Highlights

"I Do not Dare to Try and Ask" Comprehensive Framing of Chinese Older Adults' Difficulties and Corresponding Mental Barriers in Completing Smartphone Interaction Tasks

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- We not only involve older adults but also their helpers into our research, which makes the findings more comprehensive and in-depth.
- We contribute a comprehensive conceptual model which presents the relationship between the older adults' mental barriers and concrete difficulties when using smartphones to complete interaction tasks, based on the Chinese cultural background.
- Based on our proposed conceptual model, we propose corresponding design considerations for older adults' pain points, and further infer how the improvement to one factor will affect older adults mental barriers and other difficulties.

"I Do not Dare to Try and Ask" Comprehensive Framing of Chinese Older Adults' Difficulties and Corresponding Mental Barriers in Completing Smartphone Interaction Tasks

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Abstract

Psychological factors such as low self-efficacy are found to challenge older adults' smartphone usage. However, there is a lack of studies trying to frame how older adults' mental barriers relate to interaction problems, response behaviors, and challenges of dealing with them in the context of smartphone interaction tasks. We conducted a two-phase qualitative user study to explore such questions. We summarize 4 common interaction problems, 4 types of help-seeking challenges, and 4 typical response behaviors to them. We also present 5 common mental barriers of older adults that could stem from and result in their interaction problems and help-seeking challenges, and affect their response behaviors. Our work contributes a conceptual model of how older adults' interaction problems, response behaviors, and help-seeking challenges relate to their mental barriers. We highlight the importance of

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supporting older adults to overcome their mental barriers in helping them tackle smartphone interaction problems.

Keywords: older adults, smartphone interaction difficulties, mental barriers

1. Introduction

Smartphones offer numerous applications (*e.g.*, camera, Amazon, WeChat) that facilitate users' daily activities like photo taking, online shopping, and instant messaging (Baudisch and Holz, 2010; Bell and Dourish, 2007; Tian et al., 2020). In this paper, we denote these activities completed via smartphones as **smartphone interaction tasks**. Since smartphone interaction tasks require users to access a series of app pages, collect, understand, filter, and synthesize information from multiple sources (Tian et al., 2020), they are often challenging for older adults who are less tech-savvy (Zhou et al., 2014; Arning and Ziefle, 2009; Gordon et al., 2019b). Taking online shopping on Amazon as an example, a user may need to search for an item on a page, scroll the page up and down to browse recommended items, click an item to check it in detail, return to the main page, enter the version and number of the bought items, and enter passwords in the payment page. Although user experience (UX) designers have tried to optimize the workflow and page navigation, older adults can still get lost in the interface (Li, 2019). Our work focuses on understanding the problems older adults encounter and their challenges when dealing with these problems in smartphone interaction tasks. Such understandings can offer social value and insights for developing accessible smartphone applications to benefit older adults.

Difficulties of older adults in smartphone usage have been a long-standing concern in the human-computer interaction (HCI) community. Previous research has identified factors that could challenge older adults' smartphone usage from physiological (*e.g.*, visual loss (Piper et al., 2017), declining memory and spatial ability (Li and Luximon, 2020), and inaccuracy of a single action (Nicolau and Jorge, 2012; Wacharamanotham et al., 2011)) and psychological perspectives (*e.g.*, negative attitudes towards smartphone usage (Atkinson et al., 2016; Berenguer et al., 2016; Navabi et al., 2016; Franz et al., 2019b), less perceived ease of use and usefulness (Franz et al., 2019b; Conci et al., 2009; Adams et al., 2005), and low enjoyment (Conci et al., 2009)). There are also works on identifying the causal relationship between physiological factors (*e.g.*, declining memory) and older adults' problems

(*e.g.*, find a specific function) in smartphone interaction tasks (Zhou et al., 2014). Nevertheless, the research community lacks a comprehensive framing of how these factors, especially psychological ones, synergize to challenge older adults in smartphone interaction task completion. For example, problems resulting from physiological factors (*e.g.*, hard to find a certain user interface (UI) element) may also lead to psychological barriers (*e.g.*, low self-efficacy), which further affect older adults' behavior in tackling the problem (*e.g.*, not dare to take trial-and-error). To our knowledge, psychological factors are more often discussed with older adults' high-level attitudes towards technology adoption and learning (Zhou et al., 2014; Pradhan et al., 2020; Kelley and Charness, 1995; Czaja et al., 2019; Leung et al., 2012; Birdi and Zapf, 1997; Cooper-Gaiter, 2016; Berenguer et al., 2016; Franz et al., 2019a). However, they are less often discussed in the context of interaction task completion. For example, whether and how the difficulties encountered by older adults may shape their mental barriers, potentially impeding the successful completion of interaction tasks. We define the **mental barriers** as certain ways of thinking, reasoning, and worrying towards the interaction problems and problem-solving behaviors, which prevent older adults from tackling the interaction problems and completing the interaction tasks. This work aims to fill the gap between older adults' mental barriers and their encountered problems in the context of smartphone interaction tasks.

Since psychological factors are influenced by cultural context (McIntosh et al., 2022), a universal conclusion cannot be assumed. Therefore, we concentrate on the older adults in China, given its significant and rapidly growing size, and the prevalence of the digital divide among them, as evident from previous research (Deng and Fraser, 2023; Liu et al., 2021a; Song et al., 2021). We offer a comprehensive view of Chinese[1] older adults' mental barriers, interaction problems, typical response behaviors, and help-seeking challenges in smartphone interaction tasks. To design effective formal user studies with older adults, we first conducted a pilot study through an online questionnaire with 20 young Chinese who had experience of helping older adults with smartphone interaction tasks to sense older adults' problems and problem-solving practices from the helpers' perspectives. This survey also identified

[1]The proportion of the population aged 65 and above reported by the last five censuses are 4.91%(1982), 5.57%(1990), 6.96%(2000), 8.87%(2010) and 13.5%(2020) (Deng and Fraser, 2023)

28 smartphone interaction tasks, such as "Join a WeChat group", "Write and send a message", and so on, in which young people helped older adults before. We then designed and conducted a two-phase qualitative study with 16 Chinese older adults who were over 60 years old based on the findings from the pilot survey. In phase 1, we conducted four focus group sessions with participants to discuss their typical smartphone interaction difficulties and approaches for dealing with them. In phase 2, we observed participants' problems and behaviors in 28 smartphone interaction tasks collected from the survey. We encouraged participants to think aloud in this phase, which offers contextual understandings of their smartphone interaction problems and behaviors from the first perspective.

The qualitative data collected during the two-phase study are analyzed using thematic analysis (Braun and Clarke, 2012), under the hypothesis that older adults' mental barriers may causally relate to their concrete interaction problems and problem-solving behaviors. The analysis results in a conceptual model illustrating the relationship among four themes: interaction problems, mental barriers, typical response behaviors, and challenges in seeking help for smartphone interaction tasks. Our key findings show that interaction problems can shape older adults' mental barriers on the one hand (*e.g.*, Lagging awareness of mistakes could make older adults feel unconfident in completing interaction tasks independently). On the other hand, mental barriers can also lead to interaction problems (*e.g.*, Feeling afraid of making new mistakes in trial-and-error could obstruct older adults from finding the task completion path). We also show a similar relationship between mental barriers and help-seeking challenges (*e.g.*, Halfway instructions from the helper can give the impression of inconvenience or impatience, which makes older adults hesitant to ask further questions, and this in turn prevents them from getting well tutored). The formed mental barriers can also affect older adults' typical behaviors when dealing with the encountered interaction problems (*e.g.*, Some older adults even abandon some smartphone functions because of the concern about not being kindly treated by the helper).

Our work contributes a conceptual model that presents how older adults' mental barriers relate to their encountered interaction problems, problem-solving behaviors, and help-seeking challenges in the context of smartphone interaction tasks, through user studies conducted from both helpers' and older adults' perspectives. The hindrance to interaction task completion among older adults is not solely caused by the interaction problems, but also by the mental barriers that they develop, which impede their problem-

solving progress. Based on our findings, we propose some design implications that not only directly help older adults tackle the interaction problems but also target at reducing their mental barriers when completing smartphone interaction tasks.

2. Related Work

We discuss prior work that our work builds on from the perspectives of understanding older adults' challenges when using information technology, and methods of improving smartphone usage for older adults.

