Understanding How Older Adults Independently Search, Install, Grant Permission to, and Uninstall New Mobile Apps

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Abstract

Mobile apps have been increasingly integrated into people's daily lives, ranging from online shopping, transportation to telemedicine. Thus, being able to search for and install an appropriate mobile app independently to meet one's needs becomes an important life skill. While prior research investigated how to support older adults use apps already installed on their phones, little is known about whether and how they independently search for and install a new mobile app. We conducted an online survey with 164 older adults and a follow-up user study with 14 older adults to understand how they independently search for, install, grant permissions to and uninstall apps on mobile phones. We found that when searching for mobile apps, older adults had difficulty constructing appropriate search queries and discerning from similar apps. When installing apps, they were confused about app downloading and security precautions. They had to make trade-offs between preserving privacy and using apps. We discuss design considerations to better support older adults to find, install, use and uninstall mobile apps.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in accessibility**; • **Social and professional topics** → **Seniors**.

Keywords

older adult, aging, mobile apps, search, install, grant permission, uninstall, user study, senior, elderly

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1 Introduction

Globally, older adults, aged 60 and above, are expected to double (2.1 billion) in 2050 [2]. As the life expectancy of the global population increases, older adults are account for an increasing proportion of current and potential Internet users [21]. For example, in the US, 59% of older adults in the 65 to 74 age group are smartphone owners; 40% of those aged over 75 own a smartphone [1]. Older adults use their smartphones for both social (e.g., social network) and non-social (e.g., reading news) purposes [7]. Although older adults are shown to be willing to adopt technologies [34, 46] , they tend to use fewer apps and take longer to complete tasks and send fewer messages compared to younger adults [15].

Prior research investigated older adults' overall technology adoption and learning preferences [28, 37] and peer support they received [22, 36, 51] when using mobile apps. Furthermore, recent research shed light on the barriers older adults face when learning to use smartphones. For example, studies uncovered difficulties that older adults encountered when finding the target app from the ones *already installed* on their phone [52] or when navigating through different interfaces in an *already installed* app [30]. Though informative, prior research primarily focused on older adults' experiences with mobile apps *after* they were installed. However, it can be difficult to *search for a new app* from a large amount of existing ones online or in app stores to meet one's need [55]. Furthermore, *installing a new app* can be challenging and is a key trigger for which older adults seek for help [32]. Unfortunately, little is known about how older adults *search for* an appropriate mobile app from a large amount of available one, download and install the appropriate one that meet their needs. Moreover, it also remains largely unknown how older adults deal with other critical steps, including *granting permissions* when being asked by the app and *uninstalling it* if deemed unwanted. Understanding how older adults deal with these essential steps can inform designers and researchers how best to support older adults to search for, install, and uninstall a mobile app as well as manage permission requests both independently and safely. As a first step towards this goal, we sought to answer the following research question (RQ): *What are the practices and challenges of searching for an appropriate mobile app, installing the app, granting permissions, and uninstalling it for common tasks by older adults independently?*

To answer our RQ, we adopted two methods—survey and user study—to both quantitatively and qualitatively understand how older adults search, install, and uninstall mobile apps on a mobile phone as well as manage app permissions. Our research aimed to

uncover the difficulties that they may encounter during the process, the strategies that they adopt to overcome the difficulties. Specifically, we conducted an online survey with 164 older adults and then a user study with 14 older adult participants aged 60 and above. Both the survey and the user studies included participants from the US and China. In the survey, we explored older adults' past experience with mobile apps and their perceived performance for mobile app search, installation, permission granting, and app uninstallation. In the user study, we asked participants to think aloud while searching, installing, granting permissions to, and uninstalling mobile apps related to social networking and health, which are among the most popular types of apps based on our survey findings and previous research [44]; in the meantime, we also observed their behaviors and took notes. We interviewed them afterward to further understand their strategies and difficulties.

Results show that while participants in general had the need to search and install an app on their mobile devices, they tended to seek help from others than did it themselves and preferred to get help in-person than online. When searching for a mobile app, they faced four main types of challenges: *psychological barriers and the lack of knowledge to get started*, *constructing effective search queries*, *discerning the target app from similar ones*, and *navigating reviews*. while they had little difficulty downloading and installing apps from official app stores (e.g., Apple App Store), they had difficulty doing so through browsers or third-party platforms. In particular, they were confused about *the downloading process* and *the security precautions* provided by browsers or third-party apps. Moreover, although participants were generally on high alert about permission requests, they often had to give in when they had to use the app. Compared to other steps, participants did not encounter much difficulty when uninstalling the newly installed apps. Finally, we present the implications of the findings and highlight potential future directions. In sum, this work makes two contributions:

- Both a quantitative and a qualitative understanding of older adults' strategies and challenges in finding, installing, granting permissions to, and uninstalling mobile apps independently through a survey and a user study.
- The design implications informed by our findings to help improve older adults' independent mobile apps search, installation, permission granting, and uninstallation experiences.

2 Background and Related Work

Our research was inspired and informed by prior work on *older adults' online searching behavior*, *older adults' mobile apps usage*, and *older adults' privacy and security concerns*, which helped us understand how older adults engage in searching tasks in general, including the strategies they used and the challenges they encountered, and how older adults perceived and handled privacy and security concerns in general.

2.1 Older Adults' Online Searching Behavior

Researchers have explored older adults' motivations for searching information online. Health-related information is one of the most popular information that older adults seek online; Older adults are increasingly utilizing online resources for their health information needs [19]. Many older adults have prior experience of searching information related to personal health and health care [13]. These findings showed that older adults not only have the need of searching information online but also engaged in searching tasks frequently.

Older adults use different tools or strategies for searching, such as using browser built-in search box, browser address bar search, web search engine, and website [19]. Some older adults would try different strategies to achieve desired results [19]. When older adults search for health-related information online, the searching keywords they used are often straightforward with no advanced searching skills involved [20]. In our research, we are also interested in understanding the strategies that older adults adopt to search for a new app to meet their needs and how they formulate search queries.

Older adults are found to struggle when formulating conceptual knowledge such as constructing searching keywords [48] and reformulating search terms [45]. Editing searching terms is another challenge for older adults, especially for those who had tremors [23]. Moreover, older adults have limited knowledge of searching options, which causes them to have more failure in accomplishing search tasks [49]. Constructing effective search keywords is one of the challenges that older adults encountered [19]. Besides formulating keywords, finding the relevant apps in App Store is another challenges for mobile device users [55]. The difficulty in recognizing app icons is another factor that causes challenges in finding the relevant apps that are already installed on smartphones among older adults [52]. In sum, prior work mostly focused on older adults' experience with searching for general information or apps that are already installed on their phone. However, little research is focused on understanding how older adults search for and install a new app from online platforms to meet their needs and the changes they experience in this process. In this work, we are motivated to investigate such experiences among older adults.

2.2 Older Adults' Mobile Apps Usage

Prior work showed that health-related apps were commonly used by older adults on a weekly basis, especially exercise-related mobile apps [40]. Unlike traditional health care that is difficult to widely implemented, mobile healthcare-related apps can offer economical services regardless of time and location [27, 54]. For example, mobile health apps can help reduce long waiting time at hospital, poor access to transportation, and reduce cost of healthcare services [3]. Moreover, mobile-health apps can also help older adults monitor their health conditions and provide heath-related information, such as temperature, blood pressure, heart rate, and atrial fibrillation, etc [4–6, 17].

