Developing a Heuristic Tool for Evaluation of Mobility as a Service (MaaS) Mobile Application Interfaces

Joy Richardson, Henrietta Howarth & Jisun Kim

University of Southampton, UK

ABSTRACT

Mobility as a Service (MaaS) mobile phone applications are being launched in many towns and cities worldwide and are heralded as the ultimate modern mobility solution by combining private, public, micro and active travel options. However, in order to encourage adoption by the public the user-experience (UX) is of high importance. A useful way to evaluate the UX of an app interface is to use heuristics analysis, yet none of the existing heuristics tools are tailored towards mobility apps. This means they are not suitable for a systematic evaluation of MaaS interfaces.

Therefore a new heuristics tool was developed in order to evaluate the interfaces of mobility apps, including MaaS. This was achieved through the evaluation of existing heuristics combined with the determination of the needs of the mobility app user. A number of iterations were developed, tested and revised in order to design a useful and usable tool.

KEYWORDS

Heuristic, Interface Design, Mobility, MaaS

Introduction

Advances in Information and Communication Technology (ICT) over the last ten years (Goncalves et al, 2020) and the widespread adoption of the smartphone which allows us to be constantly connected to the internet, (Montag et al 2019) are pushing change in the transportation sector. Whilst hundreds of models exist common features or a smartphone are; Digital Display, rechargeable battery, SoC (System-on-a-Chip), camera, storage and memory, modem and sensors (Nuhel, 2021). It is this combination of features, combined with advances in ICT infrastructure which has enabled the development of new transport solutions.

Mobility as a Service (MaaS) was a term popularised in Helsinki in 2014 (Hensher et al, 2020, Pangbourne et al 2018). The term usually refers to a single platform, such as a smartphone application (app) where it is possible to plan, book and pay for a variety of travel modes including public transport (such as busses or trains), private transport (such as own car usage), active travel (such as walking, running or own bike use), on-demand services (such as taxis) and micromobility (e-scooter and bike hire) (Enoch, 2018, Matyas & Kamargianni, 2018, Magoutas, 2017). Often there is an aim that implementation of the MaaS will increase the use of sustainable mobility and the reduction of personal car usage within a defined geographic area (Liimatainen, 2020, Pangbourne et al, 2018).

There have been many MaaS trials worldwide but there is no standard way that the MaaS interfaces display the information to the user, Figure 1. shows screenshots from MaaS interfaces from three

different developers; Jelbi in Berlin, Whim in Helsinki and Mein GVH in Hanover. An important factor in encouraging public download and use of any smartphone application is a positive user experience (UX) (Hoehle & Venkatesh, 2015). Therefore it is essential to ensure that when MaaS apps are developed they are simple and easy to use (BritainThinks, 2021).

