Older Adults and Free/Open Source Software:
A Diary Study of First-Time Contributors

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ABSTRACT
The global population is aging rapidly, and older adults are becoming increasingly technically savvy. This paper explores ways to engage these individuals to contribute to free/open source software (FOSS) projects. We conducted a pilot diary study to explore motivations, barriers, and the contribution processes of first-time contributors in a real time, qualitative manner. In addition, we measured their self-efficacy before and after their participation. We found that what drove participants were intrinsic motivations, altruism, and internal values, which differed from previous work with older adults and with the general FOSS population. We also found that self-efficacy did not change significantly, even when participants encountered significant barriers or setbacks. The top 3 barriers were lack of communication, installation issues, and documentation issues. We found that asking for and receiving help, and avoiding difficult development environments were more likely to lead to success. To verify these results, we encourage a future large-scale diary study that involves multiple demographics. Given our pilot study, we recommend that future outreach efforts involving older adults focus on how to effectively communicate and build community amongst older contributors.

Categories and Subject Descriptors
K.4.M [**Computers and Society**]: Miscellaneous

General Terms
Human Factors

Keywords
open source software, older adults, daily diary, qualitative research, diversity, age diversity

1. INTRODUCTION
Both the US and global population is aging at a rapid rate. According to the US Census Bureau, over 1/5 of the population will be 65 years and older by 2030 [36].

With this increase in the size of this older population, we expect to see an influx in technically experienced older people, as suggested by a Pew Internet Research survey that found once adults aged 65 and older go online, 82% go online at least 3 times a week [33]. This increase in use of technology may lead to more technically experienced older adults in the future.

Volunteering, as contributing to FOSS could be considered, has been shown to have health benefits for older adults [25]. Contributing to free/open source software (FOSS) may be beneficial to older adults, as staying cognitively active into retirement is related to higher health and well-being [30]. An influx of older adult contributors could also benefit FOSS communities, as the number of FOSS projects is growing at an exponential rate [12].

Even though 31.7% of US employed software developers are 45 years and older [14], FOSS communities are more homogeneous and often lack age diversity. Arjona et al. found that only 12.03% of FOSS contributors are 45 years and only, and only 7.09% of contributors are 50 years and older [2]. Older adults' increased participation may benefit FOSS communities. Davidson et al. interviewed people aged 50 and older who were already contributors [10] as well as community leaders and found 10 unique benefits associated with older adults participating in FOSS communities such as: having a wealth of software development and professional experience, having seen and understand technology trends, having life experience as a user, parent, and spouse, and having general wisdom and maturity.

While the interviews done by Davidson et al. [9] provided valuable insights, it is necessary to study how motivations and benefits/barriers affect the contribution process in *real-time* as older adults try to contribute to FOSS projects for the first time. We are especially interested in the first-time experience, because this first experience is the key to whether people ultimately manage to integrate with the community [19]. Because it may be difficult for experienced developers to remember the details of their first experiences, we decided to conduct a daily diary study where technically experienced older adults (aged 50 and older) logged their daily experiences of attempting to contribute to a FOSS project for the first time. This study is the first of its kind in relation to FOSS contribution, and a large-scale study with multiple demographics should be conducted to verify our results. Note that we chose 50 as our age cut-off because it is the eligibility threshold for the American Association for Retired Persons (AARP) [31]. Our research questions are as follows:

RQ1. *Does participation in a FOSS project impact participants' self-efficacy?*
RQ2. *What motivates older first-time contributors?*
RQ3. *What are the benefits and barriers faced by older first-time contributors?*
RQ4. *What is the "natural" contribution process for older first-time contributors?* The reason why we pursue RQ4 is to develop

an understanding of the contribution process to help us identify healthy and unhealthy paths, in order to help ensure healthy paths for future contributors.

The rest of the paper includes a literature review of the research on the FOSS joining process, motivations, barriers to joining FOSS projects, and research on daily diary studies. This is followed by a description of the study methodology and subsequential data analysis. Then, results are reviewed, focusing on self-efficacy, motivations, barriers, and successful/unsuccessful contribution processes. The paper concludes with guidelines for future researchers regarding involving older contributors in FOSS projects.

2. LITERATURE REVIEW

First, we review the FOSS joining process, as we are studying the joining process of older first-time contributors. Additionally, we review motivations of FOSS developers with the goal of comparing motivations of older first-time contributors to existing literature. Because contributing to FOSS is a form of virtual volunteering, we also look toward the literature in virtual volunteering. As we witness older first-time contributors' barriers to participation in the daily diary portion of our study, we review literature around barriers to joining FOSS communities. The last portion of the literature review focuses on daily diary studies, as that is the methodology employed in this study.

2.1 FOSS Joining Process

There are many models for FOSS project structures and their joining processes. The most well-known is perhaps the Onion Model, which proposes a project as a hierarchy, where people become contributors by first being passive users, then bug reporters, then eventually code contributors [35]. Another model is the Onion Patch, where its proposed that skills are transferrable between projects, and the hierarchical process is not necessary to join a project [20]. Crowston and Howison posit that different projects have different structures and contributors may want to stay in a particular role and may not have the goal of advancing through the ranks [8]. To the best of our knowledge, there have been no studies looking at the step-by-step process of someone looking to join a FOSS project, and none have focused on that process for older first-time contributors.

