"I Never Imagined Grandma Could Do So Well in Technology": Evolving Roles of Younger Family Members in Older Adults' Technology Learning Process

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While younger family members play significant roles in supporting older adults' technology use, an in-depth understanding of evolving relationships within the family is still limited. We interviewed 20 older adults and 18 younger adults to reveal how younger family members are involved in older adults' technology learning process. Our findings suggest that, besides being supporters, younger family members also play as guides, protectors, preventers, and monitors at older adults' different technology learning stages. We contribute an empirical understanding of how younger family members' role transitions happened at different stages due to their reconfiguration of expectations towards older adults. We highlight needs to facilitate older adults' technology learning by promoting a holistic understanding of older adults within families, and facilitating family members' teaching and protecting older adults in a comfortable way.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**; *Empirical studies in HCI*.

Additional Key Words and Phrases: older adults, technology learning, family, family support

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1 INTRODUCTION

Older adults have been perceived to be resistant to adopting new technologies and have difficulties in learning new technology [17, 24, 28, 35]. Even though technologies are emerging and become infrastructural today [16], older adults' adoption and learning of new technologies such as smartphone is still limited [3]. Therefore, prior research focused on supporting older adults' learning and use of new technologies. Researchers revealed that older adults' family members play a significant role in their adoption and learning of technologies [17, 34, 36, 38, 44], such as introducing new technologies, encouraging use, helping to buy new devices, and providing instructions.

While research suggested family members play vital roles in supporting older adults to use technology, it is still unclear from the literature how family dynamics influence older adults' technology learning. Some recent studies have suggested that family members may experience difficulties in supporting older adults' technology learning [44]. For example, older adults may feel reluctant to ask their family members for help [38]. Family members may also struggle to explain simple technology tasks and were frustrated by the slow teaching process [44]. Besides, while the support from family members has been highlighted in prior literature, most work emphasized the support at a certain moment (e.g., adoption and acceptance [34, 44], help seeking [34, 38, 44], early stages of learning [38]). However, research suggested older adults' use of technology is a long-term and evolving process [23], which may need continuing and evolving support. These findings call for an in-depth understanding of evolving relationships between older adults and their

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family members during older adults' technology learning. Considering this research gap, we proposed the following research questions:

RQ1. What roles do younger family members play in older adults' technology learning, and how do these roles evolve in older adults' different stage of technology learning?

RQ2. How do older adults perceive the involvement of their family members?

To answer the above research questions, we conducted semi-structured interviews with 20 older adults and 18 younger adults, including 9 pairs of older adults and their younger family members, to include perspectives from both groups. We focused on the relationship between older adults and their (grand)children, as (grand)children seem to be among the most important people when it comes to how older adults adopt and learn to use new technologies in comparison with other members in the family (e.g., spouse) [36, 44, 45, 49]. We also try to include a wide range of technologies through encouraging participants to share all experiences they felt relevant.

Based on the interviews, we discover that besides being supporters, younger family members also play as guides, protectors, preventers and monitors, and these roles may evolve in older adults' different stage of technology learning. We find that the younger people act mainly based on their expectation of aging during the first two stages. During the adoption stage, younger family members may play as guiders, who try to provide older adults their ideal retired life with technologies. Moving to the onboarding stage, they will teach older adults basic use of technologies with assumed difficulties, and create a safety net for older adults to protect them from assumed threats and negative effects.

We then identify a reconfiguration of expectation among younger adults; during the maintenance stage, younger adults start to have a more concrete understanding of older adults' technology use. The teaching process is not always smooth due to older adults' forgetfulness and a possible knowledge gap between the two generation in terms of basic concepts (e.g., cloud system) and inner logic of technology (e.g., common design pattern adopted by technology). These challenges in teaching and learning may lead to impatience of both sides. Besides, out of many younger adults' expectation, many older adults start to explore new functions/applications, which then may lead to a latent tension between younger family members' protection and older adults' agency in technology use. Some younger adults become preventers and even monitors when they feel older adults' technology use is off control. While such protection may be accepted by many older adults we interviewed, it may also lead to older adults' discomfort.

With these findings, we uncover an evolving relationship between older adults and their younger family members in different stage of older adults' technology learning process. The evolving relationship can be attributed to younger adults' reconfiguration of expectation towards older adults, and we find such evolving relationship can be situated in a Chinese cultural context. We then call for needs to facilitate older adults' technology learning by promoting a holistic understanding of older adults within the family, facilitating family members' teaching and protecting older adults in a comfortable way.

Taken together, the main contributions of this work are two-fold:

1) We contribute an empirical understanding of younger family members' evolving roles in older adults' technology learning process.

2) We provide design implications for facilitating older adults' technology learning by promoting a holistic understanding of older adults within families, and facilitating family members' teaching and protecting older adults in a comfortable way.

2 RELATED WORK

Given our research focus on family members' roles in older adults' technology learning, we situated our work in two research areas: 1) older adults' learning of new technologies, and 2) family members' support for older adults' technology use. We first review older adults' preferences and challenges in technology learning. Next, we present current findings on family members' role in older adults' learning.

2.1 Older Adults' Learning of New Technologies

Older adults have long been perceived to be resistant to using new technologies and have difficulties in technology learning [11**?**], which spurs researchers to investigate factors influencing older adults' adoption of technologies and how to facilitate older adults' technology learning. Many past researches explained older adults' difficulty in technology learning to factors related to a general decline in cognitive ability in aging, such as cognitive decline in working spacial memory and lower perceptual speed [10, 14]. One recent study pointed out that older adults faced challenges especially during the onboarding process [38], and even tech-savvy older adults need help during the initial phases of new device ownership [41, 47].

Despite these difficulties, research suggested older adults' learning and adoption of new technologies can be motivated by a series of intrinsic and social factors [9, 34]. Perceived usefulness and value in experiencing new technologies play an intrinsic motivational role in increasing adoption [9], which may explain why older adults are generally willing to use technology for practical goals, such as online communication with family members [5] and online shopping [31]. Meanwhile, older adults' social networks (e.g., family members, friends) can be influential in encouraging older adults to use new technologies [34]. It is worth noting that older adults may disuse specific technologies despite initial acceptance [23], and continuing support from family, friends, and service providers can encourage older adults to use new technologies [21, 29]. As such, older adults' learning of new technologies is a long-term and dynamic process, and challenges are emerging during adoption, onboarding and further use, which may emphasize the need for continuing support during older adults' whole learning process.