2.1. Understanding the Challenges Faced by Older Adults When Using Information Technology

Together with the advances of new information and communication technologies (ICT), there have been extensive studies on investigating the difficulties faced by older adults in using these new technologies (see Table 1). These studies range from Internet service Morrell et al. (2000); Adams et al. (2005); Melenhorst et al. (2001), computers Selwyn et al. (2003); Wagner et al. (2010) and feature phones Kurniawan et al. (2006); Kurniawan (2006, 2008) in early and middle 2000s, to more recent devices such as large touchable screens Lepicard and Vigouroux (2010); Caprani et al. (2012), VUI-based voice assistants Pradhan et al. (2020); Trajkova and Martin-Hammond (2020), and immersive VR interfaces Huygelier et al. (2019). The prevalence of smartphones -the most popular mobile information devices- led to many studies focusing on elderly users' challenges in daily life smartphone usage Franz et al. (2019c); Kobayashi et al. (2011); Mohadisdudis and Ali (2014). Although these previous studies were conducted at different times with different research methods (survey Rosales and Fernández-Ardèvol (2016); Leung et al. (2012), interview Franz et al. (2019a), in-lab or field observation Leung et al. (2012); Harada et al. (2013), and data-driven Gordon et al. (2019a), *etc.*) and focused on diverse technological products or services, they consistently report on similar findings. Older adults generally have interests in using new technologies Rosales and Fernández-Ardèvol (2016); Harada et al. (2013), but they have more difficulties than younger ones due to user characteristics specific to their demographic (*e.g.*, declines in spatial working memory, lower perceptual speed, lack of relevant technology experience, low self-efficacy, and a higher negative reaction to errors Czaja et al. (2019); Leung et al. (2012);

Table 1: A comparison of representative research in aspects of focused technologies, derived barriers, methods, and limitations

Focused technology	**Derived challenges and barriers**	**Research work**	**Methods**	**Limitations**
PC, early internet, voice assistant, feature phone, virtual reality	Psychological barriers including technology acceptance attitude and anxiety to error	Cooper-Gaiter (2016); Birdi and Zapf (1997); Wagner et al. (2010); Adams et al. (2005); Melenhorst et al. (2001); Pradhan et al. (2020); Trajkova and Martin-Hammond (2020); Huygelier et al. (2019); Conci et al. (2009)	Survey, interview, in-lab observation, focus group, and probe-based user experiments	High-level attitudes with weak link to concrete interaction problems and task completion barriers
PC, voice assistant, feature phone, virtual reality, touchscreen	Physiological barriers including perceptual and cognitive barriers	Wagner et al. (2010); Selwyn et al. (2003); Birdi and Zapf (1997); Kurniawan et al. (2006); Kurniawan (2008); Lepicard and Vigouroux (2010); Caprani et al. (2012); Pradhan et al. (2020); Trajkova and Martin-Hammond (2020); Piper et al. (2017); Huygelier et al. (2019); Nicolau and Jorge (2012); Wacharamanotham et al. (2011)	Survey, focus group, probe-based user experiments, quantitative comparative studies, interviews, and in-lab observation	Characteristic-level findings without connecting to contextual interaction breakdowns
PC, early internet, feature phone, voice assistant	Structural barriers including knowledge gap and financial or access barriers	Morrell et al. (2000); Selwyn et al. (2003); Melenhorst et al. (2001); Kurniawan et al. (2006); Pradhan et al. (2020); Trajkova and Martin-Hammond (2020)	Survey, focus group, and probe-based user experiments	Analyzed as factors influencing technology adoption without considering relationships to specific barriers in concrete interaction tasks
	Psychological barriers including technology acceptance attitude and anxiety to error	Franz et al. (2019c); Leung et al. (2012)	Interviews	High-level attitudes with weak link to concrete interaction problems and task completion barriers
	Physiological barriers including perceptual and cognitive barriers	Mohadisdudis and Ali (2014); Pang et al. (2015); Kobayashi et al. (2011); Li and Luximon (2020)	Interviews and in-lab observations	Characteristic-level findings without connecting to contextual interaction breakdowns
Smartphones	Structural barrier including knowledge gap and financial or access barriers	Franz et al. (2019c); Mohadisdudis and Ali (2014); Pang et al. (2015)	Interviews	Analyzed as factors influencing technology adoption without considering relationships to specific barriers in concrete interaction tasks
	Contextualized difficulties preventing the completion of a smartphone interaction task	Harada et al. (2013); Li (2019)	In-lab observations	The contextualized findings do not conceptually relate to the framing of physiological, psychological, and problem-solving behaviors

Birdi and Zapf (1997); Cooper-Gaiter (2016)), as well as other social constraints such as financial barriers Pang et al. (2015); Mohadisdudis and Ali (2014).

Most of the prior works mainly investigated user characteristics that could challenge older adults' smartphone usage from physiological perspectives (*e.g.*, visual loss Piper et al. (2017), declining memory and spatial ability Li and Luximon (2020), and inaccuracy of a single action Nicolau and Jorge (2012); Wacharamanotham et al. (2011)) and psychological perspectives (*e.g.*, negative attitudes towards smartphone usage Navabi et al. (2016); Franz et al. (2019b), less perceived ease of use and usefulness Franz et al. (2019b); Adams et al. (2005) and low enjoyment Conci et al. (2009)). However, there is a gap between the user characteristics and the contextualized difficulties that prevent older adults from completing a smartphone interaction task. Two relevant works about interaction task completion problems were from Harada *et al.* Harada et al. (2013) and Qingchuan Li (2019). Harada *et al.* Harada et al. (2013) focused on elderly users' interaction problems in three daily applications (call, address book, and map). Their study revealed a few common challenges, such as confusion towards unexpected responses, ignoring the state of the screen while typing, and performing wrong gestures on certain buttons. Qingchuan Li (2019) mainly focused on navigation challenges that older adults encountered when completing smartphone interaction tasks and proposed two user models to describe the relationship between older adults' cognitive characteristics and their navigation behavior. Despite these two significant studies, there remains a lack of identification of older adults' mental barriers that prevent them from tackling interaction problems and completing interaction tasks, as well as a conceptual model framing how older adults' mental barriers can relate to interaction problems and affect older adults' behaviors for dealing with the interaction problems.

2.2. Improving Smartphone Usage for Older Adults

Knowing the characteristics of older adults, researchers and designers have proposed a large number of approaches to improve the usage of smartphones for such a population.

2.2.1. Interface Design for Older Adults.

A large amount of research has provided a theoretical basis in the form of usability Dumas and Salzman (2006); De Barros et al. (2013) and accessibility guidelines Díaz-Bossini and Moreno (2014) to design intuitive in-

terfaces for older adults. Generally, interface design guidelines for older adults are categorized into three dimensions: look and feel (visual design, layout design, etc.), functionality and hierarchy M.Al-Razgan and H.AlAjmi (2012); Zaphiris et al. (2007), and execution (reflecting in the redesign of size, font, and space to address usability issues caused by physiology factors) Morris (1994); Zaphiris et al. (2007); Patsoule and Koutsabasis (2014); Phiriyapokanon (2011). In addition, specific design approaches solving some of the prominent problems, such as the strategies of redundancy design Blackler (2006); Mahmud et al. (2020) and interface metaphors Prior et al. (2008), have been proposed. With the enormous growth of mobile devices and applications, users are forced to build new norms and conceptual models to accommodate novel functions. People with disabilities and the elderly population are regarded as vulnerable groups in adapting to the new technology due to the convergence of physiological conditions Díaz-Bossini and Moreno (2014). As the two major mobile operating systems, Android and iOS break down their accessibility considerations into four categories – cognitive, motor, vision, and hearing. These OSes put forward their built-in accessibility features to improve smartphones usage for people with disabilities and older adults. For example, VoiceOver (iOS) and TalkBack (Android) make user hear what's on the screen; ZOOM (iOS) enlarges the screen to the user's liking; and Siri (iOS) and Voice Access (Android) help users control their phone with voice Whitaker (2020).

However, the interface design guidelines proposed from the perspective of usability and accessibility fail to represent the complexity that older adults face. As smartphones are rapidly changing, existing guidelines are not completely applicable Zaphiris et al. (2005); Kurniawan and Zaphiris (2005); Kim (2010). Moreover, older adults form a heterogeneous population Vines et al. (2015); Nurgalieva et al. (2019); Anderson and Perrin (2017), and their interaction with smartphones should also be viewed through the lens of a sociotechnical system Barbosa Neves et al. (2023). Vines *et al.* Vines et al. (2015) propose to put less emphasis on the deterioration of cognitive and physiological abilities of older adults and reconfigure them as active agents in the information era. Therefore, instead of following the deficit-driven design philosophy Guan et al. (2021), it is essential to explore how older adults understand the interaction problems they meet and how their thinking, reasoning, and worrying in front of the interaction problems affect their problem-solving. Based on such findings, we can propose design implications beyond the view of usability and accessibility to support older adults

to overcome mental barriers, where other smart technologies like voice assistants Pradhan et al. (2020) and large language model Bubeck et al. (2023) can play a role.

2.2.2. Learning from Others for Better Phone Usage.

The use of technology for older people often depends on the availability of training Barnard et al. (2013). Evidence suggests that age-related physiological and cognitive declines may be improved by computerized cognitive training designed to compensate for these deficits Shah et al. (2017). Many older individuals, especially the healthy and well-educated, also show inclusiveness for learning new technologies, provided they receive adequate training Huber and Watson (2014); Mayhorn et al. (2004); Mitzner et al. (2008). Despite the willingness to learn to use existing mobile technologies, most older adults experience difficulties. Learning difficulties experienced by older adults have been attributed to many factors (e.g., natural declines in cognitive abilities Rogers and Fisk (2010), lack of computer experience, problems with devices' user interface Kim et al. (2016)). Previous studies suggest that it is not sufficient to develop training programs and expect that they will be similarly effective for younger and older adults Hickman et al. (2007). Older users require special training methods, including the types of tasks for which they would like to receive training, their preferences for whom they would like to conduct the training, where and when they would like the training to take place, and what methods they perceive as most effective Mitzner et al. (2008). The past literature also offers some principles for the design of online help, manuals, and other form of tutorials to support older adults learning to use smartphones Leung et al. (2012), based on which the assistive tool Synapse was designed Jin et al. (2022) to support them learning smartphone interaction tasks through trial-and-error.