2.2 Motivations of FOSS Developers

Assuming someone decides to join a FOSS project, and how to do so, it is important to understand what drives them. Understanding why people contribute to FOSS helps researchers and communities recruit enough people, and a diverse enough contributor population to ensure a sustainable future for FOSS projects. It also helps projects put forth compelling rationales for why someone should join or contribute, and align rewards in an optimal way.

Hars and Ou [18] and Ghosh et al. [15] among others [5, 23, 32, 35] have explored what motivates FOSS developers to contribute. Key motivations included both internal and external reasons, for example "altruism" and "developing human capital", among others. Different demographics may be driven to contribute by different motivations, as they are dealing with different stages and challenges in life. This is why we were interested in examining the motivations of older adults for contributions. For our research, we built on the list of motivations developed by Davidson et al. [10] in interviews with older adults: Intrinsic Motivation, Altruism, Community Identification, Internal Values, Learning, Career-Related Benefits, Reputation, Personal Project Need, and

"I'm doing it because someone asked me to". These motivations align with motivations from the FOSS literature [15, 18] and the adult volunteering literature [7, 21].

2.3 Virtual Volunteering and Older Adults

Older adults participate in a wide-range of volunteer activities and have been shown to volunteer more than younger adults [26]. Mukherjee interviewed 22 older adults aged 53 to 65 about their experiences with virtual volunteering [27]. Mukherjee's work is relevant because the definition of virtual volunteering can be expanded to include FOSS contributions. Benefits and barriers were uncovered. Examples of benefits were flexibility and the ability to participate with mobility restrictions. Barriers included organization communication, website usability, and broadband connection issues. Davidson et al. compared Mukherjee's findings with their study of experienced older FOSS contributors and found that there was an overlap in the barrier related to organization communication, but that other barriers (such as website usability and broadband connection issues) were not as relevant to older FOSS contributors [10].

2.4 Barriers to Joining/Contributing to FOSS

Researchers have looked into the barriers new developers face while joining or contributing to a FOSS project. According to King et al., when newbies try to join a FOSS community, the first step is participating in the mailing list [19]. One of the main issues with that is the effect of a new contributors' gender or nationality towards the kind of replies that they receive over the mailing list. In most cases this is not a barrier as the community tries to remain as neutral and helpful as possible. There have however been instances where a rude reply has discouraged someone from continuing to contribute. Another result from that work was the low number of female participants. It was not just technical issues that lead to this but rather the culture, reward structure, and social aspects that acted as barriers [19].

Steinmacher at al. [34] found 5 categories of barriers to newcomers:

- Social interactions,
- Finding ways to start,
- Code issues,
- Documentation problems,
- Newcomer's previous experience.

These were among the main issues commonly found in FOSS communities after a systematic review of 21 candidate papers on the topic. Davidson et al. conducted a study of experienced older FOSS contributors and categorized challenges of contributing in two main categories: social challenges and technical challenges [10]. *Social challenges* included "general", company doesn't allow it/makes it difficult, conflict with others, difficulty with communication, and mismatch in expectations. *Technical challenges* included "general", not understanding the code base, introducing bugs, adopting new tools/languages/process, and licenses. Section 4.3 shows barriers found in the current study as compared to Davidson et al.'s work.

2.5 Daily Diary Studies in Computing

The daily diary study methodology has been used to collect longitudinal data in many disciplines, including psychology, health and medicine, education, anthropology, architecture, etc. There have also been daily diary studies in various settings within computer science. For example, Begel and Simon used daily video diaries to collect data about important events of the day of eight novice developers at Microsoft [4]. Kersten and Murphy

performed a diary study to evaluate their Eclipse plugin Mylar [22]. Czerwinski, Horvitz and Wilhite used diary studies to understand how information workers perform multiple tasks among interruptions [9]. Diary studies in Computer Science are also designed to capture activities that occur in real environments with some kind of technology currently under investigation, or one subject to design [1].

Normally participants in a diary study are asked to keep record about a particular activity throughout the day or at specific times of the day. In a study conducted by Grinder et al., participants were asked to keep records of every time they used text messaging functions on their mobile phone [17]. These diaries can be highly structured, with specific pre-defined task [9, 17], or unstructured. In an unstructured diary study participants are asked to keep records of all loosely related activities. For example in the study conducted by Palen et al., participants were asked to give entries of all the activities they do with their mobile phone for six weeks [28]. In another study, Palen et al. used both structured and unstructured diary studies to expand the dairy study from paper based to voice mail over mobile phone or landline phone to collect data easily [29]. In diary studies, data entries by participants can be paper based [1], or digital (such as the use of spreadsheets) [9], videotaped [4], or even over the phone [28, 29].

Regular interaction between the investigator and participants is very important, because it helps participants understand the scope and importance for the diary entries. This interaction can be done through daily interviews or over email. Though diary studies have high external validity (showing participants' experiences in the real world), there are also drawbacks. For example, it is almost impossible to be completely sure that participants are responding to the daily diary questions in an unfiltered way. The second concern is that daily diary studies follow a case-study approach. The goal here is to get a depth of understanding of a handful of individuals' experience rather than statistical validity. The sample sizes therefore are typically smaller than a comparable controlled study, but tend to gather more longitudinal data. This is why our study is only intended as a first exploration; future studies will need to be done to explore the generalizability of our results.