Many researchers tried to investigate older adults' preference for the setting of technology setting, which may provide insights for how to better support older adults' technology learning. This line of work has mostly focused on designing better training materials for older adults (e.g., [10, 15, 51]). However, while older adults are found to be more inclined to using instructions manuals than learning through trial and error [28], recent studies have shown that older adults generally prefer to learn independently as opposed to interrupting family members or waiting long periods of time for customer service [18, 33]. Pang et al. also found that older adults now lean toward self-paced learning, flexible learning methods, and were less reliant on instruction manuals than before [38]. These new findings indicate that older adults' preference for learning may change as technology evolves and user population changes, which may call for new ways to support older adults' technology learning.

2.2 Family Members' Support for Older Adults' Technology Use

Family members play significant roles in supporting older adults' technology use [34, 44]. Prior research suggested family can provide both information and influence for older adults' adoption and learning of new technologies [12, 34, 38, 44, 46]. Family members can first facilitate older adults' technology adoption by demonstrating the relevance and usefulness of certain technologies [34, 46]. Besides, family members can also be important sources of providing instructions. Overall, older adults are more likely to go online if they feel they may have someone who can support [22]. For example, Friemel

et al. found that older adults preferred support at home from family and friends most when learning Internet use [12]. Similar results can be seen that a lack of technical support may make older adults feel resistant to using new technologies [12, 25], and technical support from grandchildren is especially important for older adults' technology adoption [34, 44].

Research on cybersecurity and privacy also indicated that family support is important for older adults during their technology use, as older adults are more susceptible than adults of other age groups [13, 27]. Much prior research investigated collaborative efforts in families to protect older adults from potential digital threats [37, 42, 43]. Researchers found that the technology-rich younger generation often enacts guidance and provides technical support for seniors, and they play a role of "family tech manager" [37, 42, 43]. With support from family members, older adults tend to be comfortable to have their digital footsteps monitored and stewarded by their tech managers.

While these research provides important insights for supporting older adults' technology learning and use through introducing family members as supporters, what remains unclear right now is the family dynamics and evolving family relationship when older adults receive help from their family members. While prior research mainly framed family members as supporters, some research suggested that sometimes older adults and their families may disagree on the needs for specific technologies [40], and younger adults may force their ideas upon older adults [21]. Some older adults also describe frustrations with how support is given by certain family members and shy away from asking the same individuals for technical support again [40]. In [37], the authors also found some cases where strict guidelines established by family members posed conflicts between older adults' safety and their willingness. Indeed, older adults voice varying preferences for ways to learn how to use new technologies, either through family support, step-by-step instruction, independently playing with the device, reading instruction manuals, or a combination of these methods [4, 12, 38]. These findings call for an in-depth understanding of the family relationship in family members' support and how older adults perceived the support they received.

3 STUDY METHODOLOGY

We conducted a qualitative study to investigate what the roles of younger family members are in older adults' new technology learning progress and how these roles evolve between different stages. According to the research purposes, we first design the interview questions and process, and a pre-test of questions was carried out with several participants, which was used to iterate the questions and process. Then, the interview questions and process are determined for the following data collection. During the interview, we did not restrict the conversation to any particular technologies. Instead, we encouraged participants to share their experiences and feelings they felt most relevant. After getting the interview data, transcript, code processing and analysis were conducted to extract meaningful information. Finally, the qualitative analysis was used to generalize what we found among the results.

Participants and Recruitment. Table 1 and Table 2 detail our participants' demographics. To reach a diverse group of people, we recruit participants from three sources: 1) authors' personal social network (e.g., friends, relatives), 2) older adults' online communities (e.g. WeChat group established by older adults), and 3) online communities (e.g. DouBan). We recruit both older adults and younger adults, who or whose older family members are using technologies. We also ask if their family member (i.e., (grand)children who provide supports or (grand)parents they support) is willing to participate in the study, if applicable. While many older adults and younger adults are willing to participate in the study, many of them don't want to bother their families. Finally, we recruited 20 older adults (gender: 12 female, 8 male; age: median = 70.5, average = 71.15, SD = 6.49) and 18 younger adults (gender: 11 female, 7 male; age: median = 32.5, average = 34.27, SD = 9.41). Among our participants, there are 9 pairs of families.

Table 1. Participant Demographic Of Older Adults

ID	Gender	Age	Relationship (ID)
S1	Male	65	daughter (Y1)
S2	Female	74	daughter (Y2)
S3	Male	74	daughter (Y3)
S4	Male	81	son (Y4)
S5	Female	65	one son
S6	Female	77	one daughter
S7	Female	72	one son
S8	Female	70	one daughter
S9	Female	75	two sons
S10	Female	65	one son
S11	Male	70	one son
S12	Male	64	one son
S13	Female	66	one son
S14	Male	88	granddaughter (Y8)
S15	Female	66	daughter (Y8)
S16	Female	79	daughter (Y14)
S17	Female	72	grandson (Y18)
S18	Female	71	grandson (Y18)
S19	Male	61	one son
S20	Male	68	grandson (Y11)

Table 2. Participant Demographics of Younger Adults

ID	Gender	Age	Relationship (ID/age)
Y1	Female	35	father (S1)
Y2	Female	45	mother (S2)
Y3	Female	44	father (S3)
Y4	Male	47	father (S4)
Y5	Female	42	father (70)
Y6	Female	39	father (66)
Y7	Female	28	grandfather (S14)
Y8	Female	30	mother (S15)
Y9	Female	25	mother (62)
Y10	Male	30	mother (65)
Y11	Male	22	grandfather (S20)
Y12	Female	23	grandmother (82)
Y13	Male	27	father (60)
Y14	Female	52	mother (S16)
Y15	Male	26	grandfather (76)
Y16	Female	45	mother (71)
Y17	Male	35	father (71)
Y18	Male	22	grandmother (S18)

Semi-structured Interviews. From July to August in 2021, we conducted semi-structured interviews with our participants. All interviews are conducted one to one. Questions for older participants included how they started using technologies they mentioned, what support they received from their younger family members and how they perceived the support, etc. Questions for younger participants included how they chose technologies for older adults to use, how they supported their (grand)parents in technology learning and related feelings, etc. During each interview, we will focus on specific situations and ask follow-up questions to try to get a detailed understanding. Since all our participants are Chinese, interviews were conducted in Mandarin. The interviews were audio-recorded upon the explicit permission of the participants to avoid ethical issues, and notes were taken during each interview. Participants recruited from authors' social network are willing to participate in the study as volunteers. For other participants, considering the difficulty in recruitment, we offered 200RMB to all pairs of families and 25RMB for younger participants as compensation.