Learning from others is an effective way for older adults to tackle interaction problems and complete interaction tasks. The social concerns of older adults for help-seeking can significantly affect their behavior in dealing with interaction problems, which deserves further exploration.

3. Exploratory Pilot Study through Online Survey

We conducted an online survey during which we administered a questionnaire to young people who had experience in helping older adults tackle smartphone interaction problems. The survey served three effects. First, it

offered an understanding of older adults' problems and response behaviors in smartphone interaction tasks from the helpers' perspectives. Second, it provided findings on the helpers' practices and challenges when facilitating older adults. Third, it informed us to design the smartphone interaction tasks for the formal study with older adults.

3.1. Participants and Survey Protocol

17 survey questions were designed by 5 HCI researchers through a discussion to sense older adults common interaction problems and help-seeking contexts, listed in the appendix (Table A.9). The first question "Did you have the experience of helping an older adult to solve smartphone usage problems?" aimed to filter out those who had no prior experience of helping older adults. Q2 to Q10 are questions about demographic information and basic smartphone usage background of participants the older adults they recently helped. Q11 to Q17 are questions about the interaction problems that older adults encounter when using smartphones, how the helpers help the older adults, the effectiveness of the assistance, and participants' thinking of how to better help the older adults. We posted the questionnaire on online social platforms and got 30 feedbacks. Among these participants, 20 answered positively to Q1.

45% (9/20) of the valid replies were from male participants and 55% (11/20) are from female participants. The participants aged from 18 to 38 years old (M = 23.50, SD = 0.50). Their occupations included student, engineer, teacher, and administrative officer. They all had university degrees or above. All of them were familiar with smartphone operation. The older adults they helped were 45% male and 55% female, aged from 60 to 80 years old (M = 69.86), SD = 4.64). Their education level ranged from below primary school to above university level. 90% of the older adults helped by the survey participants were relatives.

3.2. Findings from the Survey

We present three findings about older adults' interaction problems as well as help seeking and receiving contexts.

3.2.1. WeChat is the application that most of older adults ask for help

From the survey result, we found that 50% of the proposed interaction problems were about completing interaction tasks with WeChat such as using

Table 2: Frequency of system applications and third-party applications that older adults asked for a help

System application	Count	Frequency	Third-party application	Count	Frequency
Phone call	9	45%	**Communication app**: WeChat, QQ, etc.	16	80%
Short message	5	25%	**Social app**: Weibo, Douyin, Xiaohongshu, etc.	2	10%
Camera	8	40%	**Browsers and tools**: Learning Power, Baidu, UC, etc.	2	10%
Time/alarm clock	4	20%	**Finance app**: Alipay, Bank of China, etc.	6	30%
Network settings	10	50%	**News and magazines**: Toutiao, Netease News, etc.	5	25%
Keyboard Input	5	25%	**Tourism app**: 12306, Ctrip, etc.	1	5%
Other system settings	1	5%	**Shopping app**: Taobao, JD, Pinduoduo, etc.	6	30%
			Catering app: Meituan, Dianping, etc.	2	10%
			Games: Doudizhu, Xiaoxiaole, etc.	3	15%
			Maps and navigation app: Baidu Maps, Didi Texi, etc.	4	20%
			Video playback: iQiyi, Tencent Video, etc.	4	20%
			Music and audio app: QQ Music, Himalaya, etc.	3	15%
			E-book and reading app: WeChat Reading, Kindle, etc.	3	15%

Table 3: Interaction tasks

No	Interaction task	No	Interaction task
T1	Make a call to a saved contact	T15	Send a message to a WeChat group
T2	Pick up a call	T16	Search a historical text from a WeChat group records
T3	Save a new contact	T17	Send an image to a WeChat group
T4	Edit and save a memo	T18	Favorite a message on WeChat
T5	Check messages	T19	Check balance on WeChat Pay (wallet)
T6	Copy a message to memo	T20	Link a bank card to WeChat Pay (wallet)
T7	Write and send a message	T21	Send a Red packet to a group on WeChat
T8	Install applications	T22	Present Health Declaration QR code
T9	Take a photo	T23	Purchase a certain product (toilet paper) online
T10	Add instructional text to a photo	T24	Pay public transformation through Metro&Bus QR code on Alipay
T11	Share a photo to a WeChat group	T25	Schedule a package pickup online
T12	Connect to WiFi	T26	Receive and open a file on WeChat
T13	Scan a QR code on WeChat	T27	Accept a WeChat Red packet
T14	Join a WeChat group	T28	Find a certain image saved on the phone

WeChat for payment and searching a historical text from WeChat messaging records. Additionally, online payment and banking activities were also obviously problematic activities. As Table 2 shows, network settings, phone call, and camera are smartphone functions older adults most often seek help with. As for third-party applications, communication applications such as WeChat and QQ are the apps that older adults most frequently seek help for. According to all the interaction problems that we collected, we designed a list of interaction tasks (see Table 3) that older adults may mostly have problems with, which performed as material in the formal user study.

3.2.2. Demonstration without dedicated teaching failed to work well

As Table 4 shows 95% of the participants indicated that live demonstration is the most common way of helping older adults tackle interaction problems. However, based on the description of real practices, they rarely

Table 4: Ratio of common ways that older adults got help

Approaches to getting helps	Count	Frequency
Live demonstration	19	95%
Remote video communication	6	30%
Screen recording demonstration	1	5%
Drawing instructions on pictures or screenshots	3	15%

Table 5: Ratio of three types of helping effect

Types of helping effect	Count	Frequency
With your help, the older adult solved the problem and mastered the method of dealing with it	5	26.32%
With your help, the older adult solved the problem and learned how to with it at that time, but soon forgot it	7	36.84%
With your help, the older adult solved the problem but did not learn how to deal with it	7	36.84%

teach older adults effectively. Many of the participants suggest they only demonstrate once or twice and then let the older adults get familiar with the operation by themselves. For example, SP8 suggested that *"I first try it by myself, then demonstrate to him once and let him get familiar with it by himself"*. Some of them just directly complete the interaction task on behalf of the older adults without any instructions. Take the feedback from SP19 as an example: *"I just take over her smartphone and directly operate on it"*. Table 5 shows that these assistance practices did not work well and only 26.32% of help-seekers master the approach to dealing with the encountered problem. This finding reveals that older adults are facing challenges in getting well tutored by the helper.

3.2.3. The way to offer the help and the attitude of the helper both have an impact on the effect of assistance

Answers to Q17 showed helpers' ideas of how to assist older adults better when encountering interaction problems. Many participants agree that face-to-face assistance is the most effective way, while this can not be timely. SP4 and SP4 raise the challenges of offering remote help. *"When instructing the steps remotely, it is not intuitive when describing the operations. Additionally, I can not see his smartphone interface that I am not familiar with,*

which prevents me from giving more precise feedback" (SP9). *"When doing remote help, seeing the real-time smartphone interface is best. Otherwise, it is difficult for me to determine how to solve the problem"* (SP4). However, as mentioned above, even with face-to-face assistance, older adults still face challenges of getting well tutored. Most participants, such as SP6 and SP9, also emphasize the importance of helpers' attitude in the helping process. *"Older adults' passion is important and that is highly related with our attitudes"* (SP6). *"I may inadvertently show impatience and they may dare not to try some operations for fear of causing problems"* (SP3).

3.2.4. Summary of the survey findings

Through this survey, we got an initial understanding of older adults' problems with smartphone interaction tasks and their challenges when seeking help to deal with the problems. We found communication apps like WeChat and QQ, designed for instant communication but have developed into comprehensive and diversified online communication and life service platforms, are the apps in which older adults most frequently meet problems. Therefore, we designed 28 interaction tasks (see Table 3) that mostly needed to be completed with WeChat for the following formal user study to acquire a contextual understanding of older adults' problems. We also reveal some of the challenges of offering effective help to older adults. Without dedicated teaching, the effect of the demonstration is limited. Space and time barriers can further hinder effective help. Additionally, the helper's attitude, which is highly related to older adults' passion, also significantly affects the effect of the assistance. These findings provided valuable insights of older adults smartphone usage and help-seeking difficulties from the helper's perspective. To directly communicate with older adults and further explore how they usually complete the interaction tasks and deal with problems, we proceeded to the formal user study

4. Methods of the Formal User Study

We conducted a two-phase user study with older adults to explore their difficulties in completing smartphone interaction tasks (see figure 1). During the focus group discussion, we explored the general difficulties older adults face when using smartphones through focus group discussion sessions on four topics. This allowed us to gather insights from participants' spoken expressions regarding smartphone interaction problems in their daily lives.

