

Using Semi-Formal Models to Design a Fintech Chatbot for Older Adults

Swaroop Panda^{1,2}

¹Department of Computer & Information Sciences
Northumbria University
Newcastle Upon Tyne, UK
swaroop.panda@northumbria.ac.uk

Effie Lai-Chong Law²

²Department of Computer Science
Durham University
Durham, UK
lai-chong.law@durham.ac.uk

Formal models are important within HCI research as they furnish structured frameworks facilitating comprehension, prediction, and the design of interactions between humans and technology. Given the digitisation of numerous banking operations, the design of fintech chatbots for older adults assumes significance. It is imperative to meticulously consider their distinct requirements and inclinations during the design and development process. In this work, we introduce semi-formal models intended for the development of a fintech chatbot designed specifically for older adults. We use two semi-formal models, namely Hierarchical Task Analysis and Design Space Analysis with QOC (Questions-Options-Criteria) framework elucidating their applicability in outlining financial transactions such as bank transfers, facilitating the chatbot's design and formulating an evaluation strategy.

Semi-formal models, Chatbots, Older Adults, HTAs, QOC

1. INTRODUCTION

Formal models play a crucial role in Human-Computer Interaction (HCI) by providing structured frameworks for understanding, predicting, and designing interactions between humans and technology (Weyers et al. (2017)). These models help researchers and designers to systematically analyse user behaviours, cognitive processes, and system dynamics. By formalising aspects such as user goals, task structures, interface designs, and system behaviours, these models enable a deeper understanding of the underlying principles governing human-computer interactions. Additionally, formal models facilitate the evaluation and comparison of different interface designs, aiding in the identification of usability issues and potential improvements.

As the digitisation of banking services continues to advance, there arises a critical need to develop a fintech chatbot tailored specifically for older adults, a demographic with unique needs and preferences. Given the increasing reliance on digital platforms for banking activities, including transactions, inquiries, and account management, the design of such a chatbot holds significant implications for enhancing accessibility and usability among older adults. Factors such as cognitive abilities, technological familiarity, and preferences for intuitive and existing interfaces must be carefully considered to ensure

the chatbot effectively addresses the diverse requirements of this demographic (Maqbool and Munteanu (2018)). Furthermore, integrating features such as voice recognition, simplified navigation, and personalised assistance can contribute to a more user-friendly and inclusive banking experience for older adults.

Semi-formal models (Law et al. (2023)) have been used for crafting and assessing a fintech chatbot customised to meet the specific requirements of older adults. We use Hierarchical Task Analysis (HTA) (Annett (2003)) and Design Space Analysis (Braun et al. (2017), MacLean et al. (2020)) to showcase the application of these tools in the design and evaluation of the chatbot, as well as in facilitating bank transfers through the chatbot.

2. BACKGROUND

2.1. Formal & Semi-Formal Models in HCI

Formal and semi-formal models primarily differ in their level of rigour and the methods employed. Semi-formal methods utilise structured and systematic notations that offer greater precision than natural language but do not attain the full rigour characteristic of formal models. Several approaches have been suggested for integrating formal and semi-formal models into HCI research (Harrison and Thimbleby

(1990); Palanque and Paternò (2012); Weyers et al. (2017); Oulasvirta et al. (2018)). These methods encompass a range of techniques utilised for designing interactive systems, modeling user behaviour, and analysing user-system interactions. These models additionally provide invaluable insights into verifying systems, guaranteeing accuracy and resilience amid user interactions.

By utilising techniques such as user interviews, which traditionally yield qualitative insights and observations, Bowen et al. (2023) showcase the transformational potential of these informal data sources into structured, formal models. This process allows for a deeper understanding of user behaviours, preferences, and needs, which are then translated into concrete representations using formal methods like Petri nets (Murata (1989)) and semi-formal models like BPMN (Law et al. (2023)).

