Guidelines for Creating Senior-Friendly Product Instructions

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Although older adults feel generally positive about technologies, many face difficulties when using them and need support during the process. One common form of support is the product instructions that come with devices. Unfortunately, when using them, older adults often feel confused, overwhelmed, or frustrated. In this work, we sought to address the issues that affect older adults' ability to successfully complete tasks using product instructions. By observing how older adults used the product instructions of various devices and how they made modifications to simplify the use of the instructions, we identified 11 guidelines for creating senior-friendly product instructions. We validated the usability and effectiveness of the guidelines by evaluating how older adults used instruction manuals that were modified to adhere to these guidelines against the originals and those that were modified by interaction design researchers. Results show that, overall, participants had the highest task success rate and lowest task completion time when using guideline-modified user instructions. Participants also perceived these instructions to be the most helpful, the easiest to follow, the most complete, and the most concise among the three. We also compared the guidelines derived from this research to existing documentation guidelines and discussed potential challenges of applying them.

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CCS Concepts: • **General and reference → Computing standards, RFCs and guidelines**; • **Social and professional topics → Assistive technologies**; **Seniors**; • **Human-centered computing →** *Empirical studies in HCI*;

Additional Key Words and Phrases: Guidelines, seniors, older adults, product instructions, user manuals, user-friendly, senior-friendly, user-centered design, technology support, instruction design

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1 INTRODUCTION

For older adults, technologies can be beneficial to increasing their independence and improving their perceived quality of life [35]. Older adults are generally positive about technologies [32] and use technological products in a wide range of domains, such as household activities, communication, work, and entertainment [16, 37]. However, compared to the younger adult population, they are likely to use fewer products and also products that have been around for a longer time [37].

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Because of the difficulties that they face when learning to use new technologies [18, 34], they may only use some products in limited ways [37] and even eventually abandon them [16].

Older adults often consult other people, such as their family and friends [6, 16], to overcome challenges that they encounter when using technologies. This approach, however, depends to a large extent on the availability and expertise of the people around them. Moreover, older adults may feel hesitant to approach people for help for fear of troubling others [44]. Alternatively, they may use a trial-and-error approach that requires them to focus and remember each trial outcome, which can be difficult due to declining cognitive abilities in fluid intelligence and working memory [23]. Consequently, older adults prefer to rely on instructions and manuals [28, 33] to gain a better understanding of the product, learn specific functions, avoid making mistakes, and become more self-supporting and confident when they use the device [5, 44].

Unfortunately, older adults also face difficulties when using product instructions. Although general guidelines for creating product instructions exist [9, 39], older adults still often describe product instructions as being daunting, overwhelming, frustrating, and filled with jargon [5, 28]. Previous research suggests that product instructions should be designed to be user-friendly, just like the products that they are written for [44]. The literature describes six factors contributing to older adults' perceived difficulty in using product instructions: unfamiliar technical terms, incomplete process explanations, unnecessary technical details, insufficient orientation to users' perspective, intermixing of basic and special functions, and overly lengthy and complicated sentences [5, 21, 25]. Furthermore, older adults tend to use different search strategies than younger adults to acquire information, which can be less effective in completing certain tasks [10, 11, 15]. Thus, it is important to understand how older adults actually use product instructions to design user-friendly instructions for them.

In this work, we sought to understand how to best address issues that affect an older adult's ability to successfully complete tasks with product instructions. By observing how older adults consult product instructions when using various devices and the modifications that they propose for improving them, we formulated a set of 11 guidelines for developing senior-friendly product instructions. We chose products that older adults would often and occasionally use, which are mainly for household activities, entertainment, and work [16, 37, 38, 41, 44]. We considered paper-based manuals as this is the most widely employed way of presenting instructions [44]. We then validated the usability and effectiveness of the guidelines and showed that writers, even with limited expertise, are able to apply the guidelines to improve the quality of product instructions when compared to originals or those modified by interaction design researchers who had research experience with older adults. Overall, the results showed that older adults had the highest task success rate and the lowest task completion time when using product manuals developed using our guidelines. They also displayed a higher preference for these product manuals as they felt that these product manuals were the most helpful, easiest to follow, most complete, and most concise. We further compared the guidelines derived herein to existing documentation guidelines, and we discuss potential challenges of applying the guidelines.