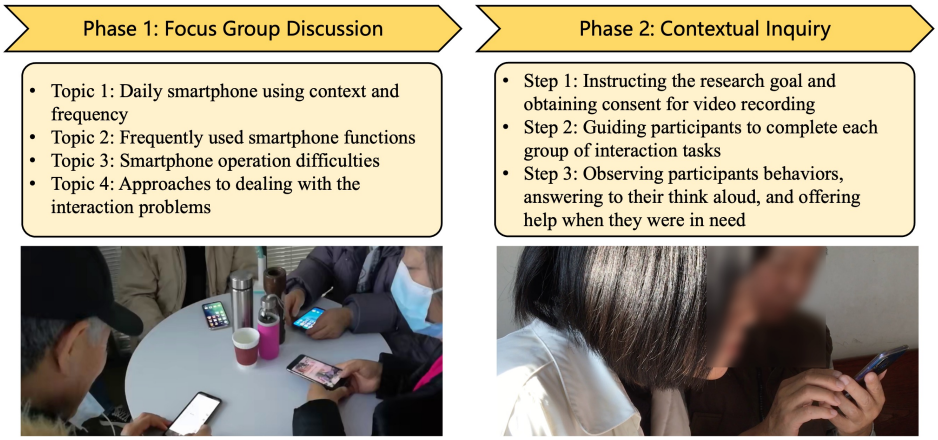

Figure 1: User study Process

Following the focus group discussions, we invited each participant to participate in a contextual inquiry regarding smartphone interaction task completion. The participants were required to complete 28 interaction tasks (see Table 3) we prepared based on the findings from our preliminary survey. By observing and interviewing participants through this process, we were able to gain a deeper understanding of the specific contextual details of the interaction problems encountered by older adults and how they addressed these challenges. Data collection during both phases of the study was conducted with the participants' explicit consent.

We recruited 16 participants (9 females and 7 males) from local communities in Beijing, aged between 60 and 81 (M = 67.60, SD = 5.17). The participants were recruited based on two criteria. On the one hand, all of them should be aged 60 or above. On the other hand, the participants should often meet difficulties when using smartphones and express a frequent need for assistance with smartphone usage in their daily lives. Participants professional backgrounds varied, including teachers (n=2), engineers (n=3), retailers (n=2), company staff (n=2), and government officers (n=4), a waiter (n=1) and drivers (n=2). The educational background of the participants were diverse, primarily junior (n=6) or senior middle school (n=6), with cases of primary school (n=1), junior college (n=2), and technical secondary school (n=1). Most participants used Android phones (n=11), while some others used iPhones (n=4) and one primarily used a feature phone. The participants' demographic details are shown in Table B.10) In phase 1, all participants took part in focus group discussion sessions. However, during

phase 2, P4 withdrew due to smartphone functional issues. Each participant took part in the user study with informed consent and used their own smartphone to complete the tasks. They all received monetary rewards for participation.

4.1. Phase 1: Focus Group Discussion

4.1.1. Topics

We introduced four topics for the focus group discussion to stimulate discussions regarding the participants' smartphone interaction problems.

- Topic 1: Daily smartphone using context and frequency.
- Topic 2: Frequently used smartphone functions.
- Topic 3: Smartphone operation difficulties.
- Topic 4: Approaches to dealing with the interaction problems.

Topics 1 and 2 were designed as warm-up topics, serving to encourage participation from each participant and evoke their memories regarding smartphone usage in their daily lives. Topic 3 aimed to gather common interaction problems that frequently arise during the completion of smartphone tasks, while Topic 4 delved into the strategies utilized by older adults to tackle these interaction problems and the challenges they encountered. All of participants went through these four topics.

4.1.2. Procedure

We divided participants into four small groups, each consisting of four participants and two moderators who were HCI researchers. The moderators presented open-ended questions for each topic, such as "Do you encounter any difficulties in your daily smartphone use?" As participants shared their views and experiences, moderators asked follow-up questions to encourage further discussion. The study began with warm-up topics to establish a connection among participants and encourage them to share their experiences with daily smartphone usage. Once participants felt comfortable, Topic 3 and Topic 4 were introduced, allowing them to discuss challenges and troubles encountered in their daily smartphone use. The entire process, lasting approximately an hour, was recorded with participants' consent for qualitative analysis.

4.2. Phase 2: Contextual Inquiry Regarding Smartphone Interaction Tasks Completion

4.2.1. Interaction tasks

To gain a deeper understanding of participants' responses to interaction problems on smartphones, we designed 28 specific interaction tasks. These tasks were selected based on our survey results from the pilot study, and the detailed list can be found in Table 3. To ensure a smooth flow of the study, we grouped tasks with strong relationships together, resulting in 11 task groups (refer to Table 6).

Table 6: Group of Interaction tasks

No	Description of the completion process of a task group
1	Connect to the given WiFi (Task No.12)
2	Install AliPay (Task No.8)
3	Moderator call each participant in turn → Participants pick up the phone call (Task No.2) → Participants hung up the phone → Participants save the phone number of the moderator (Task No.3) → Each participant give the phone call to the moderator (Task No.1)
4	Participants send an text message (Hello) to saved moderator's phone number (Task No.7) → Moderator replies to the text to each participant → Participants check the message (Task No.5) → Participants copy the text message and paste it into the memo (Task No.6) → Participants save the changes in the memo (Task No.4)
5	Active the scan QR codes function in WeChat (Task No.13) → Participants scan the QR code provided by the moderator to join the group chat (Task No.14) → Participants send a message in the group chat (Task No.15) → Participants share an picture in the group chat (Task No.17) → Moderator sends a file in the group chat → Participants receive and open the file (Task No.26) → Participants favorite this file (Task No.18) → Moderator provide a key work → Participants search the given key work in the chat history (Task No.16)
6	Moderator sends an Red Packet in WeChat group → Participants accept the Red Packet (Task No.27) → Participants check their balance in WeChat Pay (Task No.19) → Participants link a bank card to WeChat Pay (Task No.20) → Participants send an Red Packet of 1 Yuan in the group chat (Task No.21
7	Present Health Declaration QR code (Task No.22)
8	Take a photo (Task No.9) → Find this photo from photo albums (Task No.28) → Add text, participants' name to this photo (Task No.10) → Share the photo to the WeChat group chat (Task No.11)
9	Participants active a random online shopping app → Moderator set a given product, toilet paper → Participants search and purchase the given product (Task No.23)
10	Show Metro or Bus QR code on AliPay (Task No.24)
11	Use AliPay to simulate the process of booking a delivery pick up (Task No.25)

4.2.2. Procedure

At the start of the study, we explained our research goals and process to the participants and obtained their consent for video recording. We then guided participants through the completion of interaction tasks within each task group, following the order and descriptions in Table 3. Participants were encouraged to vocalize their thoughts and emotions and seek assistance when needed.

If participants requested help, the interviewer initially observed their attempts to resolve the interaction difficulties independently. Based on their behavior, the interviewer would inquire about their understanding of the causes and potential solutions for such interaction challenges. If participants were unable to overcome the difficulties, the interviewer would provide guidance and support to help them successfully complete the specified interaction task.

Each interviewer was responsible for guiding two participants, and a 1-minute break was granted following the completion of each task group. Video recordings were made of each participant's interaction process for further analysis. This phase of the study lasted approximately 1 hour.

4.3. Qualitative Data Analysis

We collected 4.80 hours of audio data in phase 1 and 8.04 hours of video data with audio information in phase 2. The audio data included older adults' common smartphone usage scenarios and motivations, their commonly used apps, smartphone usage difficulties, approaches to addressing these difficulties, and the challenges of doing so. The video data included participants' interaction behaviors in completing smartphone interaction tasks (without sensitive actions *e.g.*, typing passwords), think-alouds, and their conversations with moderators when seeking help. Due to privacy concerns, we did not collect screen recordings or interaction trace logs. Table 7 presents the data details and the purposes of collecting audio and video data. We transcribed the audio and video records, and the participants' behaviors recorded in videos were transcribed into observational notes. These data were utilized in the qualitative analysis.

With the thematic analysis approach Braun and Clarke (2012), we analyzed the qualitative data through several rounds of coding discussion and refinement. Firstly, four researchers independently coded the qualitative data, producing 181 codes during the open coding stage. Then, researchers discussed the codes together and categorized them into four groups in the initial

Table 7: Available data and unavailable data in the user study.

Available Data	**Details**	**Purpose**
Audio	• Common usage scenarios • Motivations for using smartphones • Frequently used smartphone functions • Common difficulties encountered in smartphone usage • Common approaches to deal with smartphone-usage difficulties • Challenges of dealing with smartphone-usage difficulties	Derive findings of older adults' common smartphone-usage contexts, difficulties, problem-solving strategies, and challenges of problem solving
Video	• Interaction behaviors • Think-alouds • Conversations with moderators when seeking help	Ground the findings from the audio in concrete, contextualized interactions
Unavailable Data	**Details**	**Reasons**
Smartphone screen recordings	• Smartphone screen recordings • Log data of interaction traces	Privacy concerns

coding with affinity diagramming Beyer and Holtzblatt (1999): interaction problems, typical response behaviors, help-seeking challenges and mental barriers. For each group, researchers did axial coding to cluster themes. Considering some codes captured facts of multiple themes, researchers derived conceptual links among different themes and identified how they relate to different mental barriers by analyzing such co-occurrence patterns. This analysis was based on the hypothesis that causal relationships may exist among the themes. Therefore, we treated themes as potentially linked constructs and examined how one might influence or give rise to another. In the final round of coding, researchers followed an iterative process to challenge the groupings, exchanged, removed, and updated some of the themes, and finalized a conceptual model.