In addition to health-related apps, older adults aged 65 and above were found to use various types of mobile apps for different daily activities, which include personal learning, family and friends connections, etc [29]. For example, for those older adults who prefer to live alone or being told to self-quarantine, mobile apps can be an alternative approach to communicating with their family and caregiver in real-time [4, 5, 57]. In addition, the simplification of social and medical care by mobile apps could benefit those older adults who have difficulty going outside [16, 18, 42, 56].

In sum, prior research mainly focused on understanding the benefits of mobile apps and how older adults use them. Given the growth of specialized mobile apps that could benefit older adults, it is unlikely that these apps are all pre-installed on their mobile devices. As a result, it is important for older adults to be able to search and find the appropriate mobile app and then install it on their mobile devices. However, to our knowledge, little is known about whether and how older adults search, install, grant permission to, and uninstall a mobile app. Therefore, we are motivated to take a first step to explore this problem space.

2.3 Older Adults' Privacy and Security Concerns

Previous studies have indicated that older adults involve in various online activities which include accessing online information, e-commerce, location-based services, social networks, etc [39, 47, 58, 59]. These activities often raise privacy and security concerns [8, 50]. Researchers have found that older adults have concerns that they have no idea how to protect their privacy because privacy protection is too complex [60]. Moreover, mobile device users often need to give permissions before or after installing apps. Studies have reported that Android users do not pay attention or comprehend the permission information when performing the installation task [12]. Among some groups of older adults, even if they read the permission information, they often do not fully understand the information or they are unaware of the data flow and how to personalize application permissions [36].

The privacy and security concern has somehow led older adults avoid using smartphone technology [33]. To address this issue, some studies developed applications to help older adults manage mobile privacy and security issues online, receiving advice from family members, or even strangers [31, 53]. Prior studies have also investigated how social circles help older adults understand digital privacy and security issues [26]. However, there is little work systematically examining how older adults handle privacy and security concerns arising from permission requests when they download and install a mobile app by themselves. Motivated by this gap, we seek to understand how older adults handle permission requests when they download and install a mobile app themselves.

3 Survey

3.1 Survey Design

To answer our RQ, we first conducted an IRB-approved online survey study. The survey included basic demographic questions and six sections focused on mobile device usage: (1) device literacy, (2) app search strategies, (3) app installation platforms, (4) privacy and security concerns, (5) app uninstallation strategies, and (6) overall proficiency[43]. The questions aimed to understand participants' experience with mobile devices and apps, as well as their perceived challenges during the app search and installation process. Overall, 27 questions are included in survey, these questions include single answer question, multiple answer question and open-ended question.

We prepared the survey in both English and Mandarin for participants speaking English and Mandarin respectively. All sections except demographics included multiple choice questions, Likert-scale ratings, and one optional short text question to understand older adults practices and challenges related to the aforementioned aspects. The first section of survey was Mobile Device Usage, which included questions about the types of mobile devices used and the activities performed. We listed 4 types of mobile devices (e.g, android smartphone, android tablet, iPhone, iPad) which were widely used. This section would help us understand the basic mobile device experience of older adults. The second section was Mobile Device Literacy, which included a short version of mobile device proficiency questionnaire (MDPQ-16)[43] to measure participants' overall mobile device literacy. The third section was Mobile App Search, which included questions about app searching strategies and challenges of the searching process. For those participants who had never looked for an app to install on their mobile device, the question regarding their app searching challenges would not be shown. The fourth section was Mobile App Installation, which was for the participants who had mobile app installation experience. This section would also not be shown to those who never tried to install apps. This section also includes questions about the types of app installation platform (e.g. App Store, Google Play) and the perceived security of different platforms. The fifth section was Privacy and Security, which included question about authorization experience and was aimed to understand participants' concern of permission requests. The final section was app uninstallation, which includes question about app uninstallation strategies. To save participants' time, irrelevant questions were not shown to participants based on their previous responses. For example, for those participants who answered"I have never looking for an app to install", they can automatically skip the questions regrading app searching and installing experience.

Before distributing the survey, we invited two colleagues who had HCI background to review the survey to catch any logical problems or redundant questions. Then, we invited two older adults to pilot our survey. Based on their feedback, we updated the survey questions to avoid potential confusions, and keep the survey's length appropriately.

3.2 Participants

We distributed our online survey and recruited participants by sending advertisement to local senior community centers, word-of-mouth, and snowball sampling. Our survey was distributed to the United States and China between Feb 12, 2021 and April 1st, 2021. To incentivize participation, we included a lottery to allow survey participants to voluntarily enter for a gift card of 30 dollars. Each participant entered the main body of the survey before giving an informed consent.

3.3 Mobile Device Literacy

We combined our survey with MDPQ-16 [43] to measure participants' mobile device literacy. In order to improve the MDPQ-16 questionnaire and save participants time to answer all the survey questions, we modified MDPQ-16 by adding the new operation (e.g., Install games and other applications) and combined those operations that are most relevant into one operation (e.g., Find information about my hobbies and interests on the Internet, find health information on the Internet). The 5-point scale (from 0 to 5, 0 = Never tried, 1 = Very difficult, 2 = Difficult, 3 = Neutral, 4 = Easy,

Table 1: Survey participants' demographic information

Age group	Num. (%) of participants
60 - 64	86 (52.4%)
65 - 69	34 (20.7%)
70 - 74	17 (10.4%)
75 - 79	14 (8.5%)
80 - 84	9 (5.5%)
85 & 85+	4 (2.4%)
Gender	Num. (%) of participants
Male	71 (43.3%)
Female	89 (54.3%)
Not disclosed	4 (2.4%)

5 = Very easy) was used to rate participant's ability in performing 14 tasks (e.g.send emails, update games and other applications) with mobile device that they used most. Since prior work has not presented appropriate cut off values for different levels [43], we proposed mobile device literacy level by setting 5-point Likert scales (1: Very Difficult, 2: Difficult, 3: Neutral, 4: Easy, 5: Very easy). Differing from existing studies, we produced mobile device literacy level by computing the average response score for our updated MDPQ-16.

4 Findings

4.0.1 Participants. In the end, 164 survey responses were collected online. 28 of them are from United States and 136 of them are from China mainland. Among all participants, about 4.3% of participants live in the city, 67.1% of participants live in the suburban area, and 28.7% of participants did not disclose their living area. Participants' demographic information were shown in Table 1. All our participants had prior experience of using mobile device. More than half (54.3%) of our participants were female, 43.4% were male, and 2.4% of participants did not disclose their gender. Among all participants, the largest age group was 60-64 (52.4%), followed by age group 65-69 (20.7%).

4.0.2 Mobile Device Literacy. Results show that our participants' mobile device literacy covered all five levels. Among them (N=164), about 32% (N=53) were at the level 1, about 26% (N=43) were at the level 2, about 23% (N=38) were at the level 3, about 14% (N = 23) were at the level 4,and about 4% (N=7) were at the level 5.

4.0.3 Mobile Device Usage. **Types of Devices**. Regarding the mobile devices that participants used, Android smartphones were the mostly used (65%, N = 107), followed by iPhones (23%, N = 37), Android tablets (4%, N = 7) and iPad (4%, N = 7). For other devices, participants mentioned Amazon fire and elderly devices (e.g., Newman N99, GIONEE L200, etc).

