You are planning to have lunch after your meeting in the predefined target location. Find a restaurant which is located a maximum 500 meters from your target location.
6. Find another predefined address: Use the search function of the map service.

The task number 6 was a trick question. The predefined address didn't really exist and the goal of the task was to see how the map service works in a case when it cannot find the address – and how will the heuristics answer to an error like that.

The tasks were chosen to fulfill the typical tasks for mobile map applications. For example, Wiener et al.'s (2009) taxonomy of wayfinding, including i.e. exploration, search, undirected and directed wayfinding, target approximation and path planning, was used as the basis for formulating the tasks.

The evaluators were also asked about the understandability of each of the heuristics. The questionnaire used in this asked numerical estimation of the understandability of each of the heuristics in a scale from 1 to 5. There was also a possibility to give comments of each of the heuristics. Although it was voluntary to fill this questionnaire, still 41 evaluators took part also on this part of the study.

As the author of this paper is one of the developers of the validated heuristics, and by that the research may be seen as participatory action research (PAR), it was essentially important to describe the research method strictly – so that has been the goal in this research report.

ANALYSIS OF TESTING THE HEURISTICS

A total of 903 usability problems were reported in the evaluation reports. The summary of the quantitative analysis of the evaluation is presented in Table 1.

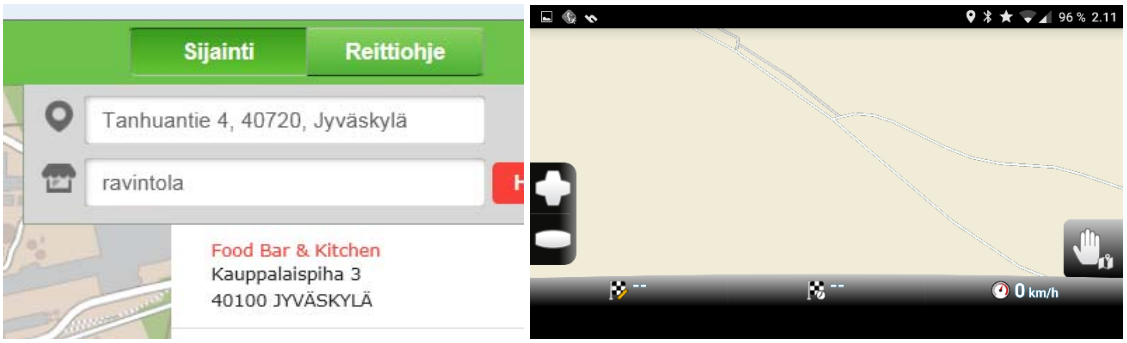
Table 1. *Found problems with the heuristics. The especially low and high values in the category All are bolded.*

Heuristic	Amount of problems found per evaluator	Severity of problems, mean (0-4, 4=the worst)	Major or catastrophic problems	Understandability, mean (1-5, 5=the best)
1. Visibility of the contextual map functions and important locations.	**All: 2,6**	minor (2,3)	42 %	3,9
	Mobile: 2,8	minor (2,3)	42 %	3,9
	Browser: 1,9	minor (2,3)	43 %	3,9
2. Match between the system and the physical surroundings of the user.	All: 1,9	**major (2,8)**	**59 %**	4,1
	Mobile: 1,9	major (2,8)	63 %	4,0
	Browser: 1,8	major (2,7)	50 %	4,2
3. User control over map functions.	**All: 0,7**	**major (2,6)**	49 %	4,0
	Mobile: 0,5	major (2,5)	36 %	3,9
	Browser: 0,9	major (2,8)	67 %	4,4
4. Consistency and standards	All: 1,7	minor (2,4)	50 %	4,0
	Mobile: 1,8	minor (2,3)	47 %	3,9
	Browser: 1,7	major (2,6)	58 %	4,1
5. Error prevention.	All: 1,0	**major (2,6)**	**54 %**	4,0
	Mobile: 1,2	major (2,7)	54 %	4,0
	Browser: 0,7	minor (2,4)	55 %	4,1
6. Recognition rather than recall.	All: 1,6	**minor (2,2)**	**38 %**	4,0
	Mobile: 1,7	minor (2,1)	36 %	3,9
	Browser: 1,3	major (2,6)	45 %	4,4
7. Flexibility, scalability and efficiency of use	**All: 2,3**	minor (2,4)	47 %	**3,8**
	Mobile: 1,8	minor (2,4)	51 %	3,8
	Browser: 3,8	minor (2,3)	43 %	4,0
8. Balanced and simplistic visual design	**All: 0,8**	**minor (2,2)**	**35 %**	4,1
	Mobile: 0,6	minor (2,3)	38 %	4,1
	Browser: 1,3	minor (2,1)	30 %	4,3
9. Recognizing, diagnosing and recovering from errors	All: 1,1	**major (2,6)**	51 %	**3,8**
	Mobile: 1,2	major (2,7)	56 %	3,8
	Browser: 0,7	minor (2,1)	27 %	3,7
10. Offering help.	All: 1,7	major (2,5)	53 %	4,1
	Mobile: 1,8	minor (2,4)	53 %	4,0
	Browser: 1,6	major (2,6)	52 %	4,3
Undefined heuristic	All: 0,2	cosmetic (1,2)	27 %	XX
	Mobile: 0,2	cosmetic (1,3)	33 %	XX
	Browser: 0,2	cosmetic (0,5)	0 %	XX
All of the heuristics, mean	All: 1,6	minor (2,4)	48 %	4,0
	Mobile: 1,6	minor (2,4)	48 %	3,9
	Browser: 1,6	minor (2,4)	46 %	4,1