5. Findings

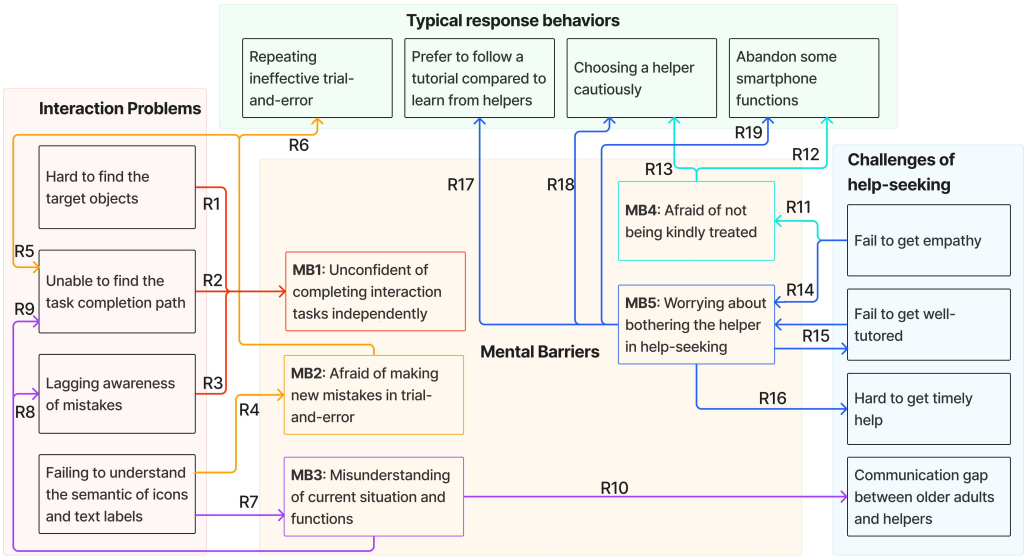

Figure 2: A conceptual model representing how older adults' mental barriers relate to the encountered interaction problems, typical response behaviors, and challenges for help-seeking. Rx is the code of a certain type of relationship and the arrow starts from the cause to the consequence. We summarize 19 types of causal relationship in total

In this section, we present four themes derived from our findings concerning the difficulties experienced by older adults while attempting to accomplish smartphone interaction tasks. These themes encompass interaction

problems, help-seeking challenges, mental barriers, and typical response behaviors. These four themes are connected together with mental barriers (MB) at the center. As Fig 2 shows, our analysis reveals five common mental barriers of older adults when encountering interaction problems and help-seeking challenges: **MB1: unconfident of completing interaction tasks independently, MB2: afraid of making new mistakes in trial-and-error, MB3: misunderstanding of current situation and functions, MB4: afraid of not being kindly treated, MB5: and worrying about bothering the helper in help-seeking** (when seeking helps). We analyze how the interaction problems and help-seeking challenges could contribute to and result from these mental barriers, and how the formed mental barriers could affect older adults' response behaviors when encountering the interaction problems. In total, we report 18 types of relationship among these factors. We first report 4 categories of interaction problems, help seeking challenges and response behaviors in section 5.1, and then report their relationship with mental barriers in the following sections. We present older adults' mental barriers that may result in and result from interaction problems in section 5.2, section 5.3, and section 5.4. Their mental barriers that may consequent from and lead to help-seeking challenges are presented in section 5.5 and section 5.6.

5.1. Summary of Interaction problems, Help-seeking Challenges, and Typical Response Behaviors

During the focus group and the contextual inquiry, we summarize 4 types of common interaction problems that older adults often encounter when completing smartphone interaction tasks. The synergy of physiological (declining visual and memorizing ability), sociological (lack of experience of smartphone usage) and psychological (mental barriers we stated as follows) factors result in these interaction problems, and we mainly present their relationship with common mental barriers in this work.

- Hard to find the target object. For example, it's hard for P10, P11, and P15 to find a certain item in a menu list.
- Unable to find the task completion path. An example would be P12's failure to adjust the font size even he once successfully completed this before.

- Lagging awareness of mistakes. For instance, P7 input an incorrect amount while transferring money online and failed to realize it in time.
- Failing to understand the semantics of icons and text labels. For example, P11 can not tell the difference between the "Wifi" and "Celluar Network".

During the focus group discussion, 15 participants stated that asking others for help is their primary way of dealing with interaction problems. For example, P2 mentioned *"I tend to ask my friends and learn from them when meeting difficulties"*. Most of the participants expressed that it is typical for them to learn how to complete the interaction tasks from their children or neighbors like P8 who indicated *"Sometimes I ask my children for help. When my children are not here, I ask neighbors."* However, such a help-seeking process is usually challenging for older adults, as detailed below.

- Fail to get empathy. For example, P8 complained that his son would get impatient when he repeated to ask questions about the same smartphone operation.
- Fail to get well-tutored. As P5 expressed, his son often demonstrates only once when teaching him some operations. This prevents him from fully understanding the operation.
- Hard to get timely help. For example, P2 shared that she often reaches out to friends for help via social media, but the feedback is not always prompt.
- Communication gap between older adults and helpers. For example, P12 often fails to understand specific terms about smartphone UI from the helper's description.

Additionally, participants showed 4 types of typical response behaviors when encountering interaction problems, which reflects how their mental barriers restrict their problem-solving and smartphone use.

- Repeating the ineffective trial-and-error. For example, when failing to copy the message, P6 simply repeats what they've already tried instead of trying new operations.

- Prefer to follow a tutorial compared to learn from helpers. For instance, P8 appeals that he want the helper to write down the step-by-step instruction for some smartphone operations so that he can learn by himself.

- Choosing a helper cautiously. For example, when asking a stranger for help, P11 tends to observe for some time and choose the one who is not in a hurry and looks kind.

- Abandon some smartphone functions. Take P10 as an example, *"Sometimes we give up when we are unable to deal with the problem and we don't use this smartphone function anymore."*

In the following sections, we elaborate on the details of these findings and analyze how they relate to mental barriers.

5.2. MB1: Unconfident of Completing Interaction Tasks Independently

Previous research has indicated that negative attitudes towards smartphone usage and low self-efficacy Leung et al. (2012); Cooper-Gaiter (2016) can impede older adults' adoption of smartphones. Our findings suggest that the low self-efficacy of many older adults is primarily developed from their unsuccessful experiences in completing interaction tasks, leading them to doubt their own physical and cognitive abilities. Some interaction problems are primarily caused by physiological factors, such as difficulties in finding the target object related to declining visual perception and difficulties in finding the task completion path related to declining memory. The emergence of such interaction problems can reinforce older adults' belief in their own weakness and, as such deterioration of physical abilities is irreversible, leading to their lack of confidence in completing interaction tasks independently (R1, R2, R3).

5.2.1. R1: Physical difficulties can lead to unconfidence in smartphone usage

Physical difficulties, such as failing to see clearly and perceive the system response quickly, can reduce older adults' self-efficacy and make them feel unconfident about completing the interaction tasks independently (Fig. 2 R1). Older adults frequently encounter difficulties in locating specific UI elements due to declining visual perception, particularly when the smartphone screen contains numerous items. During our study, we observed that participants often struggled to find an item from

a long list, particularly when using a scroll-down menu. For instance, during Task 16 (Search a historical text from a WeChat group records), participants P10, P11, and P15 took an extended period to locate the keyword "Historical Records" from a lengthy function list in WeChat. Although the target item appeared multiple times in the center area of the smartphone screen while they scrolled up and down, participants failed to recognize it. P8 and P11 revealed a glimpse into a mental model that suggests they are too old to use smartphones. *"Using smartphones is quite hard for me, as I can't see clearly when I get older"* (P11). *"There are too much objects in the smartphone, and we are too old and too slow to keep up"* (P8).

5.2.2. R2: Failing to find the task completion path can reduce the confidence of completing interaction tasks

Failure to complete interaction tasks is not regarded merely as a knowledge gap by older adults, but it deepens older adults' belief that they cannot independently memorize or master the underlying methods (Fig. 2 R2). Our participants were usually unable to memorize the smartphone task completion path, probably due to declined memory. P12 claimed that there exist some tasks they have completed before, but recalling its key steps when they want to do it again is difficult. *"In order to see the characters on the interface more clearly, I turned up the font size once. However, when I wanted to adjust the font size back, I forgot how I did it before"* (P12). This interaction problem could reinforce older adults' unconfidence in completing smartphone tasks independently, as suggested by P13: *"I now understand what to do for each step, but I can't memorize this procedure. I can't imagine how many times it will take me to memorize it. I may not know what the first step should be a few days later."*

5.2.3. R3: Requiring an intelligent assistant to check the operation due to lagging awareness of mistakes

Older adults worry that, when using smartphones independently, they may not notice their mistakes in time and therefore seek intelligent assistance to detect and correct mistakes (Fig. 2 R3). In the interview, four participants mentioned that they often fail to notice their mistakes of smartphone interaction in time, which sometimes brings extra troubles and leads to property loss. As P7 mentioned *"Once I transferred some money to others, but I input an extra zero due to inaccurate tapping. I just noticed that mistake after the payment, which caused a lot of unnecessary*

trouble." Due to her delayed awareness, P7 expressed concern about making mistakes when using smartphones to complete interaction tasks independently. She even proposed that her smartphone should be able to understand her intentions and automatically correct any mistakes she makes. *"As I often make mistakes, I hope when I press the wrong button, the smartphone can automatically correct it for me, that will be wonderful"*

5.3. MB2: Afraid of Making New Mistakes in Trial-and-error

Many older adults lack knowledge about smartphone usage, making it difficult to understand the meaning of icons and text labels. These difficulties often prevent older adults from correctly comprehending the UI content and finding the path to complete tasks. Although some proficient smartphone users may also face similar challenges when using an app for the first time, they can quickly become familiar with the app's functions through trial and error. However, we found when older adults struggle to understand the UI semantics, they often become afraid of making new mistakes when attempting to complete tasks. This mental barrier hinders their ability to find task completion paths and further prevents them from gradually becoming familiar with the UI semantics. Even when some older adults attempt trial-and-error, they often choose safe options (such as touching UI elements that they understand, even if they are not related to the target interaction task) instead of making exploratory attempts, reducing trial-and-error effectiveness.