Data Analysis. Three of the authors iteratively review and label the emerging codes. We coded the transcripts independently and discussed the results to reach a consensus. Through open and axial coding of interview transcripts [6], themes started to merge and brought us back to the transcripts to find more data for them. After several iterations of analysis, a consensus on themes was reached. All the quotes used in the paper were translated into English by the first three authors and checked by each other.

Ethical Considerations. The whole research group has received ethical training and been granted official certificates. Out of ethical considerations, besides explicitly stating our intention and background information before each interview, and collecting data upon the permission of our participants, we anonymize all data in this study.

4 FINDINGS

In this section, we will first give an overview of younger family members' roles in different stage of older adults' learning of new technologies. Next, we will detail the key findings and emerging themes in each stage of older adults' technology learning.

4.1 Overview

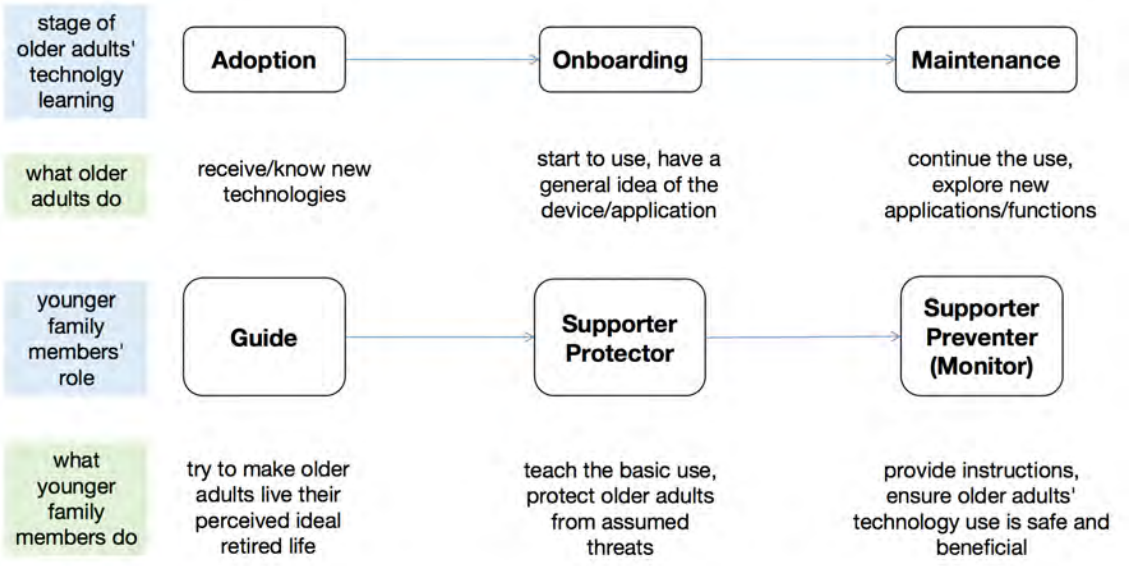

Fig. 1. younger family members' evolving roles in different stage of older adults' use of new technologies

Consistent with past findings, most of the older adults we interviewed mentioned their younger family members as one of the main persons who supported their use of technologies. Many of the older participants tended to ask help from their family members, as they are living with/near their family members and family members are probably the closest member to them. Based on the interview results, we identified three stages of older adults' technology learning where younger family members are involved. As shown in Figure 1, the first stage is **Adoption**, when older adults get the first acquaintance with technologies and younger family members mainly take the responsibility to introduce technologies to older adults. Moving to the **Onboarding** stage, older adults begin to learn to use the technologies they need. Meanwhile, younger family members will teach older adults basic use of technology they perceived as necessary and simple for older adults, and help to set up the device. The last stage is **Maintenance**, where older adults are getting familiar with the device/application, and they may explore new technical applications by themselves based on experiences in the second stage as well as their own social networks (e.g., friends, local communities). In this last stage, younger family members will monitor if older adults have specific difficulties, and they will ensure the safety and benefits of older adults' technology use.

As such, we identified evolving roles younger family members play during older adults' technology learning, as younger adults will reconfigure their expectations and attitudes of older adults' technology use when they gradually have a concrete understanding of older adults' technology learning and their use conditions. Specifically, during the adoption stage, the younger family members can play as **guides**, as they will introduce devices/applications they think appropriate or enjoyable to older adults, through which they try to guide older adults to live an ideal retired life in their mind. Moving to the on-boarding stage, they mainly play as supporters and **protectors**, who teach older adults' basic use and protect them from assumed threats such as online fraud and misinformation, through acts such as downloading applications from trustworthy sources for older adults. In the last stage, younger family members emerge as preventers and even monitors, as well as supporters. In this stage, challenges will be emerging during teaching and supporting, since older adults are forgetful and cannot understand some basic concepts and the inner logic of technology. Besides, out of many younger adults' expectation, as older adults are getting familiar with technologies, some of them start to explore new functions and applications by themselves. This leads to some younger adults' worries and concern, and they feel they have responsibilities for ensuring safety and benefits of older adults' technology use. Therefore, younger family members become **preventers** and **monitors** when they feel older adults' technology use is off control.

It is worth noting that younger family members may not be always involved in all stages of older adults' technology learning, which may depend on their perceptions of aging and their (grand)parents. That is, if they perceived older adults as relatively tech-savvy, they will recommend technologies less often and only help older adults if needed. Here, we identified two types of learning settings where older adults are 1) motivated to use specific technology, and 2) mainly "forced" to use specific technology for necessary purposes (e.g., digital banking [19], health QR code system in China [52]). If older adults actively learning and using technologies, younger family members are mainly engaged in the Maintenance stage, who will just offer help when older adults ask them for help and protect them from possible threats. Otherwise, younger family members will be engaged in all stages.

4.2 Stage I: Adoption

Many of our participants mentioned that younger adult gave or introduced older adults new technologies. Generally, our older participants tend to accept, as they are either curious about new technologies, or took family members' feeling into consideration [34]. Specifically, the younger participants told us they would choose technologies that they think are beneficial and accessible enough for older adults, such as intelligent voice assistants, smartphones with accessible design, news-reading app, online shopping utilization and so on, which may reflect their expectations of aging and an ideal retired life.