The pilot study in this paper has a daily diary component. We chose to conduct a diary study because it was not realistic to do a direct observation of our participants as they try to contribute to FOSS for the first time. Our participants worked in their own way in their chosen time. We could not have been with them every time they tried to contribute to or work with FOSS communities. Our diary study was structured as we provided the participants with a pre-defined set of questions to answer on a daily basis.

3. METHODOLOGY

As mentioned, the pilot study reported in this paper is a daily diary study. Participants were recruited through the LIFE Registry (a database of older Oregon residents who have shown interest in participating in research) [24], flyers, social media, and email announcements. The participants were required to meet the following criteria:

- 50 years or older
- Fluent in English
- Self-proclaimed expertise in software related activities including documentation, coding, QA, management
- Never contributed to a FOSS project
- Have an interest in contributing to FOSS as a volunteer

For this study, we were looking for people who were already interested in FOSS but who, for whatever reason, have never contributed before. Therefore, our outcomes will not tell us why some older adults are not interested, but rather will shed light on how to ensure successful contributions for those who are interested.

Table 1. Participant Demographics

Participant	Age	Gender	Employment	Education
1	64	F	Retired	Master's, Computer Science
2	53	M	Part-Time	Bachelor's, Human Resources
3	58	M	Full Time	Bachelor's, Computer Science
4	68	M	Retired	Bachelor's, Anthropology

Four participants were enrolled in the study. Participant demographics can be found in Table 1. Similar to Begel and Simon [4], our sample size is quite small. Even with compensation and lack of age restrictions, Begel and Simon were only able to enroll 8 participants in their study. With our need to study participants' motivations for FOSS contribution, we did not offer any compensation, as we did not want monetary compensation to confound their motivation to participate. With compensation, we may have seen a higher enrollment number. Despite this small sample size, we were able to uncover useful insights for future outreach efforts toward older first-time contributors. That said, this study is considered a pilot study, and further research is necessary.

3.1 Study Procedure

After obtaining verbal consent and confirming their eligibility, we performed a pre-interview with the participants that covered the following areas: personal background/demographics, their motivations for wanting to contribute to FOSS, and their reasons for not having done so yet. Then, we sent a follow-up email and asked them to choose their "start date" for the daily diary portion of the study (e.g. when they wanted to start trying to contribute). During the following 2 months, participants were asked to attempt to figure out how to contribute to a FOSS project. We pointed them to 3 example projects including Apache, Dreamwidth, and Sahana, but explained that they could work on any project they desired.

After the start date, the participants were asked via a daily reminder email to fill out an online form. The online form had the following topics:

1. If they did not work on FOSS that day, an explanation of why not
2. Name of the project they worked on
3. Amount of time spent on activity
4. Session goal
5. Rate the success of the session (5-point Likert, 5 is the highest)
6. What was the most successful thing they tried
7. What did not go as expected
8. If they interacted with anyone on the project, rate the helpfulness of the interaction (5-point Likert, 5 is the highest)
9. Additional comments

There were 3 ways for participants to terminate the daily diary portion of the study: 1) drop out – they stop filling out the daily diary and stop responding to emails, 2) they email when they feel they are done and would like to stop, or 3) researchers email them at the 2 month point and ask them if they would like to continue or do a post-interview.

After the daily diary study portion had ended, we requested to do a post-interview with the participants. Post interviews were conducted for 3 of the 4 participants over Skype. The post interviews covered a range of topics including asking them to explain missing/skipped days, barriers related to contributing, benefits related to contributing, their likelihood of continuing to contribute, and a rating of their experience with contributing.

We plan to follow-up with participants 6 months from their post-interview to see if there is any continued participation in FOSS.

The pre- and post- interviews were audio recorded and transcribed. All data from the online daily diary forms, pre-interviews, post-interviews, and any email communication between the participants and researchers were coded using grounded theory affinity coding, similar to the work of Dearman et al. [11, 16].

First, we chunked the data into small portions representing a full thought on one theme. There were a total of 250 chunks. Then, two researchers grouped that data into similar topics. After grouping the data, codes (themes) were assigned. This was done for all data except "motivation", where we started with predefined themes from Davidson et al.'s study [10]. All other data was coded using true affinity coding (where no codes are decided beforehand).