Hierarchical Task Analysis (HTA) is a systematic method used to decompose complex tasks into a hierarchy of simpler sub-tasks (Stanton (2006); Annett (2003); Phipps et al. (2011)). In HTA, tasks are broken down into smaller and more manageable components, creating a hierarchical structure that illustrates the relationships between different actions and goals. HTAs have been used to enhance user experience of an interaction system (Fyiaz et al. (2018)) and to facilitate the UI design of a drawing application (Sabariah et al. (2016))

Design Space Analysis is used to explore and understand the potential design alternatives within a given problem space (MacLean et al. (1991); Card et al. (1991); Bowen and Dittmar (2016)). It involves systematically examining and organising the various design options, constraints, and trade-offs that exist when creating a solution for a particular problem. It enables designers to map out the multidimensional space of possible design configurations, considering factors such as functionality, usability, aesthetics, and feasibility. Questions, Options and Criteria (QOCs) MacLean et al. (2020) are a semi-formal notation used to represent a design space around an artifact. Questions(Q) contain the different design considerations, Options(O) represent potential solutions to these Questions, and Criteria(C) are utilised to evaluate and compare Options.

2.2. Fintech Chatbots for Older Adults

In the UK, numerous banks are transitioning towards the digitization of financial services, embracing various financial technologies (Espiner (2022)). However, there exists a potential risk of marginalisation among elderly individuals if these technologies fail to accommodate their specific needs and preferences.

Sin et al. (2021) introduce the concept of *Digital Design Marginalisation*, highlighting how non-inclusive design practices contribute to the inaccessibility of online services such as personal finance, health-care, and shopping, thus exacerbating the digital divide. Related research by Maqbool and Munteanu Maqbool and Munteanu (2018) delves into the design considerations for user interfaces tailored to the financial practices of elderly individuals. Through a contextual inquiry involving elderly users in Canada, the authors propose guidelines and recommendations for the development of mobile applications. These suggestions include incorporating educational components into financial apps and implementing features that encourage elderly users to make decisions conducive to maintaining their lifestyle.

Our semi-formal models are constructed based on insights derived from the recommendations provided by Koebel et al. (2021) who offer practical guidance regarding the enhancement of user-friendliness in chatbots tailored for older adults and individuals with cognitive impairments. These recommendations advocate for the clear and straightforward organisation of content and structure within the chatbot interface, aiming to avoid overwhelming or intimidating users with excessive features or sensory stimuli. Furthermore, in interface design, prioritisation is given to elements such as ample font size and target size, alongside high-contrast visual features. It is important to acknowledge that these recommendations are less precise than those obtained from empirical studies involving older adults.

3. HTA FOR A BANK TRANSFER

A formal and structured process for a bank transfer is crucial to ensure the security, accuracy, and efficiency of financial transactions. By following a systematic procedure, banks can verify the identity of the parties involved, authenticate the transfer request, and validate the accuracy of the transaction details, as enabled by the model in Gacitua-Decar and Pahl (2008). This structured approach helps mitigate the risk of fraud or error, safeguarding both the bank and its users' interests (Kulik et al. (2022)). Additionally, a formal process ensures compliance with regulatory requirements and internal policies governing financial transactions, thereby reducing the potential for legal or regulatory issues.

The HTA outlines the use of few unique features in the chatbot,

1. A voice assistant is valuable for a chatbot as it enhances the user experience by providing a natural and intuitive way for users to interact.