5.3.1. R4: Failing to understand the semantics of icons and text labels makes older adults afraid of making new mistakes in trial-and-error

Icons and text labels are often used to indicate the function of a UI element, but older adults may struggle to understand their semantics so that they do not dare to continue the operations or take trial-and-error (Fig. 2 R4). During Task 7 (writing and sending a message), P13 could not distinguish which icon represented dialing out and which represented sending a message on the contacts page. He pointed to the two buttons and asked, "Which is the button to send a message?" Similarly, participants P5 and P11 encountered the same interaction problem after editing the message. P11 could not recognize which button was for sending the message and which one was for making a phone call. P5 became confused because two message-sending buttons appeared together due to having two SIM cards in his phone, and he could not distinguish the correspondence between the SIM cards and the two buttons.

5.3.2. *R5: Fear of making new mistakes in trial-and-error can prevent older adults from finding task completion path*

Most of the participants expressed the unwillingness to take trial-and-error when they have no idea about the interaction task because of the concern about causing phone malfunction, which prevents them from finding the task completion path by themselves (Fig. 2 R5). Although trial-and-error is a helpful method for younger adults to understand the logic of workflow and find the correct task completion path Mahmud et al. (2020), older adults often fail to benefit from such a method. *"I'm afraid of breaking it, so I don't dare to try it myself"* (P5). *"For the task that I once completed, I may try to remember the path through trial-and-error, while for those I had never tried, I do* ***not dare to try*** *it"* (P1).

5.3.3. *R6: The fear of making new mistakes during trial-and-error can render the process ineffective.*

Participants' fear of making new mistakes can result in ineffective trial-and-error behaviors when attempting to solve interaction problems (Fig. 2 R6). For instance, to complete Task 4 (Edit and save a memo), P11 explored the system setting interface to find the memo app, without checking the desktop first. Similarly, P6 explored WeChat, messages, and phone calls but eventually gave up. It appears that they chose safe options (functions they have used in the past and will not cause malfunctions) instead of those that seem effective for completing the task. Another type of ineffective behavior is repeating the same operation instead of trying new options. Take P6's behavior in T6 (Copy a message to memo) as an example, she performed a long tap on the incorrect menu item, so she failed to find the copy button. However, instead of trying other items, she kept repeating the same long tap on the same menu item and canceling it. Her statement reveals her mental model of being afraid to try unfamiliar functions, as she stated, *"I'm afraid of breaking it, so I don't dare to try it myself"* (P6).

5.4. *MB3: Misunderstanding of Current Situation and Functions*

Due to a lack of smartphone usage knowledge, the way older adults understand the UI elements is not consistent with the design semantics, which leads to the misunderstanding of the current situation and smartphone functions and causes more interaction problems (R7). This can also partly lead

to the failure to find the task completion path (R9), timely realizing the mistakes (R8), and even hinders the communication with helpers (R10).

5.4.1. R7: Unique way to understand icons and text labels can lead to misunderstanding of current situation and functions.

Some participants understand the semantics of icons and text labels in a very unique way, so they often misunderstand the function of UI elements (Fig. 2 R7). In T12 (Connect to Wifi), we asked participants to connect to the Wifi we preset, but many participants directly started the Cellular Network function. P11 said *"This(Wifi) is what I should use inside of my home and this(Cellular Network) is what I should use outside of my home."* In this case, she failed to correctly understand the difference between Wifi and Cellular Network. She thought that Wifi was the network inside her home and Cellular Network was the network outside of her home. P12 also confirmed such interaction problems and told us *"We can not understand the language of the smartphone. We can understand the words but do not know what they mean."*

5.4.2. R8: Misunderstanding of current situation and UI functions can impede users in finding the task completion path.

When participants misunderstand the situation and functions of UI elements, they tend to touch UI elements randomly rather than those related to the task (Fig. 2 R8). This behavior is consistent with the findings in Mahmud et al. (2020) and often leads to participants' frustration. For instance, when P11 attempted Task 21 (sending a red packet to a group on WeChat), which she had never tried before, she was unsure if it was correct to exit the WeChat group page and look for the red packet function elsewhere. As a result, she touched a UI element like taking a gamble, and the process showed that she could not differentiate between the icons of smartphone apps and the UI elements inside a particular smartphone app. She even exited WeChat, started Alipay, and asked us, *"Can I use this function to send a WeChat red packet?"* After we replied "no" to her question, P11 gave up without making more attempts.

5.4.3. R9: Misunderstanding of system status is also one of the main reasons for lagging awareness of mistakes.

We found that lagging awareness of mistakes is not only caused by carelessness but also results from misunderstanding of system status (Fig. 2 R9).

P14 shared a story with us that her misunderstanding of the system status led to a failure to make an online appointment with a doctor. *"Once upon a time, I made an online appointment with a doctor using my smartphone. After I submitted the personal information, the system showed that I had finished the personal information submission. I thought that the appointment had been successfully made, as displayed in the system. However, when I went to the hospital, the staff said that I did not make an appointment. Finally, I got it that after the submission of personal information, there was still one more step. I did not finish the full procedure online." "I have no other choice but to re-appoint at the offline service counter in the hospital"* (P14). Since then, P14 has given up making online appointments due to being afraid of making mistakes (Fig. 2 R3).

5.4.4. R10: Different mental models of the UI elements between older adults and helpers bring out the communication gap.

Older adults' unique mental model of UI elements (as we stated in R7) can make it difficult for them to clearly describe the situation and problem when asking for help. Similarly, it can be challenging for older adults to understand some expressions used by helpers (Fig. 2 R10). Older adults who are less tech-savvy are commonly unable to understand UI elements on the screen and the problems they encounter. *"We can not understand the language of the smartphone. We can understand the words but do not know what it means"* (P12). As a result, they are sometimes hard to communicate their problems with helpers, and such a communication gap could cause them to fail to be well-tutored. *"Sometime ago, I did not know the meaning of menu and often used the word 'catalog' to indicate menu items. This gap prevents us from understanding each other"* (P12).

5.5. MB4: Afraid of not Being Kindly Treated

The helper's empathy can significantly impact the attitudes and behaviors of older adults when seeking help. The challenges of obtaining empathetic help can increase the mental burden and social concern of older adults when seeking assistance (R11). Due to the fear of not being treated kindly, some older adults even abandon certain smartphone functions altogether (R12). Additionally, some older adults become cautious when selecting a helper and try to select the one who can empathize them(R13). For example, peer

assistance is preferred due to the availability of empathy, even though they may not be as good at solving the problem as the younger generation.

5.5.1. R11, R12: When older adults do not receive empathy from the helper, it can increase their mental burden of not being kindly treated and may even lead them to abandon certain smartphone functions.

Helpers may sometimes overlook emotional care when helping older adults tackle interaction problems, causing older adults to feel afraid of not being treated kindly when seeking helps (Fig. 2 R11), which further affects their help-seeking behaviors. Take P8's complaint as an example, *"If I repeat to ask questions to my son, he will definitely get impatient and sometimes shout at me 'Why can't you do such an easy work?' and refuse to teach me again."* P8 avoids asking his son for help and even abandons the function, stating, *"You (his son) learned it, but I did not learn. You are only 30 years old, but I am already over 60 years old. How could I do it so well? I would rather not use it (the smartphone function) anymore."* **Therefore, although help-seeking is a powerful way for older adults to learn how to use smartphone functions, it is also common for them to abandon functions they cannot handle. (Fig. 2 R12)** Take P10 as an example, *"Sometimes we give up when we are unable to deal with the problem and we don't use this smartphone function anymore".*

5.5.2. R13: Peer assistance is preferred due to the availability of empathy.

It is quite important for older adults to gain empathy during the process of seeking help, so they tend to seek help from people who can empathize with them (Fig. 2 R13). For example, P2 expressed she mainly chooses to ask peers and friends because they can understand each other. *"I mainly learn from my friends because we can communicate freely, empathize, and understand each other."* (P2)

5.6. MB5: Worrying about Bothering the Helper in Help-seeking

We also found participants are not only concerned about their own emotional feelings but also the feelings of the helper. Therefore, when they fail to get well-tutored (R15) or be treated kindly (R14), they do not try to further ask for dedicated instruction but tend to learn from tutorials (R17) or even abandon the function (R19). When choosing a helper, they also try to pick the one who are not in a hurry or looks kind, and limit the frequency of seek

help from the same person (R18). As a result, such concern also becomes a hurdle for them to get timely help (R16).

Our study revealed that participants not only care about their own emotional well-being but also consider the helper's feelings. Consequently, if they do not receive proper guidance (R15) or are not treated kindly (R14), they refrain from seeking further assistance and instead rely on tutorials (R17) or abandon the task altogether (R19). Additionally, when selecting a helper, they prefer someone who appears leisurely and looks kind, and limit the frequency of requesting help from the same person (R18). Unfortunately, this concern also becomes an obstacle for them to receive timely assistance sometimes (R16).

5.6.1. R14, R19: Unempathetic feedback from helpers makes older adults become anxious about bothering others and may even abandon the task.