Table 2. Codes: Motivation, Benefit, Personal Barrier, Project Barrier

Code	Count	Quote
Motivation		
Intrinsic	6	*You know just having fun. Coding.*
Altruism	5	*Well, you know, giving back a little bit because I use an awful lot of it.*
Internal Values	4	*First, I'm interested in the concept of open source. The fact that it's open to revision, and it's free and available to people.*
Benefit		
Personal Project Need	6	*Certainly there's a lot of open source projects out there available for me to use them in any of my projects, personal projects. So that's a benefit to me.*
Free/Cheap	1	*One of the people in the group of guys I do photography with, is on a limited income. So he was interested in this.*
Mental Challenge	1	*Well the personal thing is it's definitely a mental challenge and that's something that people in my age group need to keep up.*
Personal Barrier		
Competing Obligations	13	*Part time job until 1:15, drive back from [location] to home, then worked on marketing my business product in local community.*
No Time	13	*No time today.*
Family	9	*Up in [location] all day for our grandson's 2nd birthday.*
Travel	9	*But, and there was a couple of days that were just on a short trip to the coast or something like that.*
Health	9	*Rather ill today - had to go in to see the doctor.*
Holiday	6	*Offline for the Christmas holidays until Jan 6 so I won't report again til then.*
Weather	5	*Another snowy day and dealing with snow build-up on and around the house. Lots of shoveling of snow have left me rather weary.*
Social Mismatch	2	*And it just strikes me that many of their concerns which are very real to them were social concerns that I didn't have, like dating type of things. If anything, I just took that as this is not the place for me.*
Project Barrier		
Lack of communication	18	*I didn't have any interaction, which is discouraging in itself.*
Installation Issues	14	*So it was a huge installation process that I never got fully successfully installed the thing. And that was one of the questions I was trying to ask. So I moved on from there.*
Documentation Issues	12	*Documentation is out of date with the current toolset and non-functional*
Didn't ask for help	5	*Realizing that it's not going to be easy to find what I want to help with. I need to focus on what I want to help with; so define that first.*
Outdated Project	4	*The Git repo looks old; not sure that it is the right code base.*
Don't know how/ who to talk to	4	*Couldn't find an email address for the owner of the [name of] project*
Unhelpful communication	3	*I got kind of a non-committal answer that was basically "probably" to both questions.*
Download Issues	2	*Found that I will need to get further support for the download and use of the windows-integrated software platforms.*
Feeling like an outsider	2	*You know what, I felt like a novice to put the question that I wanted on the mailing list. That was my feeling that the mailing lists were for more about the active devs and I guess I didn't feel comfortable putting a newbie question out there.*

Table 3. Contribution Process Codes

Code	Count	Quote
Contribution Process		
Researching Projects	9	*I used [resources] to research potential open source projects and found several to look into ([project name], [project name]).*
Choosing a Project	12	*So far, I am comfortable with the decision made to move to a different open source software product, since this product seems still to be much more open to receiving input from users.*
Using Software	6	*Did use the [project name] open source software for part of the processing as a way to familiarize myself with the software.*
Look through documentation	12	*Tomorrow I will continue my review of the documentation. So far, the documentation is logical and appropriately sequential in its layout.*
Look through new contributor info	3	*Watching a video for new developers*
Setting up environment	6	*Installed MacPorts; updated Xcode*
Finding bugs/WHAT to contribute	8	*I did find documentation bugs. I can try that next in parallel with getting [project name] installed in AWS.*
Asking for help	5	*Located and reviewed logs. Signed up for [project name] user forum and posted a question about my issue.*
Success in contributing	5	*I joined the French translation team and actually contributed 5 simple translations. Whoo hoo! :-) The system they have set up for translating makes it easy to do this.*
Failures	4	*It appears that I can navigate at least some of the project's aspects, there is becoming apparent to me that I do not have the fundamental understanding of how to interact with the foundation as a developer.*
No Opportunity for Contribution	15	*Of the thirty projects I have looked at so far, none needed my skill sets. (Perl, C, Java are not in my tool bag).*

The two researchers iterated over the data twice until agreement was reached. Then, a third independent researcher reviewed the coded data independently and provided input. Then, all 3 researchers iterated twice until they all reached agreement on the coded data. The codes are shown in Tables 2 and 4 with examples of each code from the dataset. Inter-rater reliability is not reported (which is in line with Dearman et al.'s approach [11]) because we iterated until researchers reached complete agreement.

Table 4. Daily Diary Participation Data

| Participant ID	# of Entries	% Active Days	Participation (days)
1	45	59%	75
2	4	25%	3
3	5	80%	12
4	35	43%	49

Table 4 shows that participants ranged from 4 entries in the daily diary to 45. As one option of the online form was to explain why they hadn't worked on the FOSS project that day, the 3rd column shows the ratio of how many entries reported participants working on the FOSS project vs. not having had any activity that day. One measure of participation in this study is the length of time (in days) they spent on the daily diary portion (date of last entry – date of first entry). With this metric, Participants 1 and 4 were the most successful in this study. Despite the small amount of data from Participants 2 and 3, we include them in the forthcoming analysis, as studying "failure" is a vital aspect of this pilot study.

4. RESULTS

4.1 Self-Efficacy

Self-efficacy is a measure of one's confidence in their perceived ability to perform a task [3]. Self-efficacy can impact one's actual ability to complete a task [3]. It is correlated with a person's willingness to stick with a learning task, and has been studied in the context of computer science education [6]. We expected that self-efficacy would go down because of the phenomenon that "you don't know what you don't know," which means that most people are overly optimistic going into poorly understood tasks. Because the participants had technical experience but no FOSS experience, we thought they may have high initial self-efficacy and possibly run into FOSS-specific issues that would result in lower self-efficacy.