Types of Activities. The three most frequently mentioned types of activities that participants performed on mobile devices were *Utility* (e.g., calculator, camera, etc) (72%), *Social Networking* (e.g., using Facebook, WeChat, etc) (70%), *Getting Information* (e.g., podcasts, using the Internet, etc) (64%). Other types of activities included *entertainment* (e.g., playing games, watching videos) (46%), *online shopping* (43%), *finance* (e.g., online banking, Venmo) (38%), and *education* (e.g., using training software in mobile phones, etc) (12%).

4.0.4 Mobile App Search. **Practices**. Among all participants (N=164), 95% (N=155) encountered a situation in which they needed to find a mobile app to install on their device. However, a high percentage of them *did not try to search for an app by themselves*. Instead, most of them chose to "*Ask friends or family members in person*" (61%), followed by "*Ask friends or family members online*" (20%), "*Ask technical support*" (7%), and "*Ask others online*" (4%). For those who had experience search for a mobile app, they used two approached: "*Search from websites by myself*" (30%) or "*Search in app stores (e.g., Google Play, Apple apps store) by myself*" (26%).

This result suggests that almost all participants had the need to search for a mobile app. However, over half of them had not performed mobile app search alone. Instead, they sought help from others, and they preferred to do so in person than online and preferred to ask a familiar person (e.g., family or friends) than a stranger (e.g., technical support). For those who had searched for a mobile app themselves, they searched from both websites and app stores.

Challenges. The most common challenge was that most participants did not know how to search for a mobile app online (e.g., *"I don't know where to start"*, *"I'm afraid to get started"*) and often relied on others to install apps for them. Another challenge was the difficulty in discerning from similar apps, as one respondent wrote, "Sometimes the app of interest which I heard about is not easily distinguished in the app store since there are several apps which sound very similar", *"The apps' icons can be very similar"*.

4.0.5 Mobile App Installation. **Practices**. 35% of all the participants did not have experience in mobile app installation. For the 65% of the participants who had experience in mobile app installation (N=108), 41% used *pre-installed app stores on an Android system (e.g., Google Play, Samsung Galaxy Store)*, followed by *Browser* (38%), *pre-installed app store for iOS systems (e.g., Apple App Store)* (19%), and *third-party platforms (e.g., Baidu Phone Assistant)* (18%). Finally, 14% did not know the type of platforms they used to install apps.

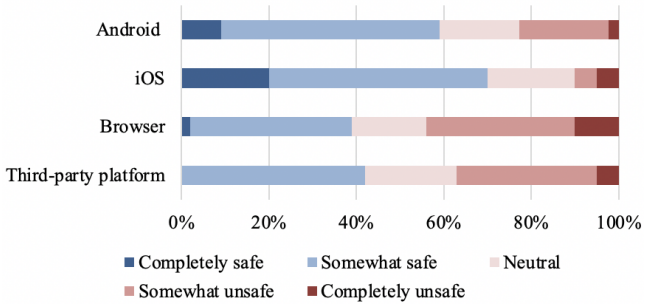

Figure 1: Perceived safety of installing mobile apps on different platforms.

Challenges. One commonly mentioned challenge was the perceived safety of mobile apps. Figure 1 shows how safe participants felt about installing apps on the platforms they used. Overall, participants felt safer to install apps from pre-installed platforms on their devices (e.g., Google Play, App Store). In contrast, they felt less safer to install apps through Browser or third-party platforms.

Another challenge was assessing whether an app version was up-to-date (e.g., *"I don't know if the app is a new version or an old*

version"). Another challenge was with the downloading process. They felt sometimes the app cannot be downloaded or the download process was too slow.

4.0.6 Mobile App Permission Authorization. **Practices**. One critical step of installing an mobile app is granting permissions that it asks for. Figure 2 shows how often participants felt that they were asked for permissions by mobile apps. Results show that over two thirds (69%) of them had been asked by the apps they installed to give permission to access certain functions (e.g., access to the camera, microphone, location, photo album) at some point of usage. Specifically, 27% of participants had such experience *sometime* , 26% *most of the time*, 9% *half of the time*, and 7% almost all the time. In contrast, only 31% of participants had *never* been asked by an app to give permissions.

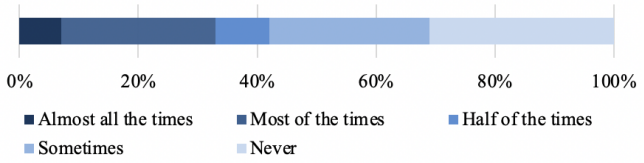

Figure 2: How often participants felt mobile apps asked them for permissions to access certain functions (e.g., camera, microphone, location, album)

Challenges. One key challenge with granting apps' permission requests was the privacy and security concerns.

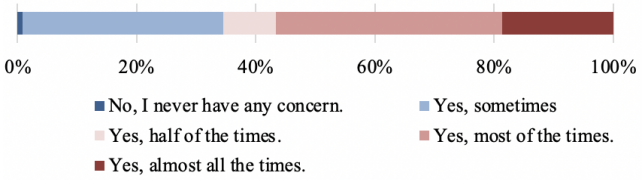

Figure 3: How often participants had security concerns when being asked to grant permissions to mobile apps.

Figure 3 shows how often participants had security concerns when being asked for permissions. Only one participant did not have any security concern, and all the rest had security concerns to different degrees. 38% of the participants (N = 113) had concerns *most of the times* when apps asked for permissions, 34% had concerns *sometimes*, 19% had concerns *almost all the time*, and 9% had concerns about *half of the time*. Overall, respondents did not have a good strategy to deal with this challenge: *"If an app asks for too many 'permissions', I would choose not to use it."*, *"Difficult to judge how safe/secure it is and how much you are inundated with ads trying to sell you something else."*

4.0.7 Mobile App Uninstallation. **Practices**. Figure 4 shows different approaches that participants took to uninstall an app from a mobile device (participants could report more than one approach except those who had never uninstall apps on their mobile device). Among all participants (N=164), one common category of approaches was to *ask someone for help*. The most popular target to ask for help was *their children* (34.1%), *family/friends from younger generations* (26.2%), *family/friends of their own generation* (13.4%), *their partner/spouse* (7.3%). Compared to these family and friends, they also consulted *colleagues* (4.9%), and *customer or IT support* (2.4%) though to a much lesser extent. Another common approach was to *work it out by trial and error* (32.9%). Other approaches included using the device's *help features* (18.9%) or *instruction manual* (9.8%) and *searching the internet* (7.9%). Among all participants, only 8 of them (N=164) have never uninstall mobile apps in any way.

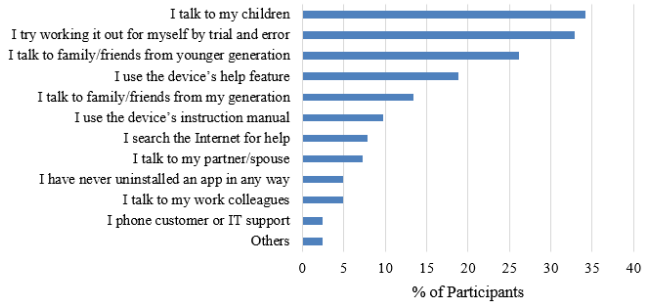

Figure 4: Approaches to uninstalling mobile apps.