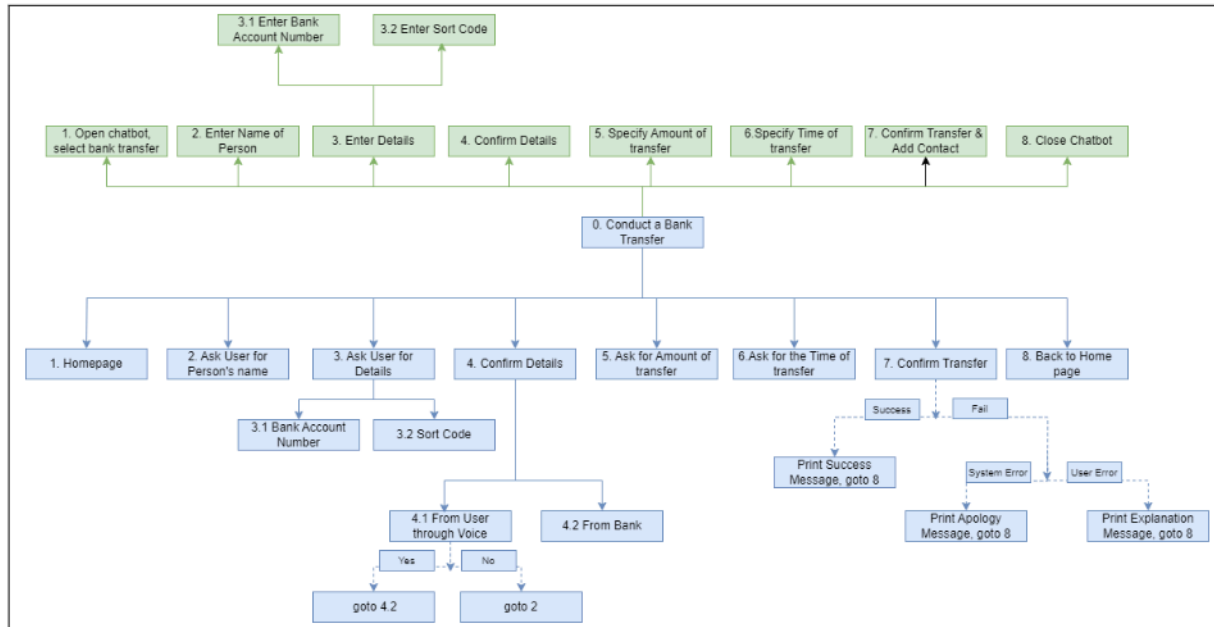


Figure 1: Graphical HTA for the Chatbot's (in blue) and the User's (in green) Actions

It improves accessibility, making the chatbot available to a broader audience, and offers convenience by allowing hands-free interaction (Pradhan et al. (2018)). Voice assistants also complement other interaction modes, offering users a choice based on their preferences and context. With features like NLP and voice recognition, voice assistants personalise the chatbot experience, creating a more engaging and immersive conversation.(Braun et al. (2019)).

2. An apology becomes necessary when a system error occurs, placing responsibility on the system rather than the user (Farage et al. (2012)). This situation arises, for example, when a financial transaction fails due to technical issues within fintech systems (e.g., banks), despite the user inputting accurate information. The purpose of the apology is to prevent the user from attributing the transaction failure to their own mistake and instead reassure them that the system encountered an issue beyond their control.
3. In this instance, when the user inputs incorrect details or the amount to transfer is more than the available bank balance, the system doesn't abruptly terminate the transaction. Instead, it provides a gradual explanation for the issue, without assigning blame to the user. This approach aims to assist the user in recognising that an error occurred due to inaccurately entered details (Yuan et al. (2020)). The overarching objective is to ensure that elderly

users feel encouraged to engage with the chatbot for financial transactions in the future.

The concepts of system apology and system explanation derive their foundation from the principles elucidated in the domain of explainable AI (Gilpin et al. (2018); Hoffman et al. (2018)). Within this paradigm, AI systems are perceived as "black boxes", necessitating their involvement in elucidating the mechanisms and decisions underlying their operations to users. The integration of such tools and methodologies within a system is also associated with a heightened level of trust in the system (Weitz et al. (2019)).

4. CHATBOT DESIGN & EVALUATION

The attitudes of older adults toward technology are diverse. While some are comfortable with and embrace new technology due to prior experience, others remain skeptical, possibly due to limited exposure or past negative encounters (Mitzner et al. (2010)). Given this spectrum of perspectives, it's crucial to design technological solutions that cater to the needs of all older adults. Designers must navigate trade-offs and accommodate varying preferences and capabilities within this demographic. For example, some may prefer simple interfaces with large text and straightforward navigation, while others may desire more advanced features tailored to their interests. Ensuring inclusivity and user-friendliness requires considerations such as accessibility features, ease of use, and clear instructions for older adults of diverse backgrounds and abilities (Farage et al. (2012)).