4.2.1 Introducing Technologies Out of Expectation of Aging. Many younger family members gave digital products to older adults as presents (e.g., Y1, Y8, Y8, Y10, Y11, Y14), gave their disused products (e.g., Y3, Y4, Y13), or recommended digital applications (e.g., Y2). Older adults are usually happy to use them, as they are curious about new technologies or will take their (grand)children's feeling into consideration [34]. When we asked younger participants what technologies they gave to older adults, or are appropriate for older adults, they usually mentioned smartphones with accessible design (e.g., with physical buttons, large screen display, large fonts), voice assistants and health-related products. The reasons given may reflect an assumed ideal older adults/retired life held by the younger people – older adults should stay healthy and happy, and live a simple life. Basic smartphones and voice assistants can help to promote an enjoyable

Fig. 2. Older adults' learning and use of new technologies: **(a)** the smartphone used by one older participant is with large screen display; **(b)** due to forgetfulness, some older adults need to write down the process on paper for later check; **(c)** the smartwatch used by S1; **(d)** "XiaoAiTongXue", an intelligent voice assistant, used by S6; **(e)** one screenshot of conversations in family WeChat group, where older adults are active in reposting videos and articles, while such information are often perceived as rumors and misinformation by the younger generation.

retired life, as older adults can use them for fun and communication (e.g., Y8, Y8, Y11, Y12), while health-related products can promote their physical health (e.g., Y1, Y5, Y11). Y8 told us,

> *"Older adults can use smartphones for shopping and watching online videos, but they don't have to use smartphones with too advanced functions. Older adults should have enough offline activities. The most important thing for retirement life is probably health, and older adults had better enjoy a simple life. (Y8)"*

For Y1, she bought new technologies for her father because she hoped these new products could bring her father topics for socialization.

> *"I supported my father to use new technologies. I hope he could be happy. He will be happy if he could brag about himself to others with these new products. (Y1)"*

Besides, younger adults often mentioned that technologies for older adults should be simple, as they will usually worry about older adults' learning abilities (e.g., Y8, Y8, Y10, Y11, Y12, Y14, Y18). Many younger participants mentioned voice assistants as the most appropriate technologies for older adults (e.g., Y2, Y13, Y14, Y15, Y18). Y14 explained why she gave voice assistants to her mother this way,

> *"She is old, but I think she should be fine with using intelligent voice assistants. Voice control is friendly to older adults, while it may not be that easy for them to use touch screens. For older adults, voice assistants are the most suitable technology. (Y14)"*

Although in most situations, older adults agree with their (grand)children on needs and preferences of technologies, we noticed sometimes younger participants' perception of aging may not be the true case. S12 told us he wouldn't use most digital products given by his son, because he didn't see the needs in the use. For example, he didn't want to be monitored by the smart bracelet. However, he would not tell his son the truth because he doesn't want to hurt his son's feeling. Similarly, many younger participants recommended/gave health monitoring devices (e.g., Y1, Y8, Y11, Y13, Y15), but older adults may think they don't need health-related products (e.g., S14), or dislike being monitored (e.g., S12, S4). We also noticed that, it may not be that easy for older adults to use voice assistants, as many older adults cannot speak standard Mandarin. For S6, although the basic use of voice assistants (Figure 2(d)) is relatively easy for her, she told us

> *"'XiaoAiTongXue'("小爱同学")[1] cannot understand dialect in Shanghai. I have to speak Mandarin." (S6)*

Similar case applies to S16, who said the voice assistant she used cannot understand what she said due to her accent.

4.2.2 Different Degree of Involvement. It is worth noting that differences lie in the degree of younger family members' involvement in older adults' technology learning when it comes to different adoption settings. Specifically, we identified two types of settings among our participants in terms of their technology acquaintance and adoption: 1) older adults show great interests and curiosity to specific new technologies, and 2) older adults are almost "forced" to use specific new technologies.

If older adults are motivated to use new technologies, they will probably know more about new digital devices/applications through their social networks outside family (e.g., friends, local community). Some of them are even more familiar with new technologies than younger adults (e.g., Y3's father, Y5's parents,Y6's father, Y2's mother) because they see the benefits and enjoyment in technology use. For example, Y2's mother (i.e., S2) is highly motivated to use new technologies, because she sees the benefits in using new technologies. Y2 told us her mother even recommended new technologies to her. Generally, such kind of older adults need fewer guides from younger family members than older adults not familiar with new technologies. As Y5 said, *"I don't need to recommend technologies to my parents. They are using more technologies than me."*

On the other hand, if older adults have no channels to know new technologies, younger adults will give/recommend older adults technologies (e.g., Y8's grandpa, Y8's mother, Y10's mother, Y11's grandpa, Y12's grandma), as described in 4.2.1. If older adults are even resistant to using technologies that have been infrastructural [16], or for necessary purposes such as communication with family members, family members will put even more effort in persuading older adults to enjoy the benefits of specific technologies or for better social integration. For example, Y4 told us he almost forced his father (i.e., S4) to use WeChat[2] for communication with colleagues, as his father was uninterested and resistant to learning.

[1] "XiaoAiTongXue" is an intelligent voice assistant produced by XiaoMi. see https://www.mi.com/redmiaispeaker-play
[2] WeChat is the most popular mobile instant messenger in China [20], which has even been infrastructural in China [54], as it has included financial system WeChat Wallet, and news subscription services.

4.3 Stage II: Onboarding

Onboarding is especially challenging for older adults [38]. During this stage, we find that younger family members mainly play as supporters and protectors, especially for older adults who are not familiar with new technologies. As many don't have an idea of their (grand)parents' needs and learning abilities, they started to support older adults out of their expectation of aging. Most of them will teach older adults basic skills that they think are necessary and simple enough for older adults, and try to make technologies accessible enough for older adults, as they assumed that technology learning is difficult for older adults. For example, younger family members will do tasks which they think are too complicated for older adults (e.g., downloading applications). Here, they may also play as protectors, as they will select applications which they think are appropriate for older adults to enjoy and avoid inappropriate ones, to try to protect older adults from assumed threats and negative effects. While older adults who are active in using new technologies may need fewer instructions from family members in this stage, younger family members may still hold concerns toward their online safety and benefits.

4.3.1 Teaching with Assumed Difficulties. According to our participants, it is younger family members who teach older adults basic use of technologies during the onboarding stage. We noticed that many younger adults only teach their (grand)parents the basic use of each application (e.g., how to read news in news applications, how to send messages in WeChat), to try to make technology use accessible for older adults, as they think learning to use technologies is difficult for older adults and older adults will not be interested in using technologies. Generally, except for families where older adults are active in learning new things, younger participants have a low expectation towards older adults' learning use and their learning abilities. For example, Y15 thought literally using a smartphone was good enough for older adults. With such a low expectation towards older adults, some will do all tasks they think are complicated for older adults (e.g, set-up), such as S9's son, Y5 and S4's daughter.