One common reason for uninstalling an app was that they found that a free app that they installed began to ask for payment, for example, when the free trial period ended. They also uninstall apps when these apps were labeled free but asked for payment after being launched.

Perceived Level of Difficulty. Figure 5 shows their perceived level of difficulty of uninstalling an app. Almost 20% of them did not try to uninstall a mobile app by themselves. For those who had experience uninstalling apps, 48% felt it was *easy* or very easy to uninstall apps. However, about a quarter (25%) held a *neutral* opinion and 7% felt it was *difficult* or *very difficult*. This result suggests that compared to searching and installing a mobile app as well granting apps permissions, uninstalling a mobile app was perceived relatively easier and more straightforward.

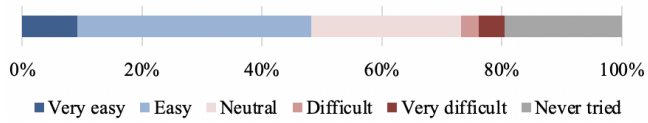

Figure 5: Perceived difficulty of uninstalling mobile apps.

4.1 Effects of Mobile Device Literacy

We performed Kruskal-wallis tests to assess whether participants' *mobile device literacy levels* affected their *perceived difficulty of searching mobile apps*, *perceived difficulty of installing mobile apps*, *perceived difficulty of uninstalling mobile apps*. Results showed that *mobile device literacy levels* had significant effects on participants' perceived difficulty of searching mobile apps ($\chi 2(4) = 29.0, N = 164, p < .0001$), installing mobile apps ($\chi 2(4) = 70.5, N = 164, p <$

.0001), and uninstalling mobile apps ($\chi 2(4) = 50.3, N = 164, p <$ .0001). These results suggest that participants who had higher mobile device literacy level tended to rate their experiences of searching, installing and uninstalling mobile apps as relatively easier.

4.2 Summary and Motivation for the follow-up Study

Our survey findings show that older adults have difficulties in searching apps, discerning from similar apps, understanding downloading related info, and judging security issues. However, it remains unknown why and how older adults encounter these challenges. This motivated us to conduct a follow-up user study to observe and understand how they actually search, install, grant permissions to, and uninstall mobile apps and the challenges they experience. Moreover, the survey findings were also used to inform the study design. For example, we used two mobile devices with Android and iOS operating systems (OSs) because our survey found that these OSs were the two most popular ones among older adults. Informed by the typical activities reported in the survey, we designed the tasks for participants to work on in the follow-up study.

5 User Study

We further conducted an online user study to gain a deeper understanding of the practices and challenges of mobile app search, installation, authorization, and uninstallation among older adults.

5.1 Participants

Fourteen (N=14) older adults who had prior mobile device experience participated in the study. All of these participants answered our survey and giving an informed consent before the user study. Among these participants, six identified themselves as female and eight as male. Their ages ranged from 61 to 91 ($Median = 70, M = 73, SD = 9$) and only one participant did not disclose her age. Participants were recruited through advertisements posted in local senior communities in both the US and China, word-of-mouth, and snowball sampling. In the end, 10 participants were recruited from the USA and 4 were recruited from China. Participants had different backgrounds. 3 of participants have PhD degree, 2 of participants have master degree, 9 of participants did not provide their educational background. Among all participants, some were retired college professors and staff, and some were retired professionals (e.g., lawyer, office worker, teacher). We calculated all participants' mobile device literacy. Among all of them (N=14), about 14% (N=2) were at the level 1 (Very Difficult), about 14% (N=2) were at the level 2 (Difficult), about 7% (N=1) were at the level 3 (Neutral), about 50% (N=7) were at the level 4 (Easy), about 14% (N=2) were at the level 5 (Very Easy).

5.2 Study Design and Procedure

One intuitive approach to conduct the study was to ask participants to search and install an app on their own phones and share their phone screens remotely with us. However, this approach had a number of challenges. First and foremost, this approach raises privacy and security concerns. Participants might be reluctant to share their screens through which we could observe the apps they installed on their personal phones. Second, even if they were OK with sharing their phone's screens, they still needed to have robust data connections to install an additional piece of software (e.g., Zoom) on their phone and share their phone's screen. This process can be challenging to do remotely if installation ran into problems. Third, participants might be apprehensive of installing unfamiliar mobile apps asked by us, who were strangers to them, because they were unsure whether the apps would cause harms to their phones. As a result, we decided to use our own mobile devices for the study and prepare two devices, an iPhone SE 2, and a Pixel 4 (5.7"), running two common mobile operating systems (i.e., iOS and Android) so that participants could choose the one they were familiar.

Table 2: Study Tasks: these tasks covered 1) searching for two different apps, which are relevant to older adults based on survey findings and the literature, 2) using one app, including installing and granting permissions to it; and 3) uninstalling the app.

Task	Content
Task A	Search for an app that can help you communicate with your family, the app should be able to send photos and videos and share everyday moments.
Task B	Find an app that can help you monitor your sleep and show you whether you snored while sleeping.
Task C	Use the app that you just found so that you can know whether it can help you monitor your sleep or not.
Task D	Uninstall the app you just installed on the device.

During the study, participants first completed the tasks on mobile phones and then be interviewed. Table 2 shows the four tasks. We designed these tasks to represent common scenarios in which older adults would need to perform mobile app search, installation, and uninstallation as well as permission granting. We designed tasks A and B related to social networking and health (e.g., exercise) because our survey findings show that social networking is the second popular activity that older adults performed on mobile device. Prior work also found similar adoption rate of health (exercise) related apps among older adults [44]. Tasks C and D were designed to understand how older adults use the app they just installed to complete a relevant task and finally uninstall it when they no longer need the app. To understand participants' approaches and challenges with their familiar platforms (e.g., Browser, Google Play, Apple App Store), we prepared two platforms (i.e., Android and iOS) and asked our participants to use the platform they would normally use to complete our tasks.

We conducted the studies in either English or Mandarin for participants speaking English and Mandarin respectively. The user study was conducted remotely via Zoom, and two researchers (A and B) joined the study with each participant. Researcher A acted as the moderator to interact with the participant, provide instructions, and interviewed her after she completed all the tasks. Researcher B operated the test mobile device and shared the screen with the participant so that she could see the screen via Zoom in real time. Researcher A would describe each task to the participant to ensure