2 RELATED WORK

Older adults use product instructions but find them to be unsatisfying. Tsai et al. found that more than 90% of the user feedback from their interview study with 63 older adults indicated that these adults tend to read the entire or part of an instruction manual to become acquainted with new products. Older adults also refer to instructions to remember forgotten information about a product [5, 44]. However, they are often unsatisfied with product instructions. Bruder et al. found that 11 out of 20 participants in their mobile phone manual study were unsatisfied with the manual [5]. In this section, we review the general guidelines used by writers to create product instructions, the problems that older adults have with using these instructions, and previous projects that have explored how to improve instructional materials for older adults.

2.1 General Guidelines for Writing Product Instructions

General guidelines for writing product instructions have existed and been used by the technical communication community for decades. For example, *Technical Report Writing Today* provides principles for writing product instructions, such as providing context, explaining what the parts do, explaining how to perform a sequences of required steps, using visual logic, and developing credibility [39]. Carroll et al. proposed the idea of minimum manual design and empirically demonstrated that it was efficient in helping users learn word-processing software [9]. However, it can be challenging for instruction writers to apply general principles appropriately when creating instructions for products. To better guide practitioners in designing minimalist manuals, Meij and Carroll provided the following four principles: choose an action-oriented approach, anchor the tool in the task domain, support error recognition and recovery, and support reading to do, study, and locate [31]. Furthermore, specific guidelines for particular categories of products also exist. For example, *Write It Right* presents guidelines for writing instructions for medical devices used at home [2].

2.2 Problems Faced by Older Adults when Using Product Instructions

Unfortunately, writers often create product instructions from a technical point of view [5] and do not have the time or inclination to determine users' expectations [44]. Although most older adults use and prefer product instructions over other methods (e.g., asking others for help), these bad practices often result in manuals that are "poorly written," causing readers to feel mentally exhausted, overwhelmed, and that they spend too much time attempting to understand a device's instructions [5, 28]. Bruder et al. identified six factors that contribute to the difficulties associated with using product instructions among older adults. These factors include encountering unfamiliar technical terms, incomplete and incomprehensible explanations of what to do, too many technical details, text insufficiently oriented to the users' perspective, and unstructured explanation of basic and special functions together, as well as sentences that were too long and complicated to understand. [5]. Similar issues of using product instructions among older adults have also been found in other studies (e.g., [21, 25]).

2.3 Instructions Design for Older Adults

Instructional materials can help older adults overcome difficulties that they may face when using technologies. Bruder et al. showed that after training with instructional materials—either paper-based manuals or interactive e-learning applications—for a mobile phone, older adults needed less help than both before and during the training [4].

Previous research has proposed various methods to improve the presentation and content of instructional materials. For example, the media format of instructional materials can affect older adults' performance in completing tasks. Video instructions were previously shown to be better than textual instructions in helping older adults acquire knowledge when using a simulated ticket-vending machine [22]. Aside from the media format, how instructions are presented can also affect older adults' performance in completing tasks. For example, Multi-layered (ML) interfaces, which present users with a reduced-functionality layer first and then the full-functionality layer [43], have been shown to be helpful in improving older adults' initial learning of desktop and mobile applications [17, 27]. Instead of seeking more effective presentation format, our research uses the most common format of product instructions (i.e., printed paper) and aims to reduce the inherent complexity of instructions by exploring how content should be written so that older adults will encounter fewer or no issues when using instructions. Our work complements the research that optimizes presentation format and may potentially be used with prior work to improve instruction manual ease of use.