	#1	#2	#3	#4
■ Pre	50	36	42	37
▨ Post	35	35		43
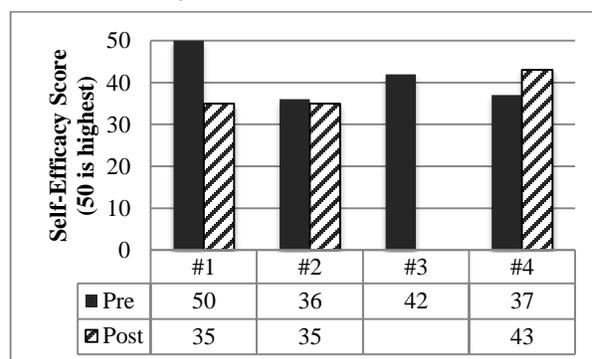
Figure 1. Self-Efficacy Scores

We asked participants to answer 10 questions related to self-efficacy of contributing to free/open source software (FOSS). The pre- and post- self-efficacy scores are reported in Figure 1. Interestingly, Participant 1 who had the highest amount of objective success (discussed in Section 4.4) also had the highest drop in self-efficacy. Participant 3 dropped out of the study and became unreachable. The other two participants showed relatively little change in their self-efficacy of contributing to FOSS.

To answer *RQ1: Does participation in the study impact participants' self-efficacy?*, there is no consistent trend in their self-efficacy scores.

4.2 Motivations

We asked participants about their motivations with the goal of comparing results from previous studies and tailor future FOSS outreach efforts. Hars and Ou's survey of the general FOSS population stated the top three motivations as: Career-Related Benefits, Intrinsic Motivation, and Reputation [18]. For people nearing or at retirement age we did not expect all of these to be as important. Ghosh et al.'s survey show the top three motivations as Learning, Altruism, and Internal Values [15]. Davidson et al. found that older contributors' top motivations were Intrinsic Motivation, Community Identification, and Altruism [10]. In response to *RQ2: What are the motivations of first-time older contributors?* – the participants from the daily diary study only reported three motivations: Intrinsic Motivation, Altruism, and Internal Values. These results are shown in Table 5. Surprisingly, we only found 3 motivations in the current study, however the motivations align well Davidson et al.'s findings. One reason for not finding community identification as a motivation in the current study may be because first-time contributors have not realized the full potential of FOSS for making friends and developing a personal community.

Table 5. Comparison of top 3 motivations of free/open source software contributors from various studies. They are in rank order of % of participants who cite that motivation.

Hars and Ou	Ghosh et al.	Davidson et al.	Current Study
Career-Related Benefits	Learning	Intrinsic Motivation	Intrinsic Motivation
Intrinsic Motivation	Altruism	Community Identification	Altruism
Reputation	Internal Values	Altruism	Internal Values

4.3 Benefits and Barriers

4.3.1 Benefits

Three benefits of contributing to FOSS were **Personal Project Need**, **Free/Cheap**, and **Mental Challenge**. In other studies, Personal Project Need is considered to be a motivation [18]. However, in the way that participants spoke about it (see quote in Table 2), it was clear that they thought that contributing to FOSS could benefit a personal project of theirs. The second benefit mentioned was "Free/Cheap", or the lack of monetary cost associated with volunteering in FOSS. Participant 3 mentioned, "*One of the people in the group of guys I do photography with, is on a limited income. So he was interested in this.*" Oftentimes, there is no cost in purchasing SDKs, trying out the software, or traveling somewhere to participate in volunteering for FOSS. The final benefit mentioned was that contributing to FOSS provides a mental challenge, which according to Participant 3, is "*something that people in my age group need to keep up.*" As mentioned in Section 1, staying cognitively active into retirement is beneficial [30], and it appears from this study that at least one participant is aware of that benefit and chooses to participate in activities that challenge their mental capacities.

4.3.2 Personal Barriers

In the daily online form and the post-interview, participants were asked why they skipped days. In response to those questions, personal barriers were uncovered. These were barriers not related to project issues, but rather personal conflicts or issues. Participants noted 8 different personal barriers (see Table 2), with the top 2 barriers as "Competing Obligations" (13 occurrences) and "No Time" (13 occurrences). Competing obligations included reasons for not participating that were related to being "busy" in specific ways, such as part-time work, meetings, etc.

4.3.3 Project Barriers

In the daily online form, we asked, "What if anything did not go as expected?" In addition we asked about barriers in the post-interview. In response to these questions, we uncovered 9 project barriers. The top 2 barriers were lack of communication (18 occurrences) and installation issues (14 occurrences). A close third was documentation issues (12 occurrences).

Davidson et al. uncovered a variety of barriers from older adults who are experienced FOSS contributors [10]. Interestingly, the barriers were similar to the challenges encountered in Davidson et al.'s study. However, every barrier was different, which shows the necessity of investigating the contribution process *in real time*. The combined list of barriers s shown in Table 6.