> *"If my mother buys new mobile phones, I will do the set-up and download all applications she needs for her. All she needs to do is to use the phone I set up for her. (Y5)"*
>
> *"My daughter told me that I can call a car with smartphones. She has done almost all (configurations) for me, and put money in my account. (S4)"*

While some older adults without motivations may still be resistant to using technologies their children told them to use, such strategies work for most cases. With help from their (grand)children, some older adults then depend on family members to do tasks they don't want to learn.

> *"My dad just let me deal with the cloud service configuration to help him transfer the address book to the new mobile phone. He didn't even try to learn to use it by himself. (Y13)"*

However, some younger participants said they were surprised that it was far easier to teach older adults than they imagined (e.g., Y10, Y12, Y11). For example, Y10 chose to teach his mother to use voice messages rather than typing, as he assumed typing as difficult for older adults, but finally he was surprised to find that his mother can type in WeChat.

> *"There were definitely difficulties, but it was a little simpler than I thought. I thought that she might even have difficulties in simply sending a message and opening an application, but I found she could even type some simple messages (in WeChat). I taught her how to send voice messages at first, because I thought it might be hard for her to type. (Y10)"*

Y12 also told us, although she only taught her grandmother to send voice messages because she assumed typing to be difficult, her grandma in fact preferred typing. As a former primary school teacher, her grandmother enjoyed writing

and preferred traditional ways of inputting. Besides, she told us she was even fearful before teaching older adults to use technology, however, her grandmother's learning abilities is far beyond her imagination.

> *"It was much easier than I thought when I taught her at the beginning. I saw online that many people said it was really hard and suffering to teach older adults to learn to use mobile phones. However, in fact it was not that difficult. My grandma can even shop online. She is willing to learn these, which was indeed beyond my imagination, although it was still not that fast. I thought she would not be able to understand with one or two years, but she actually could use the smartphone in two or three months. (Y12)"*

4.3.2 A Safety Net for Older Adults. According to many participants, younger family members will download the initial applications for older adults (e.g., Y8, Y8, Y10, Y11, Y12, Y16, Y18). When we asked the younger participants how they chose applications for older adults, most told us they would select applications they regarded as safe and appropriate for older adults to enjoy. Here, we find that the younger generation may try to create a safety net for older adults. That is, they will download safe and easy-to-use applications for older adults to enjoy. For example, Y8 will not download KuaiShou for older adults.

> *"I thought some videos on Kuaishou was vulgar, so I am not willing to download it for my parents. I won't tell my mother this app, and they don't have any channels to know such kinds of new apps. I will prepare all she needs for her. (Y8)"*

Y12 remembered she only downloaded WeChat for her grandma to communicate with family members, and the family didn't want grandma to get access to information from untrustworthy sources such as TikTok, and retirement life could be simple. Within this scope provided by family members, older adults then select applications they felt interested in using . Some older adults will tell the family members their needs, and younger adults will try to find appropriate ones for older adults.

Applications mentioned included WeChat, news applications, short video platforms, and simple mobile games. Again, younger adults' choice of applications for older adults may reflect an assumed ideal retired life and older adults hold by the younger people – older adults should stay healthy and live a simple and happy life, therefore they may need applications for health-related information, entertainment and communication with family members. Y8 was a typical case who downloaded all applications for her mother, and she explicitly mentioned that she would avoid applications inappropriate for older adults, such as KuaiShou. Y8 described the ideal retired life this way,

> *"Retired life should be simple and healthy. I don't want my parents to spend too much time on the mobile phone. I hope they can have enough offline activities. Besides, misinformation is prevalent online. Older adults don't have to know too much about information which they don't need. They can get what they need through trustworthy sources such as television news instead of reading online information. (Y8)"*

Y11 said he would carefully select news applications for his grandfather, to ensure that the application is developed from a trustworthy organization.

> *"I am worried about the fake news on the Internet. The news app I downloaded for him was pretty reliable. At least I thought it was reliable. (Y11)"*

Indeed, it is common for younger adults to have assumed worries about older adults' technology use. For example, Y2 tried to make her mother cautious before her mother used smartphones.

> *"I told my mother a lot about online safety before she used smartphones. For example, I told her to put little money in online accounts, so that she would not lose too much even if she meets online fraud.". (Y2)*

4.4 Stage III: Maintenance

During the maintenance stage, we find that younger family members mainly play as supporters, protectors, and even monitors. In this stage, as older adults use more functions and explore new ones, younger family members gradually got a concrete understanding of older adults' technology use and related challenges. First, the teaching process is not always smooth and needs evolution due to older adults' forgetfulness and unfamiliarity with the inner logic and related abstract concepts of technology. Besides, out of many younger participants' expectation, many older adults start to learn and explore new functions by themselves, which made many younger adults become protectors, as they are worried about older adults' online safety and benefits. Some younger adults even become monitors when they feel older adults' technology use is off control. Here, there may exist a latent tension between the protection and older adults' agency.

4.4.1 Teaching Strategies that Need Evolution. Many of our participants tend to ask their family members for help, who are often perceived as technology expert by them [37]and probably the most available and patient person they can find. Although many older participants avoid bothering their (grand)children as reported in [28], some of our participants won't feel reluctant to ask their (grand)children for help because they knew their (grand)children are "XiaoShun" ("孝顺")[3] to them (e.g., S15, S16, S20). But they still try to relive the burden of their (grand)children out of caring. A typical way adopted by older participants is to collect questions into a list and ask their (grand)children at one time, if the problem is not urgent (e.g., S14, S15, S20, Y10's mother, and Y12's grandmother). As S15 and S20 reported,

> *"I don't feel I am bothering my daughter. She is quite patient and "XiaoShun" to me. But I know she is busy in work, so I will wait her to visit me at weekend, and ask my questions at that time. (S15)"*

> *"I don't feel I am bothering my grandson, because I will call him in the evening when he doesn't have class. If the problem cannot be solved through phone calls, I will leave the questions behind, waiting him back at weekends and asking him. (S20)"*

In this stage, on the side of younger adults, as older adults continue using technologies, younger adults have got a more concrete understanding of older adults' learning of technologies. Challenges then have been emerging in the teaching and learning process, which requires an evolving teaching strategy. We find that although the basic use at the beginning stage is relatively simple for our participants, our participants will face many difficulties when they continue using the device/application. For many families, the teaching process will be evolving during older adults' further use of technology. That is, younger adults will gradually realize the difficulties older adults faced in technology learning, and they need to teach them in a way that can be understood and accepted by older adults. The case of S14 and Y7is one of the most typical case. As Y7said,

> *"I just realized my poor ability in teaching when I support my grandfather to use the smartphone. For example, my grandfather cannot understand what home button is, and I should work hard to explore a more childish way of teaching. As for the home button, I just told him the only button under the screen, which works for him. (Y8)"*

As an unsuccessful case, S4 told us he cannot understand what his son taught him,

> *"Although I may seem to understand my son's words when he taught me, actually I didn't truly understand. If I asked him again, he tend to be impatient. He told me to exercise my brain, but I can't. My brain is not so sharp as I was young. I am much more forgetful now, which younger people may not understand. (S4)"*

[3] "XiaoShun" means filial piety in Chinese, which is highly valued in Chinese culture.