The heuristics number 1 (Visibility of the contextual map functions and important locations) and 7 (Flexibility, scalability and efficiency of use) were most efficient for finding the problems. The heuristics number 3 (User control over map functions) and 8 (Balanced and simplistic visual design) were in use to find the least amount of problems.

The most critical problems were found with the heuristics 2 (Match between the system and the physical surroundings of the user), 3 (User control over map functions), 5 (Error prevention) and 9 (Recognizing, diagnosing and recovering from errors). This finding indicates these heuristics to be essentially important. Although the least severe problems were found with the heuristics 6 (Recognition rather than recall) and 8 (Balanced and simplistic visual design), these heuristics cannot be seen as totally useless as the percentage of found major or catastrophic problems was still over 30 %.

Examples of the problems are presented in Figure 1.



Figures 1A (left) and 1B (right). 1A: From the evaluator's problem report: A usability problem concerning the heuristic number 3: User control over map functions. The evaluator reported that when he was trying to mark a POI on the map, all the search results were reset. 1B: An example of catastrophic problem: the map is not corresponding the physical surroundings; there is too little map data, road names or even the roads are missing.

There were 10 reported problems (1 % of all) that were not categorized under any of the heuristics. As the amount is very small, that indicates that the heuristics work well in finding the usability problems as well as supporting to revolve the solutions for the usability problems.

33 of the reported problems (4 % of all) were not connected to any of the assigned tasks. It seems that most of these are because of neglected completion of the analysis report but at least some of them were problems that were not connected to any of the tasks. These problems were mostly related to the outlook, color and aesthetics of the application. This raises the suggestion that, besides the specific tasks in the heuristic analysis, there should always be included the overall evaluation of the aesthetics of the user interface.

Although the analysis is done also between the mobile and browser-based map applications, there should not be too much attention paid on the differences of these. That is because the applications differed between each other and naturally had differences also by means of usability. It is though interesting that the heuristics were equally effective in finding usability problems with both, mobile and browser-based applications. Naturally there were heuristics that did not work that well with browser-based application that is typically used in a stationary manner and not by mobile device.

Understandability of the Heuristics

Also the overall data of the understandability is presented in Table 1. The data of one of the evaluators had to be excluded as the evaluator hadn't understand the questions correctly.

The overall understandability of the heuristics was good: mean 4,0 in the scale from 1 (very difficult to understand) to 5 (very well understood). The understandability of the heuristics was also compared to each other. The heuristics that were the most difficult to understand were numbers 7 (Flexibility, scalability and efficiency of use) and 9 (Recognizing, diagnosing and recovering from errors).

Some of the comments that were seen as the most substantive in the development of the heuristics, are presented following.

Conflicting with the heuristic 1, it was stated that the map view is not natural to stay visible at all times in a mobile device when the screen is small and the active use of functions covers it. Also the different use cases concerning transportation methods were noticed.

Concerning the heuristic 4, the evaluators stated that the standards or commonly known symbols are not always clear to the evaluators. It was also pointed out that the language problems are not identified to any of the heuristics and they could be put part of the heuristic number 4. Also the need for allowing differing solutions for example because of company-wide practices was discussed.

Heuristic number 5 was commented with the notice that the prevention of user getting lost could refer also to getting lost in the application menus. One evaluator identified overlapping of the specification "offer possibility to recover from errors" and the heuristic number 9.

About heuristic 8 one evaluator pointed out that the capability to obey this heuristic depends on the experience of visual design and that is why this heuristic may lead to undesirable results. The problem is similar to heuristic number 4 – if the evaluator isn't experienced with using map applications, he may not have the needed experience of the standards.

In the comments of heuristic number 9 it was stated that it is good to show also the exact error code e.g. behind a link for the power users that are willing to find out more about the errors. Two evaluators felt that saving the user's previous searches for fast repetition should not be part of this heuristic.