Table 6. FOSS contribution barriers faced by older adults.

| Social	Technical
Davidson et al.	
General	General
Company doesn't allow it/makes it difficult	Not understanding the code base
Conflict with others	Introducing bugs
Difficulty with communication	Adopting new tools/languages/processes
Mismatch in expectations	Licenses
Current Study	
Feeling like an outsider	Installation Issues
Lack of communication	Documentation Issues
Don't know how/who to communicate with	Outdated Project
Unhelpful communication	Download Issues
Didn't ask for help	
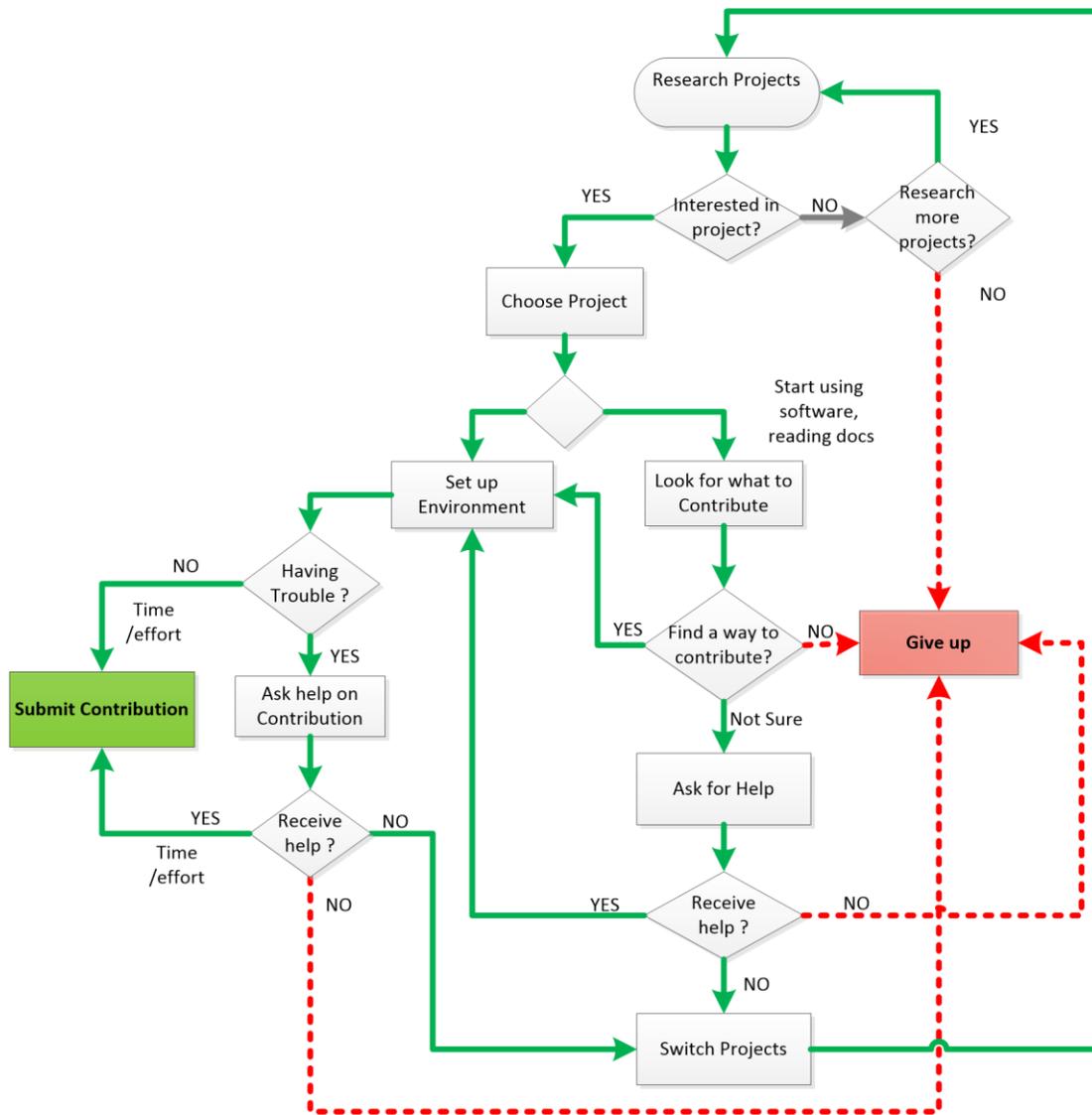
Figure 2. Contribution Process. Green (solid) lines are "healthy" contribution paths. Red (dotted) lines are "unhealthy" contribution paths.

4.4 Contribution Process

Another finding from this work was the creation of a preliminary contribution process diagram (see Figure 2). The daily diary study showed participants' *natural* contribution process, where researchers performed no intervention, other than requesting they fill out the daily online form. The green (solid) lines highlight the "healthy" contribution paths that could lead to a successful contribution. The red (dotted) lines highlight the "unhealthy" contribution paths. The findings from this research found 4 "unhealthy" paths that led to participants giving up. This model should be used and tested with multiple populations, to further understand the FOSS contribution process. Figure 3 shows participants' success rating for each session reported in the daily form. The following subsection reviews participants' experiences with the FOSS contribution process.

4.4.1 Participant 4

Project Interests. This participant started with a project that had a humanitarian focus because of their altruism motivation. After having communication issues with the project, they switched projects to one that aligned better with their hobby.

Original Goal. They wanted to contribute documentation to a project. They had taught students in the past how to use FOSS, and found documentation issues, so they wanted to improve documentation geared toward users.

Accomplishments. Participant 4 was the second most successful participant in the study, as they found a project of personal interest to them that they wanted to contribute to.