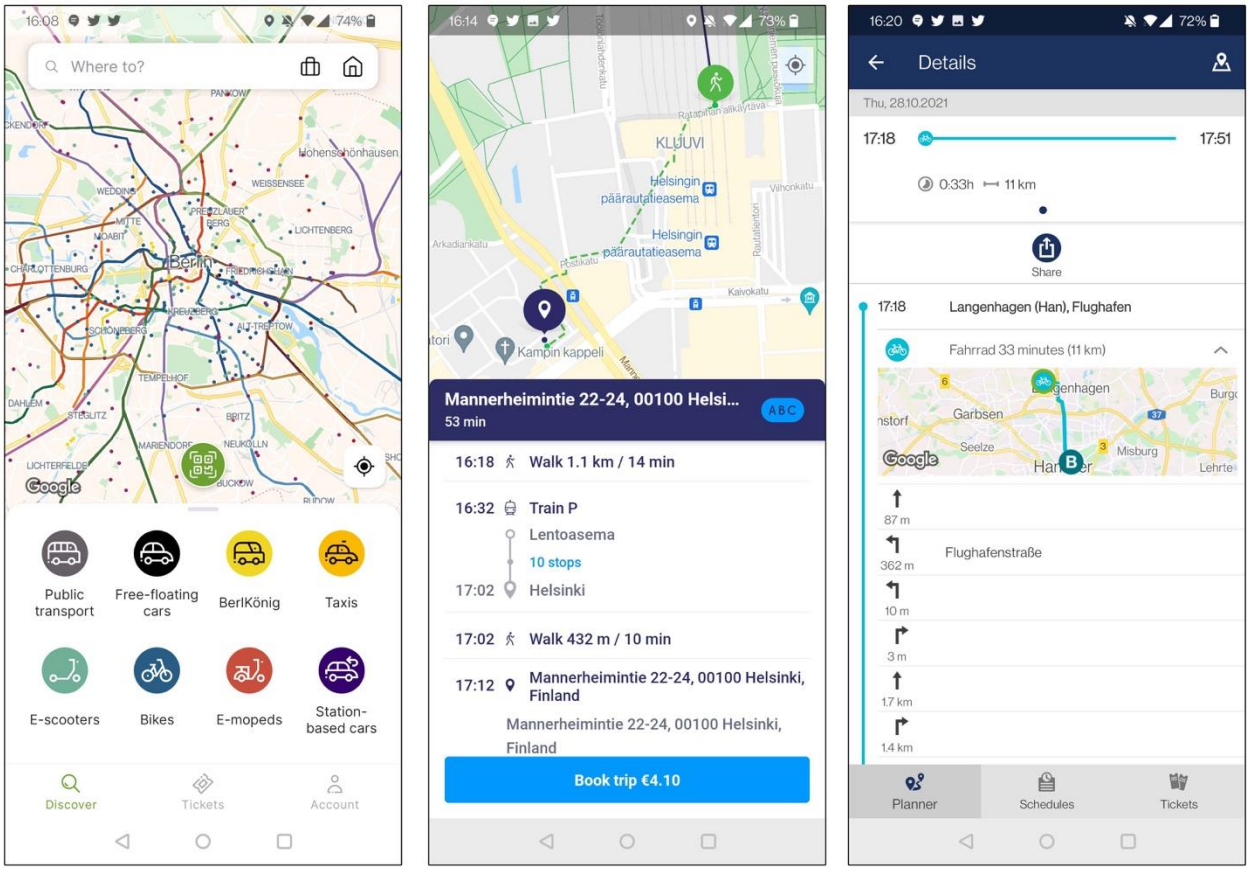

Figure 1: Examples of Maas Apps (screenshots taken 28th October 2021)

As part of the Solent Future Transport Zone (SFTZ) project it is planned for a MaaS to be developed for the region in line with the UK government's "vision for a greener, cleaner transport system is underpinned by technological innovation" (BritainThinks, 2021). The Human Factors Engineering team at The University of Southampton has been tasked with evaluating the new MaaS interface. As a first stage in this process it was determined the benchmarking of the existing mobility apps used in the Solent area would be undertaken. A selection of eleven applications which could be used for all mobility modes available were chosen but it was immediately clear that they would be difficult to compare due to having such different functionality and design.

Maas should be accessible by all citizens, (Almao & Golpayegani, 2019). Due to the broad demographics of the target population of MaaS users, it is expected potential users will have a wide range of travel needs, journey types and IT skills and resources. The target population of the Solent MaaS project includes users across all age and gender groups and the project aims to employ an inclusive design process. For this reason MaaS development should support the differing travel needs and journey types of all genders and ages (Criado Perez, 2019, Francis & Pearce, 2020), but it should also support the age and gender differences in interface design preferences and needs (Lin and Hsieh, 2016).

Heuristic analysis was identified as an effective method for measuring UX of these apps. Heuristic analysis is a method for finding the usability problems in a user interface design so that they can be addressed as part of an iterative design process (Nielsen & Molich, 1990). Heuristic analysis can be efficient in measuring when faced with limited time and human resources (Billi et al 2010, Joyce et al, 2016) with evaluation possible to be carried out by as few as three to five persons (Billi et al, 2010). A heuristics analysis tool is usually in the form of a checklist. This has the benefit that evaluators of varying experience levels will complete all elements of an evaluation (Joyce et al, 2019). Checklists therefore can contribute substantially to the improvement of the validity, reliability, and credibility of the evaluation (Scriven, 2005).

Developing a New Heuristics Tool

Review of Existing Heuristics Tools

A review of existing heuristics tools was undertaken in order to determine which theory of heuristics can be most appropriately applied to evaluate app interfaces on a touchscreen smartphone with a focus on travel and mobility. The tools varied widely with Neilson advocating having just 10 rules (heuristics), (Neilson, 1993) in contrast to Gomez who listed a massive 230 including sub-heuristics (Gomez, 2014). Table 1 shows the 12 main heuristics and associated sub-heuristics identified which were considered applicable to MaaS interfaces.