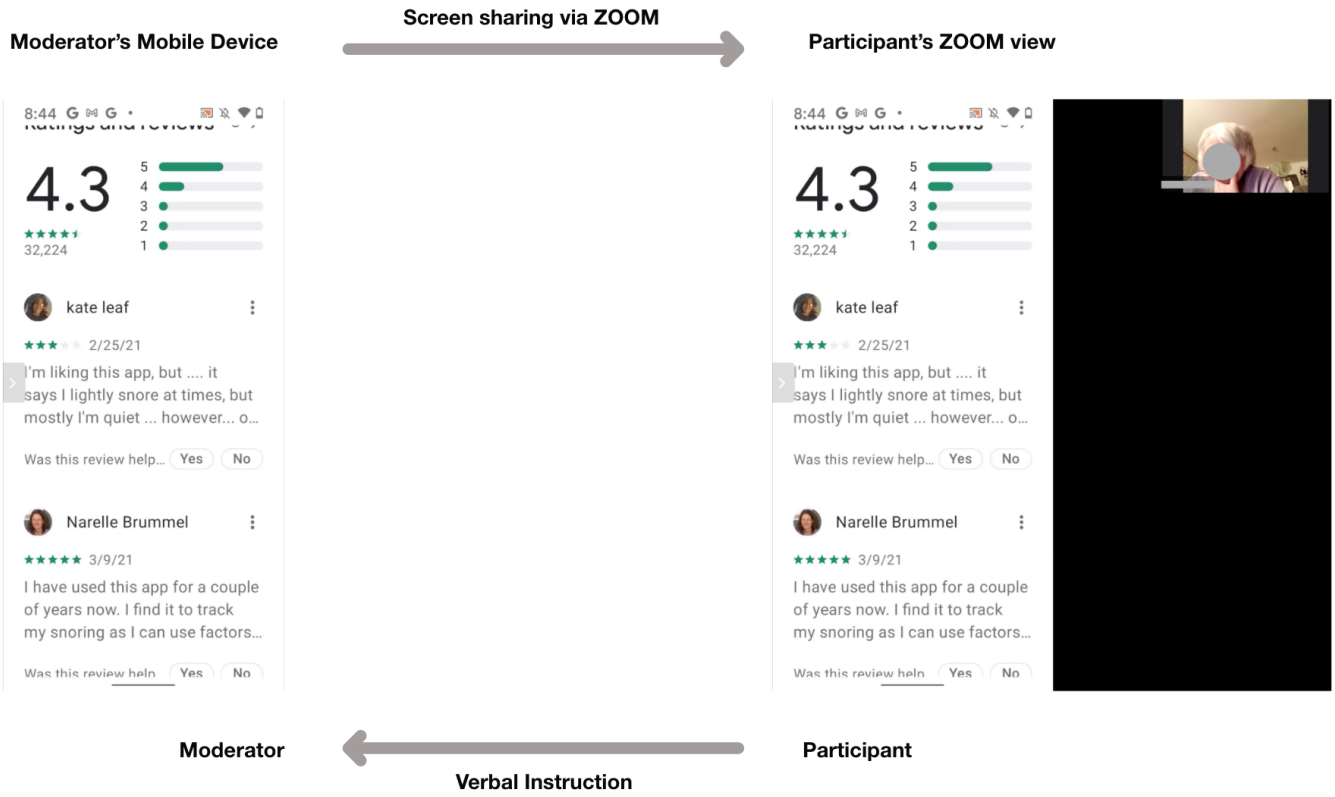

Figure 6: User study setup between a moderator and the participants. The moderator shared the test mobile device's screen with the participants, monitored their think-aloud verbalizations, and operated on the mobile device accordingly.

that she understood the task and continued to think aloud during the study. The participant saw the shared phone's screen and verbalized what they wanted to do. Researcher B listened to their verbalizations and acted as the "remote hand" of the participant to operate the app on her behalf. Figure 6 illustrates the relationship and interactions between Researcher B and participants in the user study.

After participants finished the tasks, we conducted semi-structured interviews with them to understand their strategies and challenges encounter in the tasks. The questions were about their task-related strategies and challenges as well as features and designs they wished to have to assist them to search, install, grant permission to, and uninstall mobile apps. We also asked follow-up questions based on their answers and our observations during the studies. The study took approximately 60 minutes. The study sessions were screen and audio-recorded. Each participant was compensated with $17.

5.3 Data Analysis

Participants' think-aloud verbalizations (i.e., verbalized thought processes) and interview data were transcribed from the audio recordings. Two coders first read through think-aloud verbalizations and interview data to familiarize themselves with the data and then coded the data independently by focusing on the practices and challenges of mobile app search, installation, permission, and uninstallation. Since think-aloud data included fragmented utterances that could be hard to understand, the coders referred to the screen recordings to better understand what participants meant. Afterwards, the two coders met to discuss the codes in their weekly meetings to gain a consensus on their interpretations of the data and derive themes emerging from the data.

6 Findings

In this section, we present the findings in terms of searching for mobile apps, installing mobile apps, granting permissions to mobile apps, handling privacy and security, and uninstalling mobile apps. In each section, we explained the participants' strategies and challenges in detail.

6.1 Searching for Mobile Apps

Participants' app search strategies included three general phases: 1) *Choosing Search Platforms*; 2) *Iterating Search Keywords*; and 3) *Deciding the Target App*. We presented the details for each phase next. Finally, we presented the *challenges* that participants encountered when searching for desired apps.

6.1.1 Practices. Participants searched for target apps through both official app stores pre-installed on mobile devices (e.g., iOS app store, Google Play) and search engines (e.g., Google). One reason for choosing search engines over app stores was that app stores

showed too many app options that were overwhelming. In contrast, search engines tended to show less relevant app options in their search results.

> "I would use Google and have it find it for me instead of going to Google Play because sometimes it's just..it's so overwhelming to see so many options [in Google Play]." - P05

During the search process, participants iteratively changed their search keywords based on the search results and also the search recommendations.

> "[Typing *monitor sleeping*] OK, it doesn't show any related apps? [Typing *monitor sleeping mode problem*]. No. How about this? [Typing *How to monitor human sleep mode*]. That's not the... so maybe *monitor* is not the right word..." - P04
> "[Typing *sleep monitor*] I would...(the predictions show up)...OK, let's try *sleep monitoring free*..." -P7

When deciding which app to install, participants considered the app's name, rating, and cost. When the apps came from other sources (e.g., the third party) and did not have publicly available reviews like the ones in pre-installed app stores (e.g., Google Play, Apple Apps store), they were also more wary of the safety of the sources of the app.

> "Recently I got two Apps related to COVID from the state ...I went back and forth about whether I should trust whether they were really from the state...In the end, I figured they were from the state and went ahead and installed them, because of course I'm interested in what's going on with COVID."- P8

6.1.2 Challenges. Participants encountered three types of challenges when finding the apps to complete the tasks: 1) Constructing search queries, 2) Discerning from similar apps, and 3) Navigating reviews in app stores.

Constructing Search Queries. Participants had difficulty constructing the most appropriate search terms to locate the target app efficiently. Some did not know what was allowed to put into a search query. For example, one participant thought that the browser only allowed for one or two keywords in the search bar. Instead of using sentences or questions that would provide search engine with more contexts to find relevant apps, using short keywords might result in a large amount of tangentially related apps. Consequently, participants mentioned that the difficulty in constructing precise keywords might cause unwanted searching results.

> "For a long time I didn't know what to look for, I didn't know how to describe it, so I would have said something like snore APP and it would have taken me much longer to find it. And then I accidentally discovered that I could just ask the question for precisely what I needed and that would get me what I wanted much faster. I don't think I realized for very long time that I could put an actual question in Google, and I've been doing that for I don't know 20 years...nobody ever told me to ask a whole question [in the search query]." - P8

Discerning from similar mobile apps. Participants feel frustrated to find the app they want in either App Store or browser, especially if the searching results show several similar apps. Based on participants' think-aloud verbalization, "Which one should I choose?" is a common question that participants asked when they found several similar apps in searching results. One participant (P9, Male, 61) mentioned that he hesitated to use App Store because he depended on someone else to help him determine which app was the one he wants since the variations of apps' symbols and names are minor. Moreover, some participants mentioned safety issues as another reason that caused them to feel hard to determine apps.