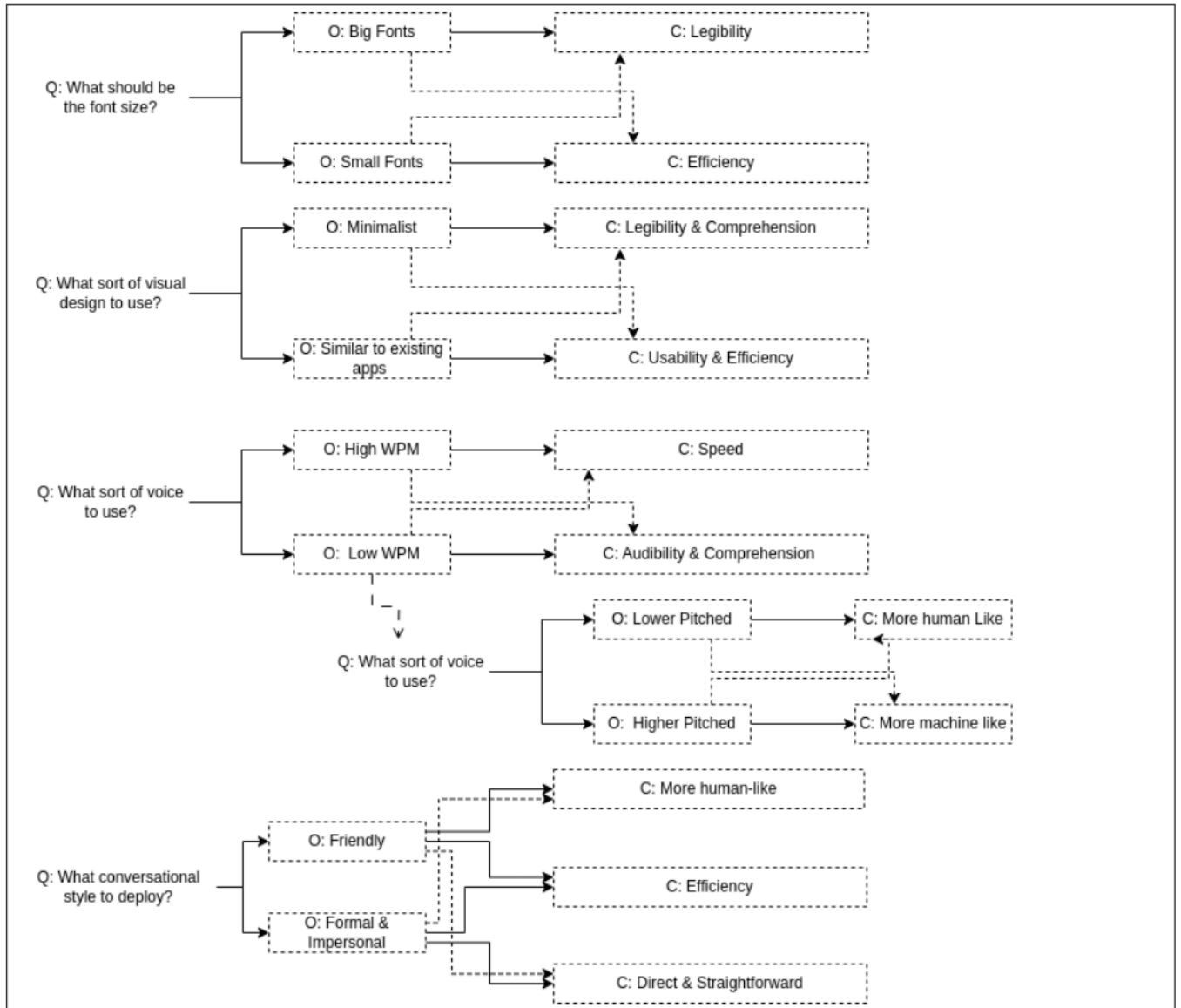


Figure 2: QOC for the Design of the Chatbot.

One way to analyse such tradeoffs is using QOC (Questions, Options, Criteria). The QOC methodology facilitates the delineation of pertinent inquiries encompassing various aspects, including but not limited to font sizes and voice quality. It aids in identifying diverse alternatives for addressing these inquiries, such as the selection between smaller or larger font sizes and swifter or more deliberate text-to-speech conversion rates. Additionally, QOC assists in establishing distinct criteria for evaluating trade-offs, such as balancing considerations between legibility and efficiency, or prioritising speed against audibility.

The bold lines that connect the Options and Criteria represent a positive impact while the dotted lines represent adverse impact. The dashed line linking an Option with a Question indicates a subsidiary question arising from the selection of said Option.

4.1. Design

For the chatbot design, key considerations (adapted from Farage et al. (2012); Koebel et al. (2021); Maqbool and Munteanu (2018) to be older adult friendly) that we include are font size selection, visual design, voice characteristics, and conversational style. Each aspect offers multiple options, each accompanied by specific criteria for comparison and trade-offs. These options and criteria are created keeping in mind the needs of older adults. This is depicted in Figure (2).