Table 1: The Twelve Heuristics and Sub-Heuristics Selected for Consideration in the New Tool

Heuristic	**Sub Heuristic & Source**
Attractive and Simple Design	Aesthetic and minimalist design (Nielsen, 2020; Gomez, 2014; Watkins, 2014). Each interface should focus on one task (Joyce, 2014). Design a visually pleasing interface (Joyce, 2016). Pleasurable and respectful interaction (Gomez, 2014). Encourage users to use content, as well as respond to the content (Watkins, 2014). Facilitate easier input (Joyce, 2016). Aim at creating an aesthetical user interface (Silva & Holden, 2014). Visual Clarity (Ravden & Johnson, 1989).
Use Plain English Which May Be Understood by a Diverse Audience	Speak the user's language (Nielsen & Molich, 1990; Nielsen, 1993). Match between system and the real world (Nielsen, 2020; Gomez, 2014; Watkins, 2014). Focus the writing on audience and purpose (Chisnell & Redish, 2005), Write in a language that is simple, clear and adequate to the audience (Silva & Holden, 2014)
Make User Journey Intuitive	Minimise user's memory load (Nielsen & Molich, 1990; Nielsen, 1993). Recognition rather than recall (Nielsen, 2020; Gomez, 2014; Watkins, 2014; Silva & Holden, 2014). Intuitive interfaces make for easier user journeys (Joyce, 2016). Design a clear navigable path to task completion (Joyce, 2016). Clearly label content categories; assist recognition and retrieval rather than recall (Chisnell & Redish, 2005) Reduce short-term memory load (Shneiderman, 1998). Compatibility - The way the system looks should be compatible with user conventions and expectations (Ravden & Johnson, 1989)
Be Consistent across all modalities of the App	Be consistent (Nielsen & Molich, 1990; Nielsen, 1993; Gomez, 2014; Shneiderman, 1998; Ravden & Johnson, 1989). Consistency and standards (Nielsen, 2020; Watkins, 2014).

	Use theme, consistent terms, conventions and standards familiar to the user (Joyce, 2016). Use consistent and explicit step-by-step navigation (Silva & Holden, 2014).
Provide Feedback to Ensure user is aware of their Status	Provide feedback (Nielsen & Molich, 1990; Nielsen, 1993; Watkins, 2014). Visibility of system status (Nielsen, 2020; Gomez, 2014). Provide immediate notification of application status (Joyce, 2016). Clear feedback on actions (Chisnell & Redish, 2005; Shneiderman, 1998; Ravden & Johnson, 1989).
Allow User Control for All	Provide clearly marked exits (Nielsen & Molich, 1990; Nielsen, 1993). User control & freedom (Nielsen, 2020; Watkins, 2014; Gomez, 2014; Silva & Holden, 2014). Let the user stay in control (Chisnell & Redish, 2005). Allow configuration options and shortcuts (Joyce, 2016). Permit easy reversal of actions (Shneiderman, 1998) Support internal locus of control (Shneiderman, 1998) Appropriate Functionality (Ravden & Johnson, 1989) Flexibility and efficiency of use (Nielsen, 2020; Gomez, 2014; Watkins, 2014; Ravden & Johnson, 1989).
Provide Shortcuts & Allow Use of Phone Features to Streamline Processes	Provide shortcuts (Nielsen & Molich, 1990; Nielsen, 1993). Use the camera, microphone and sensors when appropriate to lessen workload (Joyce, 2016)
Provide Clear Error Messages with Instructions for Recovery	Good error messages (Nielsen & Molich, 1990; Nielsen, 1993). Recognise, diagnose and recover from errors (Nielsen, 2020; Gomez, 2014; Watkins, 2014). Assist users should a problem occur (Joyce, 2016). Provide clear feedback when presenting error messages (Silva & Holden, 2014). Offer simple error handling (Shneiderman, 1998). Inbuilt facilities for handling errors which occur (Ravden & Johnson, 1989).
Prevent Errors	Prevent errors (Nielsen & Molich, 1990; Nielsen, 1993; Nielsen, 2020; Gomez, 2014; Watkins, 2014; Joyce, 2016). Better to prevent an error than recover from it (Silva & Holden, 2014). The system should be designed to minimise the possibility of user error (Ravden & Johnson, 1989).
Provide Help in FAQs	Help and documentation (Nielsen, 1993; Nielsen, 2020; Gomez, 2014; Watkins, 2014; Silva & Holden, 2014). Informative, easy-to-use guidance and support should be provided (Ravden & Johnson, 1989)
Ensure Trust in App	Privacy (Gomez, 2014)
Inclusive Design	System does not rely on IT skills (Gomez, 2014; Shneiderman, 1998) Cater for diverse mobile environments (Joyce, 2016) Do not rely on colour alone (Silva & Holden, 2014) Be aware of colour blindness (Silva & Holden, 2014)