> "From what I see on the screen, I feel if I cursor down, I would just get apps after apps and none of them would be the app I'm looking for and it's just very frustrating." - P14

Figure 7 shows searching results for "Zoom" in App Store. Participant (P10, Male, 71 years old) was confused after the searching results showed up. He mentioned that several versions of Zoom showed up, which all had similar icons and design.

> "I'll give you an example, when you go look for zoom in an app store, there are a dozen of different zooms. There are minor variations in the symbols and things, so I have to rely on somebody else saying this is the correct zoom so that's why there's a hesitant to use the app stores, because there are just so many similar dumb names, let me say branding configurations and things like that and it becomes very confusing." - P9

Navigating reviews. Narrow window causes unclear information of App's ratings. Participant (P9, Male, 61 years old) mentioned "I wonder where other options are, it's appear to be options to the right of critical." In figure 8, ellipse 1 shows category options of review, due to the limitation of mobile device' screen size, only 3 options were shown. participant (P9, Male, 61) wants to read the worst review to determine whether he would install the app or not. First he asked our researcher to scroll down to the bottom of the page to see the worst review but there was no way to locate to the last page. (Participant subconsciously thought the worst review would be at the bottom of the page.) Then, he asked our researcher to click the three lines icon behind most relevant (See ellipse 2). However, the pop-up notification did not include information about worst review (see the second page) so he went back to the first page and then tried to click the three doc icon (see ellipse 3) but it still did not shows the information he wanted. After a while he realized that he could click "Critical" button which was located in ellipse 1 and scroll left to see the other star options (See ellipse 4).

> "Honestly, I wish they were all standard but they're not going to be. If they were standard like if I know I can scroll down and it shows the rate, you know what what I'm familiar with ratings is going on Amazon. When you go on to Amazon you search for product they'll have the ratings five to one and you take your prompt and you click on one. And it gives you the one you go into the product click on five is five. In that app, I had to go up to the top. And because of this, the narrow window because of my mobile device I couldn't see the whole the whole I couldn't see the

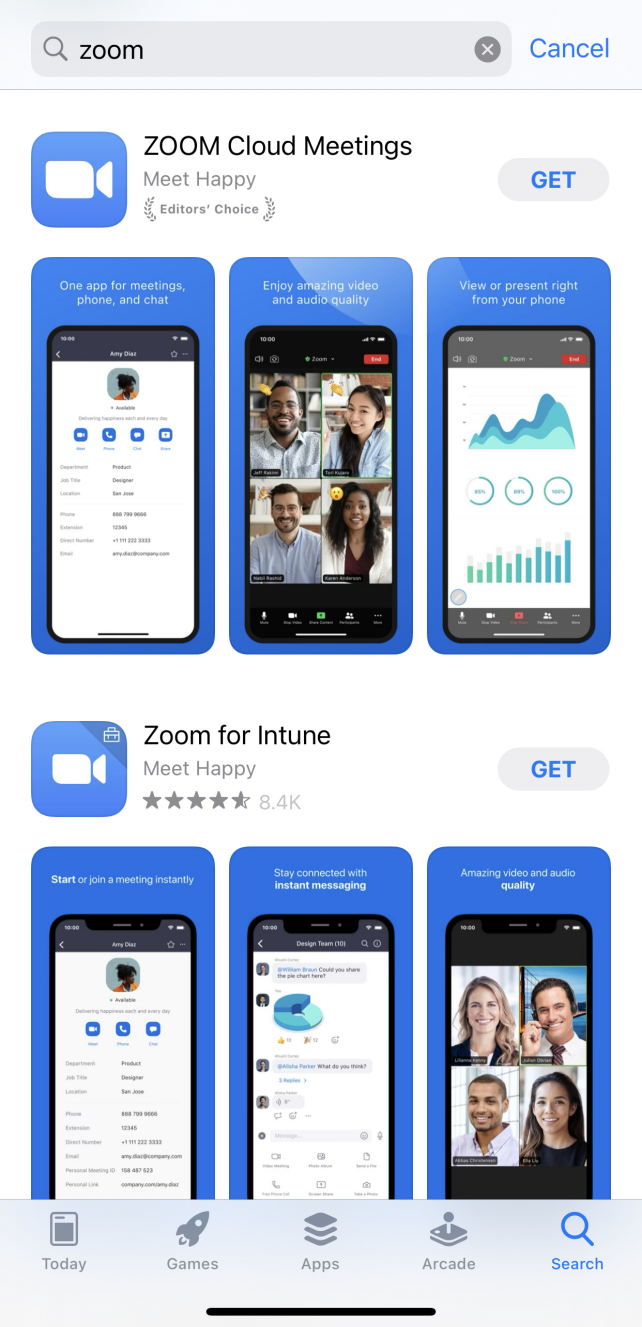

Figure 7: Two Apps showed up after searching "zoom" in the App Store. Both were from the same developer and had similar icons and names, which confused participants.

> whole description, where I was going with that and, finally, when you scroll back up there, I said Oh, I can scroll to the right, and I can pick on that one yeah that would actually work well, but because then the mobile device you can't see the whole screen." - P9

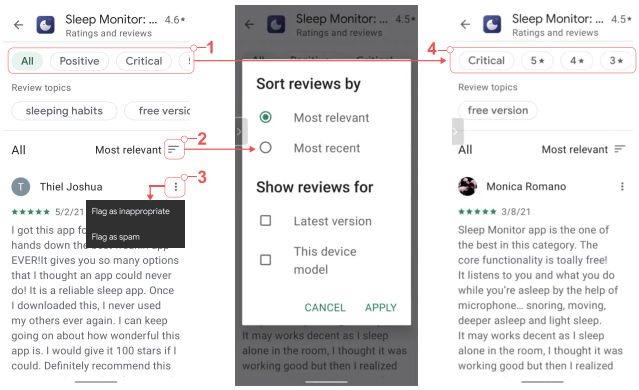

Figure 8: Process of finding app's worst review.

6.2 Installing Mobile Apps

Participants did not encounter difficulties when installing apps through *official app stores*. They either pressed "Get" button in the Apple App Store or the "Install" button in the Google Play. In contrast, when searching and installing apps outside of app stores, such as through search engines, the steps were complicated and confusing.

Confusing App Download Process. Some search engines provided multiple app download options that confused our participants. For example, when searching "WeChat" app in Baidu, two download options (i.e., "Safe Download" and "Regular Download") were shown without explanation of the differences (Figure 9). What's more, after clicking "Safe Download", a pop-up window was shown at the bottom of the screen and disappeared after some time. This quick time-out mechanism was problematic to some participants who did not even notice the pop-up window.

To make things worse, yet another "Download" option was in it. While this option might be meant for download confirmation, it actually caused more confusion. *"I don't understand...I just clicked download, right? Does that mean I still need to download it?"*- P2

Confusing Security Precautions. While certain security precautions were meant to reduce the risk of installing malicious apps, the precaution information did not empower our participants to understand the situation and make the right decisions. For example, the Amazon Appstore showed the security warning with two options (i.e., "cancel" and "setting" in Figure 10). However, while "cancel" might help participants avoid potential risks, it did not help them complete the tasks. On the other hand, they could not relate "Settings" in this context. *"What am I canceling and what am I setting?...What settings do I change?"*-P9.