Previous research has also explored approaches to optimizing instructional content for older adults. To explore what instructions should be given, Hickman et al. compared guided action training materials with guided intention training materials. Guided action training materials specify which steps to perform and in what order. Guided intention training materials specify where users need to allocate their attention. They found that guided action training materials helped older adults to complete tasks with more speed and accuracy [24]. They suggested that if learning materials are always available to older adults, it is preferable to provide them with instructions with guided step-by-step actions. Step-by-step instructions, however, can be presented with different levels of details. To examine how much detail should be provided, Morell et al. compared simple step-by-step instructions with the same instructions expanded with explanations and found that simple instructions were more effective in helping older adults learn to use computer software [34]. Fisk et al. further provided some principles for the design of training and instructional programs to help older adults learn technologies over time, such as using sets of holistic practice tasks, providing supportive information, promoting deeper learning, considering environmental factors, and reducing training demands [18].

These general principles and guidelines are used primarily for designing training materials, tutorials, and instructional programs to help older adults learn to use technologies. It remains unknown the extent to which they are applicable to product instructions. Furthermore, we are also interested in exploring whether there are additional guidelines that writers need to consider when creating product instructions for older adults. Our research extends this line of investigation by focusing specifically on identifying guidelines to make product instructions user-friendly for seniors.

Previous research has shown promise in involving older adults during the creation of products that they will use [20, 30, 40]. Furthermore, it has been reported that older adults are able to modify product instructions to make them easier to use. For example, they may use an extra sheet of paper as a quick reference card, rewrite or mark manual content in blank areas, and create customized diagrams [44]. Our research is inspired by these works and further explores how to make product instructions easy to use for older adults by involving them in the loop.

3 STUDY 1: DEVELOPMENT OF THE GUIDELINES FOR CREATING SENIOR-FRIENDLY PRODUCT INSTRUCTIONS

3.1 Goal

In Study 1, we sought to identify design guidelines for creating user-friendly product instructions for older adults. We studied older adults' ability to use instruction manuals and complete tasks with different products—an alarm clock and a copier—in order to understand the problems that they experienced when following the instructions and the specific ways that they modified the instructions to remove these issues. We analyzed the common problems encountered by participants and examined their modifications to identify potential guidelines for creating senior-friendly product instructions.

3.2 Participants

We recruited 12 older adult participants (aged 64–77) from a large metropolitan area in North America via flyers posted in senior community centers and public libraries and via word of mouth. Only one of the participants considered himself to be tech-savvy. We asked participants about their general experiences with using product instructions in the past in the pre-study questionnaire, in

Table 1. Demographic Information About Study 1 Participants

ID	Gender	Age	Education	Retired	Occupation
1	M	74	College degree	Yes	Civil engineer
2	F	72	Master's degree	Yes	Facilities management specialist
3	F	69	College degree	Yes	Waste management specialist
4	F	64	Master's degree	No	Interpreter/translator
5	F	77	Master's degree	Yes	Social worker
6	F	67	Master's degree	Yes	Guidance counsellor
7	M	72	Master's degree	Yes	Community college teacher
8	F	74	College degree	Yes	Human resources specialist
9	F	67	College degree	Yes	Middle school teacher
10	F	70	College degree	Yes	Elementary school teacher
11	M	65	Master's degree	No	Consultant
12	F	68	High school	Yes	Customer service manager

addition to basic demographic information. Most of the participants (9 out of 12) reported that product instructions were often confusing, frustrating, complicated, demanding, too wordy, and lacking in legibility and clarity. This is consistent with the literature [5, 28, 44]. The remaining three participants had neutral attitudes toward product instructions and stated that their experiences with using product instructions were product-dependent. Table 1 shows the demographic information of the participants in this study.