As S4 mentioned in this quote, many older participants said they often forget some processes their (grand)children taught them (e.g., S4, S2). This made them repeatedly ask the same questions to the younger generation, which requires the younger children to be patient in the teaching. However, for many younger adults, it is not always easy to keep patient. As Y15 and Y2 said,

> *"The most difficulty in teaching my grandma to use smartphones is that I need to teach her many times so that she can understand, and I may be impatient. (Y15)"*

> *"Many older adults are slow in learning. For example, my mother's cousin is such a case. If you tell her to click somewhere, she is highly possible to be unable to find the place. In this way, her daughter may be impatient and just does it for her mother. (Y2)"*

Among our participants, Y7provided us a successful case that she will write down the process and draw pictures on the paper, which her grandfather can check later if he forgets the process. Similarly, Y12's grandmother told Y12 to write down the process on the paper so that she could keep them for later check.

However, for some of our participants, though many younger adults try to be patient enough, they are just repeating their words and may teach too fast, which may decrease older adults' motivation to learn. Some older adults then don't want to bother their family members anymore, or feel embarrassed for asking (e.g., S2, S7). For example, S7 described her son's teaching this way,

> *"I will not ask my son for help. He teaches too fast, and just tells me to click here or there. I cannot remember his words. If I asked him again, he would say like, "older adults don't have to learn (to use technology); (my teaching is meaningless because) you cannot understand my words." At my age, how can I understand immediately? " (S7)*

In this way, some older participants turn to local communities or their friends to ask for help (e.g. S2, S7), or just give up the ask (e.g., S4).

While many older participants told us impatience in teaching would decrease their motivations for learning, some younger adults also told us older adults will be impatient during their teaching. For example, Y4 said his father just told him the phone was frozen with a bad temper, which made him uncomfortable. If older adults are patient and willing to learn, the younger adults may also be willing to teach patiently (e.g., Y4, Y8). For example, while Y7is willing to teach her grandfather, she is not so happy to teach her mother as her mother is resistant to learning and bad in temper.

Besides older adults' forgetfulness, we noticed another challenge in teaching and learning is the possible knowledge gap between older adults and the younger generation in terms of some basic concepts (e.g., menu) and inner logic of digital products (e.g., the membership system, separate password for each application, application design). As mentioned, most younger children will only teach the basic use to older adults, because they want to keep the use of technology simple enough for older adults. However, this will cause many difficulties for older adults to use technology in the further use. For example, S14 told us his granddaughter has set up the password for him, and he even didn't know the existence of the password. However, when he changed his device, the password was required, but nobody remembered the password. S14 also told us younger adults often skip what they perceived as common sense during teaching. For example, he even didn't know what "menu" is. Similarly, many younger participants thought the most difficult part in older adults' technology learning is that older adults are not familiar with common design pattern of technology.

> *"Compared with problems like small fonts, I think the more important reason for older adults' low pace in learning is that they cannot understand common design pattern of applications. For example, we younger people can soon find the button we want to click, but this is hard for older adults. (Y15)"*
>
> *"Younger people are familiar with the inner logic of technology/applications. For example, older adults don't know the back button is always on the upper left. (Y13)"*

According to many of our participants, younger adults may finally decide to do the task for older adults without explanation and tell older adults that they don't have to understand (e.g., Y8, Y8, S4's son, Y10). As Y8 said,

> *"If my mother asked me some complicated functions, and she cannot understand even if I tried, I will just tell her that she doesn't have to use that. I teach her the most basic thing." (Y8)*

4.4.2 A Latent Tension between Older Adults' Agency and Family Members' Protection. We find that many younger adults are quite surprised when they saw their (grand)parents were using new functions/applications which they did not teach them, which they never imagined before (e.g., Y3, Y8, Y8, Y12, Y9, Y1). According to many of our older participants, they will know new applications/functions through their own social network outside family (e.g. friends, local community). As technology has been infrastructural today [16], many will also get to know/download new functions/applications when they go to a bank or take a bus. However, many younger children did not realize that their (grand)parents have their own social networks and learning abilities. Many assumed that older adults would only use basic functions they taught. For example, some mentioned that when they introduced smartphones to their (grand)parents, they assumed that older adults will only use it for communication with his/her family members.

> *"I assumed my grandfather to use WeChat only for communication with me or other family members. However, I found that he had WeChat groups with his friends, and he would also read articles on WeChat. I didn't tell him these functions. (Y8)"*
>
> *"At first, we bought grandma a smartphone for better communication in our family. But I found she had her own WeChat group with friends in the aging care home. She can even read articles and repost them in WeChat. I found this quite interesting. (Y12)"*

Y1 assumed that her father would only read news and watch online videos, but finally surprised to her father had shop through TikTok live-streaming, which even she didn't know. Besides, some younger participants also happened to find that their (grand)parents downloaded new applications by mistouch (e.g., Y10, Y11).

As such, many younger adults reconfigured their expectation towards older adults' use of technology. Although some younger participants are happy to see their (grand)parents' development in technology skills (e.g., Y8, Y9), many start to worry about older adults' technology use, especially for those whose (grand)parents are active in exploring new technologies. Worries mentioned most by younger participants included money-related issues (e.g., online fraud), misinformation and social communication. While many told us they would not be worried about older adults' technology use because they believed that their (grand)parents will be cautious to money-related actions, they still try to set a "limitation" to older adults' use of specific applications (e.g., Y1 telling her father not to buy things of over 50/100RMB online, Y2 suggesting not binding credit cards in digital payment applications, Y5 telling her father not to click links from unfamiliar sources), to prevent older adults from possible online threats. Some younger adults also feel worried about older adults' eyesight and physical health if older adults spending too much time online (e.g., Y5, Y18).