6.3 Mobile App Permission Authorization

6.3.1 Practices. Overall, participants were cautious about granting permissions to mobile apps when using them to complete tasks during the study. When being asked to grant permissions to share their personal information, such as photos, messages, keyboards, locations, documents, they often refused to share and clicked "Cancel" option and sought other apps. For participants who knew that they would be unable to use the app if they refused to grant the

Figure 9: Searching and Installing an App through a Search Engine (e.g., Baidu): 1) Two download options (i.e., "Safe Download" and "Regular Download") were shown with no explanation of the differences; 2) Another "Download" option was shown in the pop-up notification after the "Safe Download" was pressed.

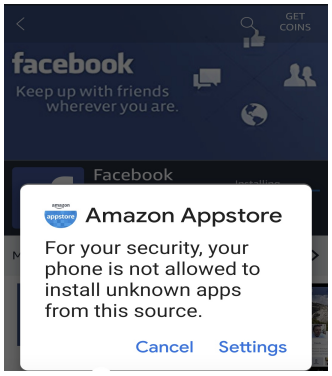

Figure 10: Cancel and Settings. The settings button does not include clear information. Participant (P9, Male, 61) was questioning the meaning of setting and what should he do after clicking it.

permissions, they tended to choose "Allow Once" or "While Using the App."

> "If the app is forcing me to give a permission, I will have to consider whether to use it. If I must use this app, I have no choice but to allow it." - P1

Another reason why participants were cautious about granting permissions was that they had bad experiences of receiving excessive amounts of notifications after they granted permissions to mobile apps.

> "I don't want the apps to send me too many notifications because my phone rings all day long [because of the notifications]. Everybody wants to poke at me and gives me notifications, and I have a life, I don't want to be poked all day long." - P7

6.3.2 Challenges. One main challenge was that if they refused to give permissions to an app, they often could not use the app anymore. This challenge forced them to make a trade off between protecting their personal information and enjoying the benefits of the app. *"It's hard to decide whether to allow an app to obtain the location information of my device. I usually don't want to share my location. However, my experience is that if I reject the request, the app downloading process will be stopped."* - P1

Another challenge was related to *changing their mobile device privacy settings*. Some participants had trouble dealing with app authorization issue because they did not know how to change the setting or answer the authorization questions that could both protect their information and utilize the app.

6.4 Uninstalling Mobile Apps

6.4.1 Strategies. In their everyday lives, participants used the following four different strategies to uninstall apps. Instead of using only one strategy, participants tended to use different strategies together.

Use Search Engine. Search engine is one of common tool participants would use to find apps uninstallation instruction when they do not know how to uninstall an app on their mobile device. Participant mentioned one of the reasons behind this preference is when their children were busy with their work and they have no time to help them solve the problem. *"I usually go to the browser to find how to uninstall an app." - P4*

Seeking Help from Social Circle. Similar to what we found from the survey study, our participants depended on their family and friends to help them uninstall apps. *"I know how to uninstall an app by asking my daughter." - P1*

Ask Professionals for Help. A less commonly used approach was to ask professionals. The reason was that they thought staff members would possess the right skills to deal with the problem. *"I know how to uninstall mobile apps after consulting a staff in a phone store, because staffs there are very professional, and I think their methods are the most correct ones." - P2*

Use a trial and error approach. Because participants could not ask for help using the above methods during our study, they uninstalled apps by trail and error. However, many participants felt that they spent too much time to figure out how to uninstall apps.

> "Now after many trials, it felt easy. But again, until I figured it out, I didn't know I could just hold the app down or how long I was supposed to hold it down

> or how hard I had to press it, so I had to do a lot of experiments. I would touch it and it would open the app, but that wasn't what I wanted to do. Then I tried something different.." - P8

6.4.2 Challenges. Most participants (N=7) had prior experience of uninstalling mobile apps except two participants. One of them used Google to search "How to uninstall app on iPhone?" and found an instruction to delete the app successfully. Another participant was very afraid of uninstalling apps by himself, he mentioned that he preferred to seek help from younger generations and was unwilling to use a trial and error approach. Uncertainty of the required pressure and duration for holding the icon on mobile phone's touchscreen is one of the challenges for uninstalling applications. Within the context of our user study, a participant highlighted the difficulty associated with pressing and holding an app's icon in order to delete it..

7 Discussion

To our knowledge, our survey and user study together is the first quantitative and qualitative investigation of older adults' strategies and challenges of searching, installing, authorizing, and uninstalling a *new mobile app by themselves*. In this section, we discuss our key findings, the open challenges and potential design considerations.

7.1 Mobile App Search

While almost all participants encountered a situation in which they needed to find a mobile app to install on their devices, they tended to ask others, in particular friends or family members, for help, and preferred to do so in person than online. For those who did search by themselves, they mostly searched from the built-in search box or app stores. This practice was similar to how older adults searched for health-related information online [19].

Four challenges emerged from our studies. The first one was *"the psychological barriers and the lack of knowledge."* Both our survey and user study showed that some participants were afraid to get started or did not know how to search for an app. Similar psychological barriers to get started with using technology were found in other contexts, such as learning technology [33]. However, it remains an open question of how to help older adults overcome such psychological barriers. One possible approach might be to introduce peer support [35], which has been shown to have positive effects on older adults' learning process, by making older adults aware of what their peers with similar backgrounds are capable of doing to boost their confidence. Earlier HCI work, such as Markercolck [41], provided some good examples to foster shared awareness of others' activities while still preserving privacy through the redesign of familiar objects (e.g., clock [41]).

The second one was about *"constructing search queries."* Participants often used simple words or phrases based on the search tasks and had difficulty constructing the most appropriate keywords. This echos the findings of prior work regarding how older adults searched for online information and constructed search queries [19, 20, 23, 45, 45, 48, 49]. To address the query construction issue, participants used search engine's automatic recommendations to iterate on their search queries. Our current study provides limited insight into how older adults choose from a list of recommendations, which is worth further investigation. In addition to using short phrases and words, some participants used complete sentences to find the target app (e.g., *"Find an app so that I can send a text messages or photos or a link to my friends"* - P11). A complete sentence often contains more contextual information for search engines to find more relevant apps than a single keyword or phrase. However, we noticed that only few participants searched with whole sentences. As one participant explained, they did not know they could have entered a whole sentence to find an app. Future work could investigate intuitive designs to inform older adults of the relevant searching tricks.

The third challenge was *"discerning the target app from similar ones"*. This happened frequently when the search results contained apps that had similar names or similar app icons. Our findings illustrated this well with the case that two similar Zoom apps showed up when the participant searched the keyword "Zoom." It remains an open question of how to best help older adults discern the target app from similar ones. One direction is to use computer vision or AI techniques to detect whether similar apps are returned for a search query. Perhaps natural language processing can be employed to analyze the meta-data and customer reviews of these apps and then suggest which one is the best match for the older adult user's needs.