Many problems (total 166, 18 % of the overall amount of problems of 903) were marked to break multiple heuristics. Especially common were the combinations of the heuristics 1 and 6 (overlapping 23 times) and 6 and 7 (overlapping 17 times). All the common cases of overlapping were:

- 23 times: heuristic 1+6
- 17 times: heuristic 6+7
- 15 times: heuristics 7+10 and 9+10
- 14 times: heuristics 1+2, and 1+4, and 1+7, and 2+5
- 13 times: heuristics 1+10, and 4+6, and 5+10
- 12 times: heuristics 2+6, and 5+9

The findings indicate the need to clarify the difference of these possibly overlapping heuristics. The overlapping of the heuristics 5 and 9 was also reported in the verbal reports so these heuristics need special attention in the formation of the updated heuristics.

RESULTS

At first the overall results of testing the heuristics and analysis of the heuristics' understandability are presented. After that the validated and extended heuristics are introduced.

Results of the Validation

In the evaluation reports, there were only small amount of usability problems that were not categorized under any of the heuristics and any of the assigned tasks. This indicates two conclusions. At first, the heuristics seem to work well in finding the usability problems. At second, the tasks seem to be adequate to point out the problems. It is still noteworthy that there were some usability problems that were not categorized under any of the tasks and these problems were mostly related to the outlook, color and aesthetics of the application. This leads to a conclusion that the evaluation of the overall aesthetics of the user interface should always be part of the heuristic usability evaluation even though it wouldn't be a part of the actual tasks.

Also the low severity value of the problems that were found outside the heuristic set indicates that the original heuristic set covers the typical and the most influential usability problems well.

As there was equal amount of usability problems found per user with both, mobile and browser-based map application, it is probable that most of the heuristics work sufficiently also with map applications that are used in stationary manner with browser-based applications.

It is essential that the evaluators understand the heuristics correctly, so it is needed to improve the understandability of the heuristics that were unclear to the evaluators. As we conducted the usability analysis for the total of four different applications, the information about the suitability and understandability of the heuristics became clear in the analysis phase. As the heuristics are supposed to be used also by non-usability professionals, also a need to simplify the used terminology is real.

Based on the evaluators comments of understandability, it is preferable to have also “other problems” section in the heuristic evaluation form.

Validated and Extended Heuristics

To make the heuristics clearer, verbs were included already in the titles of the heuristics. To avoid the overlapping that realized with the tested heuristics, the heuristic titles were detailed and descriptions updated. Also, two more heuristics were added in the simplification phase of the contents of the previous heuristics. The heuristics were also reorganized to have the similar but differing heuristics consecutively to each other in order to make the understanding of the differences easier. Next, the most remarkable changes are presented.

Heuristic 1: The heuristic was moved to be the first one as this can be seen to be the most important heuristic for map applications. The importance of preventing the user from getting lost is emphasized. (Old heuristic was number 2.)

Heuristic 2: Detailed guidance of the need for having map view visible is added. A mention about the locating the advertisement is included. The mention of giving feedback within reasonable time is relocated to heuristic 10 and the mention of map functions is divided to a new heuristic, number 3. (Old heuristic was number 1.)

Heuristic 3: The main map functions are specified. The need to indicate also the location in the application functions is added. (Old heuristic were numbers 1 and 6.)

Heuristic 4: As the support for the shortcuts of locations and previous searches is typical and useful function of map applications, it is separated to be a new heuristic. Also the notice of minimizing user’s memory load is more coherent in the context of providing shortcuts for locations and additional information than with the visibility of still typically quite few and simple map functions. The confusing heuristic title “Recognition rather than recall” was also simplified in this heuristic. “Addresses from contact book” is now mentioned. (This heuristic is mainly new.)

Heuristic 5: As the heuristic “User control over map functions” was the least efficient in the finding of usability problems and previously it was not presented in a very clear title, it is reformulated. The possible interruptions are widened. A need for returning to the previous application state after using other applications is added. (Old heuristic was number 3.)

Heuristic 6: Mentioning the standards was found challenging as the evaluators pointed out that the standards may be unknown to evaluators. Heuristic is clarified in this manner. It is clarified that the consistency refers to the implementation of the map features in different parts of the application. Examples of the preferred map symbols are given. It is not anymore strict requirement to use commonly used design solutions. (Old heuristic was number 4.)

Heuristic 7: The evaluators pointed out that there was no heuristic for the consistent use of terminology and use of language so this heuristic is added. (This heuristic is new.)

Heuristic 8: The title is clarified and the mention of preventing user of getting lost is relocated to heuristic 1. (Old heuristic was number 5.)

Heuristic 9: The error codes are guided to be shown behind links. Saving previous locations is moved under heuristic 4. (Old heuristic was number 9.)

Heuristic 10: A mention of map functions is moved to heuristic 3. The need to adapt to different use cases is added. The need of letting the user adjust the power saving options is added. (Old heuristic was number 7.)