"Give up" Mode. After finding a project relevant to their photography hobby, the participant wanted to contribute documentation edits to tutorials in a photography-related application. However, they found the documentation so well written, they felt like they had no way to contribute *("I didn't find a way to add anything to what they had")*. Their red (dotted) line or failure mode happened from "Find a way to contribute?" to "Give up". Even though they decided to give up with a documentation contribution at that point, they had high hopes of contributing by evangelizing their use of photography-related software to friends and possibly hold workshops to teach other people how to use the software.
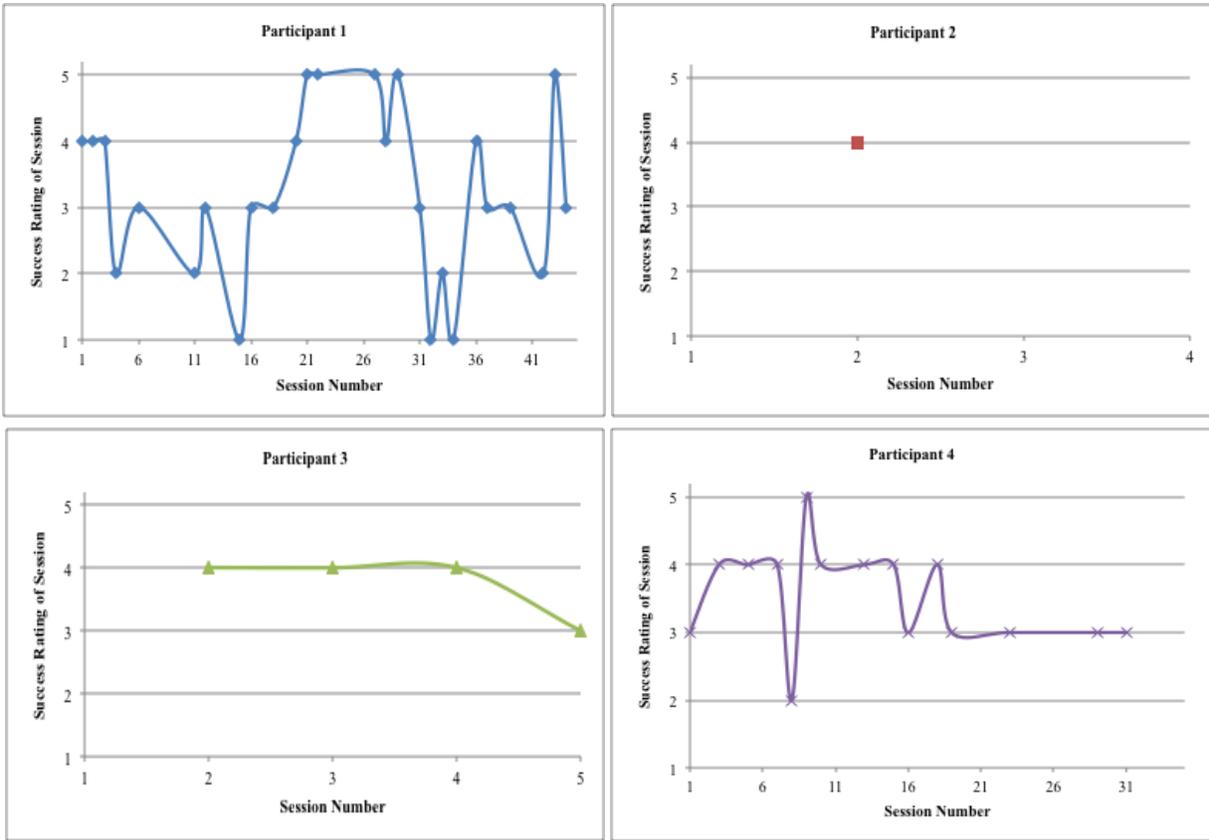
Figure 3. Success Rating of Sessions. Participants ranked the success of the session from 1 (low) to 5 (high). *Top Left*: High points: contributing translations (Sessions 21, 22, 29), reading helpful documentation (Session 27), and identifying a bug fix (Session 43). Low points: installation issues (Sessions 15, 32, 34). *Top Right*: Participant 2 was trying to find a project to invest time in (Session 2). *Bottom Left*: Low point: documentation issues (Session 5). *Bottom Right*: Low point: Did not know how/who to communicate with on the project (Session 8). High point: reading documentation and feeling hopeful about ways to contribute (Session 10).

4.4.2 Encouraging Healthy Paths

A major takeaway from the observed contribution process is that communication is vital for our participants to make a successful contribution. First, it's important for the participant to ask for help *in the correct way*. Second, it's important for the project to respond *in a helpful way*. Additionally, like with the photography-related application, it's important to value contributions other than code, to allow people from all backgrounds to contribute. However, as with Participant 39, there should be pathways for people to contribute in any way they want, including code.

4.4.3 Participant Experiences

4.4.3.1 Participant 1

Project Interests. There were many projects of interest to this particular participant, and they switched projects 4 times due to lack of communication or installation issues.

Original Goal. They had the goal of contributing code to a FOSS project.

Accomplishments. Participant 1 was objectively the most successful participant in this study in terms of making a contribution. They were successful in that they were able to provide translation contributions to a FOSS project. However, they did not *perceive* that they were successful because they were not able to contribute in the way they had originally wanted to –

through code. They also did not get feedback about their translation contributions from the FOSS project.