Some participants believe that offering help is a burden to the helper because they can not fully feel empathetic and understand older adults' frustration. Such a mental model leads to their worries about bothering the helper in help-seeking (Fig. 2 R14, R19). P1 stated his concern about not being empathized with. *"Sometimes I tried it by myself because I don't want to bother others. However, even learning from others, they can't understand my frustration. So I may even choose to abandon the function"* (P1).

5.6.2. R15: Reciprocal causation between social concern to seek help and the failure to get well-tutored.

Halfway instructions from the helper can give the impression of inconvenience or impatience, which makes older adults hesitant to ask further questions. Consequently, they are unable to receive proper guidance (Fig. 2 R15). Our preliminary survey (section 3) revealed that although older adults commonly rely on helpers to address interaction problems, helpers seldom provide step-by-step guidance until the older adults fully comprehend the task. Instead, helpers usually demonstrate or explain the method only once, which can be challenging for older adults to remember. Such circumstances were also verified by the participants, as stated by P8, *"My children sometimes teach me once, but I can't remember what to do. I can't memorize it!"*. Participants commonly expressed their social concern for seeking help again after receiving such halfway instructions. As expressed by P5 *"Sometimes he (his son) teaches how to complete the*

task, sometimes he just demonstrates once. He is so busy and does not have enough time to teach me and I also don't want to bother him a lot."

5.6.3. R16: Social concern to seek help can prevent timely help.

Older adults may hesitate to seek help from their helpers due to concerns about being a burden, which prevents them from obtaining timely help (Fig. 2 R16). Half of the participants reported that receiving timely assistance when facing interaction problems is challenging. During the focus group discussion, P2 shared that she often reaches out to friends for help via social media, but the feedback is not always prompt. Similarly, P7 expressed anxiety when encountering an interaction problem while failing to get timely help. *"Sometimes some functions could not be used. At that time, my son was not at home, and the neighbor also did not know the workaround. I feel so anxious because the people I can seek help from are very limited"* (P7). Getting timely help is difficult for older adults, while worries about burdening others make it even harder. For instance, P2 mentioned that she sometimes experiences new interaction problems shortly after resolving a previous one with the help of a friend. To avoid overburdening her friend, she waits until she has accumulated several issues before requesting assistance again.

5.6.4. R17: Due to unwillingness to bother others, older adults are more inclined to follow a tutorial.

Some older adults prefer to rely on tutorials rather than seek help from a helper because they do not want to cause inconvenience to them (Fig. 2 R17). For example, P8 shared his struggles with retaining information after receiving instruction from his children, stating *"My children sometimes teach me once, but I can't remember what to do. I can't memorize it!"* and expressed his appeal *"I want the helper to write down what to do step by step so that I can review it by myself afterward, and I do not need to ask him again."*

5.6.5. R18: Seeking help from those who appear to have free time to prevent bothering others.

Older adults' concerns about being a burden can create mental barriers that affect their help-seeking behaviors and make them cautious when selecting a helper (Fig. 2 R18). For example, P11 indicated that when she was out of the house, she would first observe people

on the street and choose the one who appeared to have free time and was likely to offer kind help. *"Sometimes I cannot manipulate the smartphone navigation on the street, I just observe first and look for those who are not in a hurry and look kind"* (P11).

6. Discussion

6.1. Novelty

Our study provides comprehensive, contextualized findings on older adults' difficulties when completing smartphone interaction tasks, linking concrete interaction problems, typical response behaviors, help-seeking challenges, and underlying mental barriers through a conceptual model. Instead of treating these factors as isolated phenomena, we demonstrate how they co-evolve and influence one another. In particular, we explain how older adults' mental barriers interact with their physiological and structural constraints to shape their contextual difficulties. A comparison of our contributions with prior related works is presented in Table 8.

6.1.1. A Comprehensive lens of contextualized difficulties in smartphone interaction task completion

Compared with prior work on contextualized difficulties older adults face in completing smartphone tasks, which typically emphasizes situational barriers Li (2019); Harada et al. (2013), this work offers a more comprehensive view. We jointly consider older adults' concrete interaction problems, help-seeking challenges, response behaviors, and underlying mental barriers, and frame these elements within a reciprocal causation model. For example, our model reveals that the misunderstanding of icons leads to the failure of task completion and ineffective communications with helpers about the current interaction problems, which reduces the older adults' self-efficacy of taking trial-and-error actions and willingness to seek help from others. The shaped mental barriers can, in turn, hinder older adults from effectively learning and using smartphone apps. Our findings supplement prior works by revealing the mechanisms that link concrete interaction problems to deeper psychological states and social dynamics. Through the understanding of such a mechanism, we argue that empowering older adults to better master the usage of smartphones should not only stop at repairing interaction problems or

providing timely help, but also aim to transform the mental barriers that sustain those problems. We further discuss concrete design implications based on our study findings in the next section.

6.1.2. Explaining how mental barriers relate to physiological and structural constraints in shaping older adults' contextualized difficulties

Our results echo prior works presenting physiological Mohadisdudis and Ali (2014); Pang et al. (2015); Kobayashi et al. (2011); Li and Luximon (2020) and structural barriers Franz et al. (2019c); Mohadisdudis and Ali (2014); Pang et al. (2015) that older adults face when using smartphones. We concretize them by showing how they affect older adults' smartphone interaction task completion. Physiological limitations (*e.g.*,, low visual acuity or fine-motor precision) manifest as target acquisition difficulties. Structural constraints (*e.g.*,, limited available helpers or low technology literacy) lead to difficulties in problem-solving. Besides, our study explains how the physiological limitations and structural constraints relate to older adults' psychological factors. We find that psychological factors (*e.g.*, fear of making new mistakes and social concerns about bothering others) can be shaped by physiological and structural barriers and, in turn, amplify the difficulties those barriers pose during concrete interaction tasks. Our findings complement prior works, which typically discuss psychological factors at the level of attitudes toward technology adoption and learning Berenguer et al. (2016); Navabi et al. (2016); Zhou et al. (2014). Based on our findings, we underscore the importance of empathy in supporting older adults' help-seeking behaviors and emphasize the need for more attention to this aspect for reducing older adults' mental barriers and motivating technology adoption.

6.2. Design Implications

Based on our conceptual model, we develop a number of design implications to support older adults in tackling interaction problems, overcome their mental barriers, and become more active in technology use and help-seeking.

6.2.1. Assessing the Elderly-friendliness of Mobile GUI with Automated Tools and Systematic Human Review

Our research has shown that older adults often struggle with completing complex tasks and identifying important elements in the user interface, which leads to low self-efficacy (Fig. 2 R1, R2, R3, MB1). Although there has been extensive design guidelines for creating graphical user interfaces that

Table 8: Comparison of prior work and our contributions across different perspectives

Perspective	Prior works	Our work
Contextualized difficulties in interaction task completion	Emphasizing situational barriers	Comprehensively framing causal relationships among older adults' concrete interaction problems, help-seeking challenges, response behaviors, and underlying mental barriers
Psychological perspective	High-level attitudes with weak link to concrete interaction problems and task completion barriers	Specifying how mental barriers are related to physiological and structural barriers and how they shape contextualized difficulties of older adults
Physiological perspective	Vision decline and fine-motor limitations	Echoing existing findings and linking constraints to concrete interaction problems
Structural or social barriers	Financial barriers, low technology literacy, and challenges of seeking social support	Echoing existing findings and underscoring the importance of empathy in supporting older adults' help-seeking behaviors

are friendly for older adults Zaphiris et al. (2005); Kurniawan and Zaphiris (2005); Kim (2010), it is still important to evaluate the elderly-friendliness of mobile applications before they are released. Currently, there are no reliable methods for reviewing mobile applications to ensure they are elderly-friendly. We suggest that the open source community and application stores like Google Play and App Store create a committee to assess the elderly-friendliness of mobile applications. Additionally, it is the responsibility of researchers in the field of accessibility and aging to develop tools and metrics for evaluating the elderly-friendliness of mobile GUIs.