In most cases, families could reach agreement on such limitations on most applications, as older adults knew it is the care from their (grand)children. However, sometimes older adults will hold different perception of specific applications

from their (grand)children. For example, many younger participants think the product quality on PinDuoDuo (""拼多多")[4] is usually not high, while many older adults are intrigued by the low price. As S11 said,

> *"My son told me not to shop on PinDuoDuo, because he thought products on PinDuoDuo are all counterfeit. But I feel PinDuoDuo like a good place where vegetables are cost-effective. (S11)"*

Similarly, many younger adults are worried about the information older adults are reading online, which are often perceived as rumors or misinformation in their mind (e.g., Y2, Y5, Y8, Y9, Y12, Y16). For example, Y2 will put much effort in fact-checking for her father, which even caused her pain.

> *"There are many articles reposted by my father in our (family) WeChat group. I need to check the validity of these articles every day. Sometimes I even need to read research papers so that my father can trust me." (Y2)*

Some even become monitors who will check what applications older adults are using, and who older adults are contacting online, if the (grand)children feel their parents' use of technology off control. Several younger participants will check their (grand)parents' mobile phone when they help older adults to solve specific problems (e.g., Y11, Y10, Y8). As Y11 reported,

> *"My grandpa will ask me for help almost every week, and I will help to check his phone at that time. I have told him which kind of information might be fake/malicious, and not to add strangers as friends (in WeChat), but I still worry he might not be able to identify malicious acts online. (Y11)"*

Y1 and Y8 can be seen as two typical cases of monitors, who will check their parents' phone and even delete applications they perceive as inappropriate for older adults.

> *"I was surprised to see that my father had Alipay in his phone. I guessed it may be downloaded when he went to bank. I immediately made a complaint against the bank. How can they fudge older adults for profits? I deleted Alipay and unbind his cards in WeChat Wallet. My father doesn't have a full understanding of these services, and he often didn't know what he did in the application. (Y1)"*

> *"I often check my mother's phone, and I know almost everything about her online activities. I pay particular attention to her online communication and payment history. You know, older adults are often cheated online. As her daughter, I feel my responsibility to care for her online activities. I will delete applications useless for her, if the deletion will not affect her daily life. (Y8)"*

While many older adults are not aware of such deletion as they are not so familiar with the device, such caring from (grand)children may cause some older adults' discomfort. Y1 felt uncomfortable with her daughter's control, and he is not fearful of online fraud, as he will not lose too much even if he is cheated online. Y8 continue using PinDuoDuo for shopping regardless of her daughters' disagreement. In fact, Y8's mother (i.e., S15) told us she disliked her daughter's check at first out of privacy issues, and she even tried to hide her phone. However, with her daughter's insistence, finally she told herself,

> *"This is the caring from my daughter. Actually, I have nothing to hide in my phone. If she can help me to identify misconducts online, that will be beneficial to me. (S15)"*

Now she even will hand over her phone to her daughter voluntarily.

Except these two cases, most younger participants we interviewed said they would not control older adults' use of technology too much, as they respect older adults as individuals (e.g., Y2, Y5, Y8, Y15, Y16) or they think specific use of

[4] A popular application for online shopping in China. PinDuoDuo is well-known for affordable products that are often unbranded or white-labeled [48].

technology would not affect their lives too much (e.g., Y3, Y5, Y8, Y12, Y10, Y15), although they do have concerns. For example, Y7told us, although she didn't support her mother to shop on PinDuoDuo, but as it would not cause too much financial loss, she would not intrude with her online shopping too much. Many younger participants also mentioned that they believe older adults are cautious to money-related actions (e.g., Y3, Y4, Y8, Y12), or they would not follow the suggestions in articles they read (e.g., Y9, Y12). Many also mentioned that although playing smartphones may have negative effects, it is still probably the best way of entertainment for older adults as they cannot go out often or have nothing else to do (e.g., Y6, Y8, Y12, Y18). However, we noticed that younger adults' perception of older adults may not be the true case. For example, when we told her father has tens of thousands RMB in his online account, she was quite surprised and perceived it as unsafe for her father.

5 DISCUSSION

In this study, we revealed how relationship between older adults and younger family members may evolve in different stage of older adults' technology learning, with younger adults' reconfiguration of expectation towards older adults. Based on the findings, we provide design implications for how to facilitate older adults' technology learning. We also discussed the cultural context of our findings, to better understand the findings in a Chinese cultural context.

5.1 Unpacking the Evolving Family Relationship during Older Adults' Technology Learning

Our exploration of RQ1 and RQ2 suggests that family members can play dynamic roles during older adults' technology learning process. While prior work mainly framed younger family members as supporters who help older adults adopt and learn technologies [34, 38, 44], we reveal more fine-grained roles younger family members may play in older adults' technology learning (i.e., guides, protectors, preventers and monitors), and such roles may evolve through older adults' technology learning process. As for RQ1, we find that the evolution of roles is probably due to younger adults' reconfiguration of expectation towards older adults. For RQ2, we find that while older adults generally feel grateful to the support from their family members, challenges and possible tensions will also be emerging during the maintenance stage. The exploration of RQ1 and RQ2 can provide design implications for supporting older adults' technology learning through promotion of a more holistic understanding of older adults within the family, facilitating family members' teaching and protecting older adults in a comfortable way.

5.1.1 RQ1: Evolving Roles with Reconfiguration of Expectation towards Older Adults. Based on our findings, we find that such evolution of roles may arise from the reconfiguration of expectation towards older adults during older adults' technology learning process. At first, the younger generation may hold relatively low expectation towards older adults' learning abilities and acceptance of new technologies. Many assumed difficulties in teaching older adults to use technology. Therefore, as guides, they will only introduce older adults technology for necessary purpose (e.g., communication with family members) or of functional benefits (e.g., health-related products), and the products should be simple enough, which, however, may not completely match older adults' needs.

Such a low expectation towards older adults will continue in the onboarding stage, and younger adults will generally hold concerns for older adults' learning abilities and security online, as older adults have long been perceived to be vulnerable to online malicious act [13, 27, 37], and have difficulties in learning to use technology [17, 24, 28, 35]. However, such perception of older adults may change when family members get to know more about older adults' technology learning. While many of their imagination about aging may be true for a large number of older adults, some older adults can be very active online, and not limited to necessary or health-related use [7, 8, 26]. This may make them

feel worried about cybersecurity issues and the benefits for older adults to use technology, which then shifted them from protectors to preventers and even monitors.

Design Implication: Younger adults' relatively low expectation towards older adults may reflect their unfamiliarity with aging and stereotypes of aging generally hold by people [1, 39]. Practitioners can consider supporting activities that can engage the whole family and making visible older adults' needs and abilities (e.g., family tracking [30], family sharing [32]), to promote a holistic understanding of older adults' abilities and use of technologies within the family. Besides, designers can include a teaching&learning tutorials for families to get a general understanding of older adults' different needs and abilities, based on which the family can choose their perceived appropriate way of support (e.g., which applications to download, which functions to teach/learn).