Considering Figure (2) employing larger font sizes in the chatbot interface may enhance legibility but could potentially diminish efficiency of use. Similarly, using a reduced words-per-minute rate alongside a higher-pitched voice may enhance the chatbot's own machine-like characteristics and improve audibility

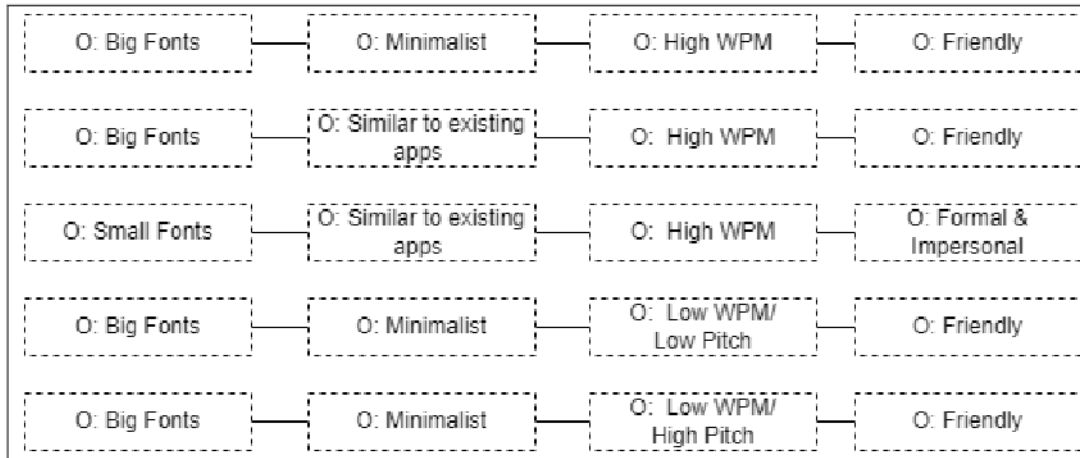


Figure 3: Evaluation scenarios for the chatbot adapted from the QOC

and comprehension. However, this adjustment may lead to a decrease in speed of task completion and may not contribute to rendering the chatbot more human-like.

4.2. Evaluation

This proposed evaluation plan is the pathway that leads to co-design approaches for designing with older adults (Sakaguchi-Tang et al. (2021); Ostrowski et al. (2021)). The plan, in Figure 3, includes the different options to facilitate user studies. The idea involves creating different iterations of the chatbot based on (initially) five distinct sets of design considerations. These iterations are subsequently presented to users for a comprehensive comparative evaluation. Fundamental to the comparative assessments is an examination of the interplay among diverse factors, encompassing visual design, font sizes, voice quality, and conversational style. We choose the iterations to emphasise few factors which we think are important to evaluate. Among these factors is the consideration of whether the preferred style of communication aligns more closely with human-like or machine-like attributes. As depicted in Figure 3, we assess the interplay between large font sizes and a minimalist visual design, considering both a lower pitch and reduced words-per-minute alongside a friendly conversational style. Additionally, we examine the interaction between large font sizes and a minimalist visual design, this time incorporating a higher pitch and reduced words-per-minute while maintaining a friendly conversational style.

Additionally, a significant aspect of our assessment entails comparing preferences regarding the minimalist design of the application versus a visual design akin to that of existing applications. We also investigate how large font sizes interact with a design resembling an existing interface, maintaining

a higher words-per-minute rate while employing a friendly conversational style. Ideally, we could evaluate as many combinations of different values of the variables as possible. But it would be prohibitively resource-demanding and impractical to implement requiring a vast number of participants. The intended cohort size for each scenario is set to be 30 participants. The experimental design involves scenario-based evaluation, requesting older adults to conduct a bank transaction in a given context (e.g., transfer money with a fictitious bank account; ensuring privacy and security no personal data is involved) using the chatbot. Subsequently, participants will be invited to provide feedback through a survey regarding their experiences during the transaction process. Thematic analysis will be applied to participants' qualitative responses to identify key patterns and insights. Based on the analysis results, our challenge is to identify and customise the most optimal interface option(s), possibly incorporating multiple adaptations to cater to varying user preferences and needs.

5. CONCLUSION

This work introduces semi-formal models aimed at aiding the development of fintech chatbots tailored for older adults. It illustrates how HTAs can assist in outlining the process of bank transfers facilitated by the chatbot. The study demonstrates the utility of design space analysis, employing QOCs for the design and evaluation of chatbot. A significant limitation of using such semi-formal models is their often inadequate representation of the complexity and variability of human behavior and contextual nuances. Thus for future work, additional assessment scenarios may be included utilizing the QOC framework and HTA, which then can be enhanced with the insights gained from the empirical data of co-design studies with older adults.

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