Many of the heuristics tools were focused on general interface design or desktop based applications, and, whilst many have points which are relevant to all, it should be noted that the user of a smartphone app may have different needs; Smartphones have no physical keyboard with a different method of input via touchscreen, there are the limitations of the small screen size (Richardson et al 2021, Punchoojit & Hongwarittorrn 2017, Salgado & Freire 2014, Joyce et al 2016) but they also

have the additional quality in that they are truly portable meaning they can be used in changing environments (Punchoojit & Hongwarittorrn 2017, Salgado & Freire 2014, Joyce et al 2016). None of the tools identified were aimed at mobility or MaaS apps and the specific user requirements these entail.

A New Heuristics Tool For Evaluating Mobility and MaaS Apps

The authors devised and then tested many iterations of a new tool by applying them to eleven mobility applications used in the Solent area. As a result of this iterative design process ten heuristics were selected with 37 sub heuristics in the form of questions as show in Table 2. Each question was phrased in order that it could be answered by selecting one of the following answers which were given a score; Fully Compliant (2), Partially Compliant (1) and Not Compliant (0). Once all questions were answered a total score could be given to the app.

Table 2: The Final Selection of Ten Heuristics and Sub-Heuristics included in the Tool

Heuristic	**Sub Heuristic**
Attractive And Simple Design	1.1 Is the landing page aesthetically pleasing, encouraging you to use it? (Consider elements such as proportion, colour use, consistency and balance) 1.2 Do all pages feature a clear layout with all elements adding value? 1.3 Are only necessary elements for the current task presented on the screen? 1.4 Is the main palette a maximum of four colours/hues (any additional colours should be for occasional use only)? 1.5 When a map is displayed are important locations (POI, landmarks, destination) clearly indicated?
Use Plain Language Which May Be Understood By A Diverse User Group	2.1 Is the app free from any acronyms, jargon, slang or shortening of words? 2.2 Is all text in 'everyday language' avoiding longer words where possible?
Make User's In-App Journey Intuitive	3.1 Do all icons related to something concrete and familiar rather than concept related or abstract? 3.2 Are icons free from reliance on cultural norms or without unintended (possibly negative) cultural meanings? 3.3 Is it obvious to a novice user where to start on each page and how to interact with, and navigate through, the app to task completion? 3.4 Is there a clear hierarchy with important features at the top or bottom? 3.5 During navigation is the map view visible and conventionally presented?
Be Consistent Across All Page And Through All Modalities of the App	4.1 Are the same language and terms used when planning, booking and paying for any transport mode? 4.2 Are the same colours and icons used across all sections of the app? 4.3 Do all sections of the App use the same design conventions and page layout?
Provide Feedback to Ensure User is Aware Of App Status	5.1 Can the user always see where they are at each stage in the process (e.g. in the plan, ticket and navigate)? 5.2 Is feedback multimodal? Textual, Graphical, Vibration and/or Sounds?
Allow User Control For All	6.1 Can the user 'undo' actions and are the results as expected? 6.2 Can users move between, and view, all stages of a selected journey during navigation?
Provide Shortcuts & Efficient Use Of Phone Features	7.1 Can the user add shortcuts for commonly used locations such as home or work to make journey planning quicker?