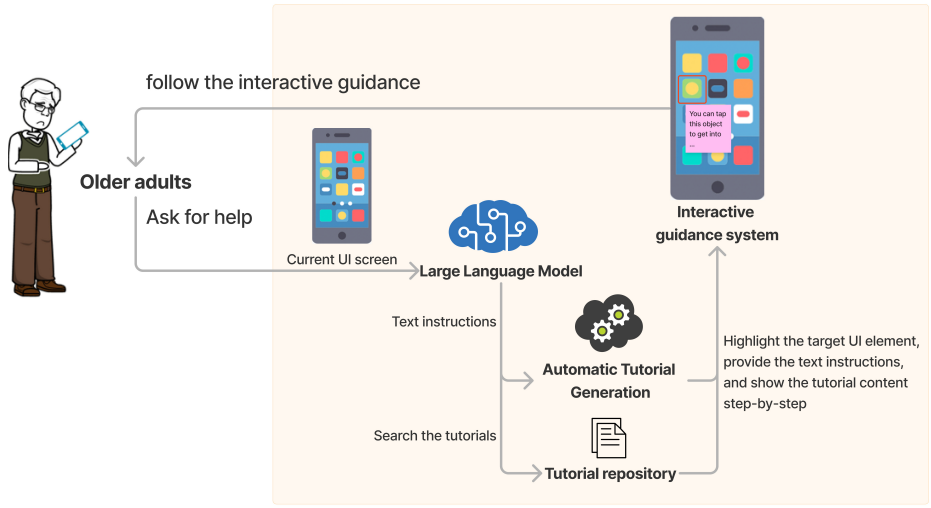

Figure 3: Design concept of the AI-based tutorial system

6.2.2. AI-based Multi-modal Tutorial Systems

Our research has shown that seeking help and learning from others is an effective way for older adults to address smartphone interaction problems. However, older adults may be hesitant to seek help due to social concerns, and therefore prefer to learn from tutorials instead (Fig. 2 R14, R15, R16, R17, MB5). This allows them to avoid bothering others too frequently. Research on smartphone tutorial systems for older adults, such as Synapse Jin et al. (2022) demonstrates promising opportunities to support older adults in directly learning from step-by-step contextualized interactive guidance and using trial-and-error with the aid of such a tutorial system. However, older adults still face some challenges in effectively using tutorial systems. Firstly, finding the most relevant tutorial for the current interaction task can be difficult. Secondly, tutorials are still created by helpers upon request, which

can increase the mental burden on older adults and limit their use of the tutorial system. the increasing popularity of large language models (LLMs) like GPTs Bubeck et al. (2023) is helping to address these issues. We advocate to develop the tutorial system based on LLMs with contextualized multi-modal input so that older adults can obtain timely help without bothering others. Fig 3 shows our initial design of such a tutorial system, the LLMs can firstly understand older adults' intentions by analyzing the older adults' speech expression and their current smartphone interaction task context (*e.g.*, analyzing the screenshot of current UI), then offer the instructions and generate the contextualized interactive guidance.

6.2.3. Offering Empathetic Remote Help with Emotional Virtual Agent

According to our conceptual model, the absence of empathy among helpers creates mental barriers for older adults (Fig 2, R11, R14), which subsequently impacts their help-seeking behavior and function adoption (Fig 2, R12, R13, R18, R19). Although empathizing with older adults when providing assistance is a well-known social norm, it can be challenging for helpers to do so. With the development of affective computing, virtual agent that can emotionally care about users will play a role in this case. Considering prior works have proposed design implications to make users feel empathy from the virtual agent Hu et al. (2023), applying it into a tutorial system as we aforementioned can positively motivate older adults' to learn and use smartphones while reducing their social concern.

6.2.4. Online Community to Support Older Adults' Technology Use

Our research has found that mental barriers are a significant issue for older adults when it comes to completing interaction tasks. Their typical responses to interaction problems and help-seeking difficulties, such as ineffective trial-and-error, not wanting to bother others too much, and avoiding unfamiliar functions (Fig 2, R6, R18, R19, MB2, MB5), can prevent them from fully participating in the information era. To address this, we advocate establishing an online community for older adults for older adults that facilitates communication about technology use experiences. The purpose of this online community is to facilitate communication among older adults about their technology use experiences. The purpose of this community is to encourage older adults to play an active role in sharing their experiences and help each other overcome mental barriers in technology use and help-seeking. Persuasive design Liu et al. (2021b) and reward mechanism will be

utilized to encourage older adults to share their technology usage problems and provide help to their peers. For example, an older adult who writes a blog about the encountered smartphone interaction problems will get reward points and those who help the person to solve such a problem will also get reward points. Such a design is inspired from Stackoverflow, although targeted at older adults who are not tech-savvy. By participating in this community, older adults can not only seek help easily but also actively share their experiences and communicate with others, improving their self-efficacy and sense of self-value. Additionally, the producers and designers of information devices can gain valuable insights from older adults' problems, which can help make new information technology more user-friendly for older users.

6.3. Potential Cultural Effects

Our study focused on Chinese older adults, and it is important to note that cultural factors may impact their mental barriers and problem-solving behaviors. In Chinese culture, older adults have traditionally been revered for their wisdom and life experience North and Fiske (2015). Despite the physical challenges of aging, they have been respected as authorities in knowledge and experience, and younger generations have sought their guidance. However, the rapid advancements and constant updates in information technology have made it difficult for many older adults to keep pace with the changing times. As a result, they have transitioned from being revered to becoming recipients of support and assistance in acquiring knowledge and skills, which can intensify their frustration when struggling to master the use of information devices.

Moreover, Chinese traditional values also make older adults cautious about seeking help. Eastern philosophy emphasizes self-management rather than attempting to effect overt changes to the environment or other people Au et al. (2013) In Chinese culture, people are concerned about what others say about them, and it is common for Chinese people to meet others' expectations to avoid social sanctions and save face Ting-Toomey (1994); Yang (1981); Au et al. (2013). As a result, Chinese older adults may be more sensitive to negative feedback from helpers and require empathy in help-seeking to great extent. This cultural effect may also explain why they do not insist on clarifying their needs to helpers when failing to receive adequate support but instead tend to learn from tutorials.

6.4. Limitations and Future Work

While qualitative studies provide valuable insights into the difficulties that older adults face when completing smartphone interaction tasks and the relationships among potential factors, quantitative methods are needed to better understand how different factors influence each other. In future work, we will leverage quantitative methods to supplement our findings. For example, we video-recorded the process during this study but did not log data in participants' smartphones due to privacy concerns. However, logging this data with participants' consent can provide a deeper understanding of the exact timing and contexts of interaction problems. By using big data analysis techniques, we can better understand the relationship between older adults' behavioral patterns and the data pattern of interaction paths when encountering interaction problems, which can benefit the development of more intuitive interaction techniques for older users.

Furthermore, we found that older adults' smartphone interaction problems can stem from and result in mental barriers. Overcoming these mental barriers is crucial for addressing their interaction problems. However, the relationship between mental barriers and other factors such as cultural background and education experience in technology use needs further exploration. In the future, we plan to extend our research in two ways. Firstly, we will explore how older adults perform when completing interaction tasks on new platforms such as spatial computing and XR devices. This will help us understand their difficulties and mental models in a new interaction paradigm. Secondly, since our participants were all from China, our findings may be more reflective of Chinese older adults, limiting the generalization of our findings. Therefore, we will consider comparing differences across different cultural backgrounds.

7. Conclusion

In this work, we present a conceptual model that reveals older adults' mental barriers and their relationship between interaction problems, help-seeking challenges, and typical response behaviors in the context of smartphone interaction tasks. This model helps in comprehending the psychological and behavioral experiences of older adults when they encounter interaction problems. It emphasizes that addressing the mental barriers is crucial in solving older adults' issues. We suggest design implications based on the model that not only enhance the user interface for the older adults but also

support them to obtain empathy and be active in technology use and learning.

8. Disclosure of Interest

The authors report there are no competing interests to declare.

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Appendix A. Survey Questions

Table A.9: Survey questions

No.	Description of the questions
Collecting metadata	
Q1	Did you have the experience of helping an older adult to solve smartphone usage problems?
Q2	What's your gender?
Q3	How old are you?
Q4	What's your job?
Q5	Please rate your proficiency of using smartphones.
Q6	What's the gender of the older adult who you recently help?
Q7	What's the education level of the older adult?
Q8	How old was the older adult
Q9	What's your relationship with the older adult you helped
Q10	What's the operating system of the older adult's smartphone, Android, iOS or others?
Collecting information about experiences of helping older adults with smartphone use	
Q11	Could you describe in detail the problems that elders encountered when using mobile apps to complete interaction tasks?
Q12	Would you please describe in detail how you have helped her/him with the problems?
Q13	What's the effectiveness of your help? (Older adults solved the problem and mastered the method of dealing with it; Older adults solved the problem and knew how to deal with it at that time, but soon forgot how to solve it; Older adults solved the problem but didn't learn how to deal with it)
Q14	What type of system application they asked a for help (*e.g.*, phone call, messaging)?
Q15	What type of third-party application they asked for a help?
Q16	Which of the following ways you usually help them in (live demonstration, remote voice communication, screen recording demonstration, picture demonstration, other)?
Q17	As a helper, what do you think are the most important factors that affect the effectiveness of your assistance?

Appendix B. Participants demographics in the formal user study

Table B.10: Participants demographics

No	Age	Gender	Education level	Smartphone OS	Career (before retirement)	Years of smartphone usage
P1	70	M	Junior middle school	Android	Government officer	2
P2	67	F	Junior middle school	Android	Government officer	10
P3	74	F	Technical secondary school	iOS	Staff training	3
P4	71	F	Primary school	Feature phone	Machinist	0
P5	70	M	Junior college	Android	Engineer	3
P6	66	F	Junior middle school	Android	Waiter	5
P7	65	F	Junior middle school	iOS	Retailer	3
P8	63	M	Senior middle school	Android	Architecture engineer	2
P9	70	M	Senior middle school	Android	Government officer	7
p10	69	F	Junior middle school	iOS	Government officer	7
P11	61	F	Senior middle school	Android	Weaver	4
P12	60	M	Senior middle school	Android	Taxi driver	5
P13	81	M	Senior middle school	Android	Bus driver	3
P14	68	F	Junior middle school	Android	Primary school teacher	6
P15	64	F	Junior college	iOS	Middle school teacher	2
P16	62	M	Senior middle school	Android	Retailer	8

Appendix C. Nomenclature Table

Table C.11: Nomenclature

Abbreviation	Full term
UX	User experience
UI	User interface
MB	Mental barrier
e.g.,	For example
R	Relationship
T	Task
P	Participant
Q	Question

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