5.1.2 RQ2: Care for Both Family Members and Older Adults. As for RQ2, during the initial two stages, we find that older adults are generally satisfied with and feel grateful to the support from the younger family members, though sometimes older adults may disagree on the needs of technology. Luijkx et al. also found that older adults may have a feeling that their children forced their ideas upon them in terms of technology adoption, but older adults will weigh the trade-off between personal feelings and worries of their children and the possible stigmatization [34]. However, according to our interviews, challenges in teaching and a latent tension may be emerging during the support and protection. These challenges and the latent tension may call for needs to care for both older adults and their family members when it comes to family members' support to older adults.

One of the main challenges is emerging from the teaching process. While older adults are generally satisfied with the instruction provided by (grand)children, sometimes they may feel frustrated during receiving support. Younger adults tend to teach skills they perceived as necessary and simple for older adults, which, however, may cause difficulties for older adults' future use/understanding of technologies. The knowledge gap between older adults and younger adults, combining with older adults' forgetfulness, may lead to younger adults' frustration and impatience during teaching, which may further decrease older adults' learning motivation and make them feel embarrassed to ask again [28]. Meanwhile, we find that the patience and learning motivation of older adults also matter for younger adults' teaching. Similarly, Portz et al. also found that family members were frustrated by the slow teaching process [44]. Prior research also suggested that older adults are less likely to figure out how to use and fix technology if (grand)children are involved, as they will wait for their family to solve the tech issue [50]. These findings may call for attention to a support model weighing both sides. That is, we need to consider the feelings of both older adults and younger family members if we want to include family members as supporters in older adults' technology learning.

Another challenge comes from the latent tension between younger adults' protection and older adults' agency. Younger adults we interviewed are likely to guide seniors to use technologies in their preferred way (e.g., shopping on their perceived reliable applications, not reading articles from untrustworthy sources), as they hold concerns toward older adults' online safety and benefits. Prior research also suggested younger family members may enforce guidelines for older adults [37]. However, such protection may be against older adults' own desires. Among our participants, although most older adults can understand their (grand)children's protection and may agree with the limitations set for them, sometimes older adults will be uncomfortable with such control, or just follow their desires (e.g., shopping on PinDuoDuo) regardless of their (grand)children's suggestions. On the other hand, while (grand)children generally hold concerns, many will not control too much if they think it would not affect older adults lives too much (e.g., losing too much money due to online fraud). Here, we may see the possibility to relive tensions between the two sides through communication and trust building.

Design Implication: As for the challenges in teaching, developers can consider making tools to facilitate younger family members' teaching (e.g., in-built tutorials with metaphors to explain basic concepts and graphs to visualize common design/inner logic of technologies). Additional support such as easily searchable minimal manuals as suggested in [38], learning notes and videos recording process can be considered, which may support older adults for later check. Besides, older adults' lack of motivation may also decrease younger family members' motivation to teach. Considering this, researchers can consider ways to motivate older adults during younger family members' teaching (e.g., include learning of basic concepts and common design of technology in tasks relevant to older adults' needs/interests, make visible the needs of learning [37]). These suggestions may also be helpful to educators and trainers who aim to teach older adults to use technology.

Regarding the latent tension between younger adults' protection and older adults' agency, if permitted by older adults, developers can consider adding features to summarize older adults' technology use patterns, which can help younger adults to better know about older adults' use, remove some unnecessary concerns and further adjust their expectation. Besides, cybersecurity can be treated as a collective practice [37], instead of making older adults invisible in the process. For example, (grand)children can set limitations for older adults under the permission of older adults. Features for family communication can also be considered so that older adults can tell their needs to family members. In this way, older adults may safely use technology with younger family members' protection in a comfortable way, so that trust may be built within the family.

5.2 Cultural Context of Family Members' Support Pattern

In our findings, the way older adults received support from their younger family members and their perception of this support was quite different from results reported from studies in Western context. Many prior studies within Western contest suggested older adults had a stronger preference for learning alone [28, 34, 38]. As has been reported in prior work [33], older adults shared concerns that their adult children were busy with their own lives, and they didn't want to intrude with technology questions until their children visit. Peek et al. also found that older adults are sometimes afraid to burden their children and family with technology needs [40]. However, in contrast to these findings, some of our older participants don't regard asking help from their (grand)children as bothering them or a burden to their (grand)children. Besides, research suggested younger adults may force their ideas upon older adults in terms of technology adoption [34], and enforce guidelines for older adults in terms of cybersecurity [37], which may be experienced as paternalistic and disempowering [37]. However, in our study, many older adults we interviewed can understand their (grand)children's protection, and perceive it as beneficial, although the protection leads to some participants' discomfort.

According to some interviews, such differences might be related to the "Xiao" (filial piety) culture in China, which is mentioned by some of our participants and provides us a lens to better understand the support pattern among our participants. "Xiao" is not only an equal and reciprocal relationship centered around care between two individuals, but also represents the authoritative hierarchical relationship between parents and children [53]. Under such a culture of "Xiao", many younger adults may feel their responsibility in teaching older adults and protecting them from possible threats, and pay particular attention to older adults' technology use. Meanwhile, (grand)parents may take their children's support as care to them, and are willing to receive support and protection from their (grand)children, not only because they see their (grand)children as technology experts [37], but also because they treat it as the care from their (grand)children. As such, the "Xiao" culture may help us to understand younger family members' roles and the evolving relationship in this study.

6 LIMITATIONS

This study has a few limitations. First, it is likely that our findings are China-centric. We do not claim to generalize our findings. We hope that the insights from this paper could help to understand other cultures. Besides, as the research topic is related to family issues, our participants may try to justify their behaviors and not tell the whole story out of social desirability [2].

7 CONCLUSION

We report findings from a qualitative study based on interviews with 20 older adults and 18 younger adults, including 9 pairs of families, to understand how younger family members may be involved in older adults' technology learning process. We found that in addition to supporters, younger family members can also play as guides, protectors, preventers and even monitors, to try to make older adults have necessary skills in technology use, create an ideal retired life for older adults and ensure safety and benefits of older adults' technology use. Moreover, these roles may evolve as younger adults got more knowledge of older adults' technology use and reconfigured their expectation towards older adults. With these findings, we uncover an evolving relationship between older adults and younger family members in different stage of older adults' technology learning. Based on these findings, we call for promotion of a more holistic understanding of older adults within the family, facilitating family members' teaching and protecting older adults in a comfortable way.

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