	7.2 Does the app allow the use of sensors, camera or microphone to streamline actions? For example, when adding payment options or driving license validation, using GPS to indicate user location? 7.3 Does the app provide Suggestions/Autocomplete/Autocorrect whilst typing locations? 7.4 Does app autosave recent searches? 7.5 Is there live tracking of services (such as real-time bus information or location of e-scooters?
Prevent Errors And Provide Clear Messages for Recovery If Errors Occur	8.1 Has the app been used without encountering any errors or bugs? 8.2 Does the App pre-empt user error through warning messages? 8.3 Are error messages presented in plain language without using technical terms or codes? 8.4 Do error messages and warnings offer constructive recovery solutions?
Provide Help And FAQs	9.1 Are there sufficient Help and FAQs in the app? 9.2 Are the Help/FAQs easy to find? 9.3 Are there options for further help where query is not answered by Help/ FAQs (e.g. live chat, messaging or email)?
Inclusive Design	10.1 Is the app suitable for users with colour vision deficiency e.g. inactive colour receptors, or weak colour receptors effecting perception of red, green or blue? 10.2 Is there sharp tonal contrast within and between elements? 10.3 Do users only need to monitor one task at a time 10.4 Are clickable items easy to identify, target and hit? 10.5 Any there additional accessibility options in settings (such as accessible places, ability to change theme to light/dark)?

Discussion

Included Heuristics

Due to the nature of device and type of app being evaluated some heuristics were included which may not be considered in traditional interface evaluation or were considered in a different way:

- Attractive and Simple Design - The questions for this heuristic have been devised to evaluate the aesthetics of the design of the interface whilst removing subjectivity, it was also considered important to evaluate the map as this is such an essential element of a MaaS app. How the icon for the app appears on the phone was also considered relevant so that it could be easily identified and selected by the user amongst the busy real-estate of the user's phone screen.
- Use Plain Language Which May be Understood by a Diverse User Group - The MaaS app is designed to be used by all members of the community and it is therefore important any text or instructions may be easily understood.
- Make User's In-App Journey Intuitive - The app should not rely on any previous knowledge or experience of using similar apps or images which are not easily identified as usability of icons can be influenced by cultural and age differences (Punchoojit & Hongwarittorrn, 2017; Richardson et al, 2021)
- Be Consistent Across All Pages and Through All Modalities of the App - for pleasant UX and to avoid confusion consistence across the MaaS the same graphics and language conventions should be used throughout.
- Provide Feedback to Ensure User is Aware of App Status - It should be clear where the user is in the Plan, Book, Pay process and feedback should make use of all modes available.

- Allow User Control for All - It is helpful for the user to be able to explore their potential journeys or travel modes and so being able to move freely within the app facilitates this.
- Provide Shortcuts & Efficient Use of Phone Features - Making full use of the available technologies within the smartphone will streamline processes and make for a pleasant UX.
- Prevent Errors and Provide Clear Messages for Recovery if Errors Occur - Whilst it is always preferable to not experience any error where they occur it is important to be able to recover quickly as the MaaS will be used 'on the go'.
- Provide Help and FAQs - Similarly to the reasons above as the MaaS will be used for live journey planning it is important there is sufficient help and that it is easy to find.
- Inclusive Design - It is hoped that the widest range of the members of the community are able to experience the benefits of using the MaaS and so any steps to make it more inclusive should be considered.

Excluded Heuristics

Some heuristics were rejected from the final version of the tool but these were still considered very important considerations for a successful MaaS. These were all included within the heuristic 'Ensure Trust in App'. These questions fell into two categories.

The first was Safety and Security which included the following questions; Is it clear the app is safe to install from the app store? Are payment options obviously secure? And Is my personal data obviously secure? Whilst positive answers to these questions is likely to encourage usage of the MaaS it was considered that these questions could not be answered by evaluating the interface currently. However it is suggested that there could be some accreditation for apps which could be displayed on the landing page to confirm that certain standards have been met, similar to the 'kite mark' system used by British Standards Institution for product safety.

The second category was Trust in the data which included the question, Is there live tracking of services (such as real-time bus information or location of scooters)? Again, this was considered an extremely beneficial feature for the MaaS app and would encourage user adoption. However it was also considered outside the scope of interface evaluation as the accuracy of the data is not part of the interface design.

Conclusion

A suitable tool did not exist for the UX evaluation of mobility and MaaS app interfaces. However building upon previous tools and advice it was possible to determine what would be important to the user of the MaaS interface. Therefore a combination of traditional UX heuristic questions and new questions targeted to the demands of a MaaS were compiled in order to develop a new tool which met the demands of this evaluation task. This tool is now being used to complete the benchmarking task of existing mobility apps available in the Solent region alongside site maps and user flow.

This tool has been used to evaluate the eleven mobility apps previously identified and has resulted in some design recommendations for the MaaS development, Future work involves using this heuristics tool to evaluate the new MaaS apps which will be released as part of the SFTZ project. The analysis will inform the development of each iteration of the product over the course of the next three years.

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