Heuristic 11: The description is simplified. Examples of informative colors are added. (Old heuristic was number 8.)

Heuristic 12: “May be necessary” is changed to “is necessary”. (Old heuristic was number 10.)

The validated and extended, new heuristics are:

1. **Match the map and the physical surroundings.** To prevent the user from getting lost the map application should show clear indication of the user's location and other important locations (e.g. destinations and Point-of-Interests, POIs). It is essential that the map corresponds in an understandable way with the physical surroundings of the user. The map should be up-to-date.
2. **Keep the map visible when needed.** The map view should stay visible as often as possible when the user is actively using the application and especially when there is a need for critical navigation guidance. If there is advertisement shown in the application, keep it away from covering any critical parts of the user interface or map view.
3. **Keep the important functions easily accessible.** Make sure that the main map functions (e.g. exploration, search, wayfinding) are easily accessible. Use short menu paths for the main functions or keep the main functions present all the time. Make it clear of which part or function of the user interface is currently used.
4. **Offer shortcuts for locations.** Minimize user's memory load by allowing the use of shortcuts for important locations (e.g. home, previous searches, addresses from contact book). Support the use of POIs. Give easy access to additional information (metadata, links, user-generated content).
5. **Allow multitasking and interruptions.** Allow the user to take control of the map application when interruptions (from the mobile device: phone call, message, notifications, etc.; or from the concrete surroundings: traffic, having a break in a cafe, bad weather, etc.) happen. Allow multitasking and keep it easy to return to the last state of the map application after use of other applications.
6. **Prefer commonly used graphical and functional design solutions.** Use well-known design solutions in the user interface if you do not have a new solution that is strongly proven to be intuitive. Be consistent within the use of interaction gestures (e.g. zooming and panning), controls, functions, elements of user interface and map features in different parts of the application. Use clear, intuitive, commonly known map symbols (e.g. arrows for directions, magnifying class for search, plus and minus for zoom).
7. **Use understandable terminology consistently.** Avoid use of special terminology. Make sure to use the same words with same meanings in different parts of the application. Use the language that is preferred to the user.
8. **Prevent errors and recover from them.** Make the map application free of errors. If errors still happen, be sure to offer the possibility to recover from them easily.
9. **Recognize errors and inform of them clearly.** When errors happen, the error messages should be expressed in plain language (error codes only behind a link), precisely indicate the problem, and constructively suggest a solution. Indicate clearly also the reasons for why the searched locations are not found.
10. **Provide flexibility, adaptability and scalability.** The application should interact with the user by giving informative feedback within reasonable time. The application needs to adapt to different use cases (e.g. pedestrian navigation in forest, driving). Make sure the user interface is scalable for different screen sizes. Let the user adjust the power saving options to lengthen the device's battery life.
11. **Follow balanced and simplistic visual design.** Use clear contrast between visual elements, balanced layout and informative colors (map: forests as green etc., user interface: alarms as red). Visual elements should guide users gaze to important elements. Avoid visual clutter.
12. **Offer help.** Even though it is better if the system can be used without documentation, it is necessary to provide help and documentation. Provide fast guidance focused on user's task and more detailed documentation with search functions. Pay attention to the understandability of the help.

CONCLUSIONS

As a result, it is shown that the previously presented heuristics were suitable for the evaluation of mobile map applications. The analysis of the understandability of the previous heuristics pointed out the need to clarify them. The new, validated and extended usability heuristics introduced in this paper are supposed to be widely usable in the development of mobile map applications.

The collected data set is very large and it would give possibilities for more detailed analysis, especially with the qualitative aspects of usability evaluation reports but also with the quantitative data. For example, the analysis of the amount of a certain problem found by different evaluators could strengthen or weaken the validity of a certain heuristic.

It was though not possible to analyze the data for this paper in more detail but the data still gives possibilities for further analyses.

A good next step for the research in the field of the usability heuristics of mobile map applications is to complete analyses of different mobile map applications with these updated heuristics. Also a comparative study of these domain-specific heuristics and general heuristics would further test the efficiency of these heuristics. Besides the steps related to usability heuristics, more usability research overall is needed to further develop the user experience of mobile map applications with the expanding use cases of them.

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Master of Economics, doctoral student of Information Systems Science, Liisa Kuparinen is finishing her PhD titled “Designing and Evaluating Mobile Map Services: the Viewpoint of Spatial Cognition in Navigation”. Previously Kuparinen has published studies related to this topic about using eye-tracking as a research method for decision of which landmarks to emphasize on mobile map applications; depth perception in tablet-based Augmented Reality and the first paper introducing usability heuristics for mobile map applications.

Besides the usability aspects of development of mobile map applications, Kuparinen is experienced in Human-Technology Interaction (HTI) related research and practice overall. Her interests also include Animal-Technology Interaction; how to support the wellbeing and research of animals, especially pets, with technical solutions.

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