"Give Up" Mode. The failure mode with Participant 1 happened because there was a lack of a response from the repository owner regarding an identified bug fix, which would be the red (dotted) line from "Receive help?" to "Give up". This participant was very frustrated at the point of the post interview, as explained in an email, *"I think I will stop trying to do any open source work for now. I've had a less than satisfying experience and I want to work on some other projects".*

4.4.4 Participant 2

Project Interests. They were interested in finding a mobile application that related to the emergency response industry because they have past experience in that area.

Original Goal. They wanted to apply their coding skills they have learned from their small business to contribute code to a FOSS project.

Accomplishments. The participant only filled out 4 daily forms and did not cite any accomplishments, other than coming to the realization that they need to define better what kind of projects they would be willing to commit to.

"Give Up" Mode. Another failure mode happened with this participant, where they stopped participating because they could

not find a project that aligned well with their skill set, as exemplified by the following quote: *"Of the thirty projects I have looked at so far, none needed my skill sets. (Perl, C, Java are not in my tool bag)"*. This would be the red (dotted) line from "Find a way to contribute?" to "Give up". They only filled out 4 daily diary entries. During the post interview they expressed concern that, *"I don't know that the infrastructure is there yet for the type of stuff we're looking for"*.

4.4.5 Participant 3

Project Interests. They wanted to find a project related to health to contribute to because of professional experience in the area.

Original Goal. As they were a professional full-time developer, they wanted to contribute code to a FOSS project.

Accomplishments. According to the responses from the daily form, they were able to get *"tools installed"* for a health-related project.

"Give up" Mode. Unfortunately, Participant 3 dropped out of the study and became unreachable after a few days of filling out the daily online form. The last entry explained, *"Tried to reinstall tools based on documentation. Docs are out of date."* It appears that were attempting to reinstall tools and failed because of documentation, but did not proceed to ask for help. "Didn't ask for help" was one of our barriers, which may prevent first-time contributors from experiencing success.

5. LESSONS LEARNED

5.1 About older adults

To provide information for future researchers and the FOSS community at large, we list guidelines learned from this research. First, it is important to educate first-time older contributors how to communicate effectively in FOSS projects. Also, it may be beneficial to educate first-time contributors about a typical "healthy" contribution process. Third, projects should be picked that align well with motivations related to altruism and internal values to potentially appeal to older adults. We hypothesize that a potential demographic who may be more successful in FOSS contribution than others is "freshly retired" older adults. Both participants 1 and 4 were "freshly retired" and were also the most successful participants in the project. This may be because they have not fully planned their retirement activities, and may be open to trying new activities that use their skillset. It may also be because they are experiencing the well-documented "honeymoon phase" of their retirement, where early retirement is marked by more enthusiasm than later retirement [13].

In addition to these insights, Participant 1 provided suggestions for future older newcomers to FOSS. First, they said, *"I think it's hard to contribute to a project if you've never used the product"*, so they recommended that one use the software extensively before trying to contribute. They stated, *"The complexity of the installation is really crucial to the success of you starting to contribute. [...] It was really easy contributing to a website, easier than contributing to an app. Installing an app is more complex."* Therefore, they recommended that newcomers could do web-based contributions because it does not require setting up a complicated backend development environment.

5.2 About projects

To enable older adults to have successful contributions, it's important to consider how projects can aid them in the joining process. First, to alleviate the barrier we discovered of not finding a way to contribute, projects should make contribution paths obvious to newcomers. With their many years of technical experience, there should be no reason that any older newcomer to feel like they cannot make a meaningful contribution to a project. Clear documentation on different ways to contribute is important. Many projects have taken to developing a list of good starting projects, but our experience shows that these can quickly become out of date, and subjects can get very frustrated when led down the wrong path. Second, responding to newcomers is important, even if they are asking questions in the wrong channel or in an inappropriate way. Finally, it is important to provide positive feedback if a contribution was accepted to encourage future contributions from that contributor.

6. SHORTCOMINGS & FUTURE WORK

The main shortcoming of this research is a small sample size. Therefore, we consider this study a pilot study and suggest future researchers conduct a large-scale version of this study and include multiple demographics (not just older adults) to continue learning about the FOSS contribution process. The daily diary study has high external validity and allowed for the creation of a preliminary contribution process model. This model can be validated by further research into this area. As far as future work, we are in the process of conducting a workshop study to use the results from this research study and results from Davidson et al. [10] to attempt to overcome barriers.

7. CONCLUSION

Four older adults (aged 50 and older) participated in a daily diary study where they attempted to contribute to a free/open source software (FOSS) project while logging their daily experiences. We uncovered three motivations of older adults (Intrinsic Motivation, Altruism, and Internal Values) that differed from previous research surrounding motivations and FOSS contributors. The top two barriers of making a contribution were lack of communication and installation issues. Additionally, the research resulted in a contribution process model that showed that asking for help, receiving help, and finding a way to contribute were all vital to making a successful contribution. The paper concluded with guidelines for future work in this area that focuses on encouraging effective FOSS communication by first-time older contributors and by projects, and encouraging projects to provide feedback. The next step in this research is to conduct a workshop for first-time older FOSS contributors to investigate which barriers can be overcome with scaffolding and how to learn how to build community amongst newcomers.

8. ACKNOWLEDGMENTS

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