The fourth and last challenge was with *"navigating reviews"*. One potential reason was that reviews on different platforms were organized in different ways. For example, participants who were familiar with how Amazon's reviews were organized felt counter-intuitive about the way how reviews in Android Play Store were organized. It suggests a need for maintaining a consistent user experience across different platforms and apps. However, it is challenging for different tech companies to adopt the same way to organize their contents due to commercial and legal considerations. One possible direction is to investigate ways to map the organization of the reviews on one platform to the one that users are familiar with.

7.2 Mobile App Installation

Our study shows that participants did not encounter much difficulty when installing a new app through official app stores (e.g., Apple App Store or Google Play Store) as the downloading process was relatively straightforward with just one button press. However, participants had difficulty downloading apps from a browser or a third-party platform. One important reason was *the confusing precautions*. For example, the browser shows different download options (i.e., safe download and regular download) without explaining why one was safer than the other and why even made a less safer option available in the first place. What's more, when participants decided to download the app, the third-party platforms sometimes blocked the process, and participants found the explanation often confusing. This suggests that although it sounds reasonable for browsers and third-party platforms to act as the "big brother" to warn users what is safe to download or to block the download process for users, they demand more convincing explanations for such actions. This raises a question of how best to assist older adults to download apps safely. In addition to providing senior-friendly explanations (e.g., by using plain language that follow older adults'

mental models [10]),it is perhaps even more helpful to suggest alternatives for older adults to achieve their goals if the apps they chose to download are not allowed to be downloaded for safety concerns.

7.3 Mobile App Permission Authorization

Overall, our user study participants showed concerns for privacy when apps asked for permission to access their mobile device. They shared concerns about privacy and security issues such as whether apps really needed access to the resources the app asked for, which seemed to be unrelated to the app itself. This suggests that older adults demand a better explanation why certain permissions are required, in particular when such permissions do not seem to be relevant to the app.

Unlike prior research [24] that suggested older adults were unaware of privacy and security risk when installing apps, our user study showed that older adults were on high alert when an app popped up a notification asking for permissions. While they were often reluctant to grant permissions due to privacy and security concerns, they had to make a compromise if they had to use the app. However, as a way to manage potential risks, they chose "allow once" or "while using the app."

7.4 Mobile App Uninstallation

In our user study, participants did not encounter much difficulty when uninstalling the newly installed apps. This result was consistent with the survey finding that only 7% of the survey respondents felt it difficult or very difficult to uninstall an app. Compared to searching for and installing a new app as well as managing permission requests, uninstalling an app was perceived to be the easiest. Most of our user study participants had prior experience uninstalling apps. Indeed, our survey study also found correlations between prior experiences (i.e., mobile device literacy) and their perceived difficulty of the tasks. Specifically, participants who had higher mobile device literacy levels tended to rate their experiences of uninstalling mobile apps as relatively easier. This suggests that improving older adults' general mobile device literacy might be beneficial to improve their experiences of mobile uninstallation.

8 Limitations and Future Work

We conducted both survey and a user study to provide a quantitative and qualitative understanding of how older adults independently search for, install, uninstall a mobile app and grant permissions. Our findings could inform the designers and researchers to better support older adults in these tasks. However, there are a few limitations. To gain a broader perspective of older adults' practices and challenges, we recruited participants from both the USA and China. The authors were Chinese working or studying in the USA when conducting the study. While the authors reached out to local communities and used word-of-mouth and snowball sampling for participant recruitment, most of the survey respondents were from China though a good portion of them were from the USA. As a result, due to the relatively small sample size and unbalanced sample distribution, we refrained from directly comparing the differences between the two countries. Nonetheless, this research uncovered practices and challenges that many older adults face when search, installing, granting permission to, and uninstalling mobile apps independently. We acknowledge that cultures might have played a role in shaping the practices in the two countries and deserve further investigation. For example, "safe download" and "regular download" offered by the browser might be more common to participants living in China than in the USA. Moreover, older adults in the USA and China may have different levels of privacy and security concerns [38]. Future work should further investigate how cultural elements might affect older adults' practices and challenges regarding mobile search, installation, permission granting, and uninstallation.

Second, we carefully designed the user study to minimize the impact of the COVID pandemic by allocating one researcher to act as the "remote hand" of the participants to help them execute their verbal instructions so that they can interact with the apps as close to in-person as possible. However, such a set-up might be slower than when older adults operate it themselves due to the network and the execution delay. This might have given participants more time to think about the possible operations. Furthermore, the presence of a researcher, even though she did not offer any help but merely followed the participants' verbal instructions, might have an effect on participants' performance, in particular when recent research suggested that older adults might perform impression management in the presence of others [14]. In addition, the size of the shared screen on Zoom might differ from the actual device, and this difference could have an impact on participants' performance. Moreover, older adults' performance or strategies might be different in reality. As a result, it is worth investigating whether and to what extent older adults' strategies and challenges in an in-person study setting might be consistent with our findings.

Third, our survey results found a correlation between participants' mobile device literacy levels and their experiences of searching, installing and uninstalling a mobile app as well as granting permissions. This suggests that age might not be the key factor distinguishing their experiences from younger adults though a similar study with younger adults is warrant. Fan et al. investigated think-aloud verbalizations of older and younger adults when they use different products and found similar subtle patterns indicating user experience (UX) problems and also revealed differences [9, 11]. Another interesting direction to explore is comparing older and younger adults' solutions to the list of challenges. As older adults were shown to less likely prefer trial-and-error than younger adults [28], we suspect that there might be differences in ways how younger and older adults handle the challenges rather than the challenges themselves.

Last but not least, as our community is moving toward designing positive aging experiences [25], we argue that there are many opportunities to design positive experiences for older adults by treating "aging as resource" rather than "aging as incapability." For example, our study show that older adults preferred to search, install, grant permissions to, and uninstall new mobile apps with others, such as their children. One possible direction is to turn the challenges into an opportunity by creating collaborative experiences between older and younger generations that would not only make technology use experience more positive but also help strengthen cross-generation emotion bonds.

9 Conclusion

We have investigated how older adults search, install, and uninstall a new mobile app as well as how they manage permission requests through an online survey study and an online user study. Our findings show that while most participants had the need to search and install an app on their mobile devices, they tended to seek help from others than did it themselves. In particular they preferred to ask help from someone whom they were familiar with (e.g., friends, family members) than from strangers, and they preferred to do so in-person than online. When searching for an app, they faced four main types of challenges: the psychological barriers and the lack of knowledge to get started, constructing effective search queries, discerning the target app from similar ones, and navigating reviews.

While participants did not encounter much difficulty when downloading and installing apps from the official app stores, they had difficulty downloading and installing apps from browsers or third-party platforms. In particular, they were confused about the precautions provided by browsers or third-party apps. The confusions were caused by unjustified precautions or the lack of alternative solutions if an app was blocked to be downloaded.

Our participants had privacy and security concerns when apps asked them for permission to access their device's resources, in particular when the permissions were not perceived as relevant to the app asking for such permissions. Our study also showed that participants were generally on high alert about such permission requests even though they might make a compromise when they had to use the app. In general, our participants did not encounter much difficulty when uninstalling the newly installed apps. This was mostly due to the fact that most of them had prior experience doing so. Finally, we discussed the implications of our findings and potential directions to better support older adults to search for and install an app that meets their needs as well as to better manage permission requests.

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