3.3 Materials and User Tasks

Study 1 used two commercial products and their original instruction manuals to discover potential issues that older adults may encounter and how they might modify the instructions. Specifically, we chose an alarm clock (*Arespark digital alarm clock*) and a paper copier (*Brother DCP-L2520DW*) for the following two reasons. First, the alarm clock and the copier represent two kinds of products that older adults have different degrees of familiarity with. The alarm clock is a common device that they may use on a daily basis. The copier is a device that they may only occasionally use and thus have limited experience with. Second, the alarm clock has a short manual (only two pages) because it has a small number of simple functions; the copier, on the other hand, is a multifunction copier/printer and has a much longer manual (more than 80 pages) because it has four moderately complicated functions (i.e., copy, print, scan and fax). For each device, we designed a task for participants to perform. The tasks directly related to the devices' main functions. For the alarm clock, we asked participants to *set the alarm one hour into the future*. For the copier, we asked them to *copy two sheets of paper (each single-sided) onto a single page (double-sided), twice*. The minimum number of steps to complete each task is 6 for the alarm clock and 9 for the copier.

Despite the potential advantages of digital formats in terms of cost and convenience (e.g., keyword search), we still opted to use paper-based product instructions for the following two reasons. First, older adults have been reported to prefer paper-based instructions to digital instructions [44]. Second, paper-based instructions are still the most common format provided with different products.

3.4 Study Design and Procedure

Study 1 followed a within-subjects design. Each participant used two types of product instructions—*original* instructions and *modified* instructions that were created by another

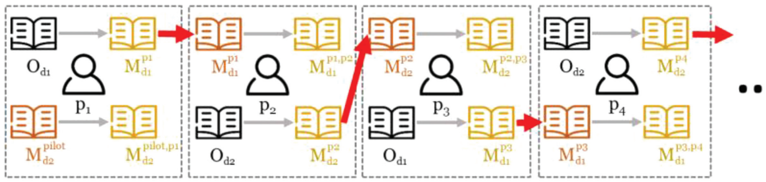

Fig. 1. Two sets of product instructions that were assigned to the first four study participants.

participant—to perform a task on two different devices. After a participant modified the *original* product instructions for one device, the *modified* instructions for the device were then used by the next participant. This new participant would use the *original* instructions for the other device.

Figure 1 illustrates the process used to assign the two sets of instructions to the participants. Prior to the study, we conducted a pilot study with an older adult to make sure that the study procedure was reasonable. Based on the pilot study, we set the study length at 2 hours with a 5–10 minute break between the two tasks. The pilot study also allowed us to gain *modified* instructions (labeled as $\mathrm{M}_{\mathrm{d2}}^{\mathrm{pilot}}$) that could be used by the very first participant (P1) of the actual study.

First, we provided the first participant (P1) with the *original* product instructions for the first device (O_{d1}). We then explained the task that we would like the participant to complete using the device and answered any questions that they had concerning the task goal. We asked the participant to follow the instructions step by step by reading each step aloud and performing the step. The participant was required to modify the instructions to remove any problems that she encountered while performing the task. If the participant was unable to complete any step on her own, we allowed the participant to watch a help video clip explaining how the step is performed. Pre-recorded videos, instead of verbal explanation, were used to avoid potential biases that could be introduced via verbal communication. This is important because the words used in verbal communication can influence how the participant might modify the instructions.

After completing the task, the participant produced a *modified* version of the instructions ($\mathrm{M}_{\mathrm{d1}}^{\mathrm{p1}}$) for the device. Then, after taking a break, the participant followed the same procedure to compete the task on the other device using the *modified* instructions ($\mathrm{M}_{\mathrm{d2}}^{\mathrm{pilot}}$) that were created by the pilot study participant.

Similarly, we provided the second participant (P2) with the *modified* product instructions that were created by the first participant (P1) for the first device ($\mathrm{M}_{\mathrm{d1}}^{\mathrm{p1}}$) and the *original* product instructions for the second device (O_{d2}). We repeated this process with subsequent participants—providing the next participant with the previous participant's *modified* instructions for a device and the *original* product instructions for the other device. In this way, each participant used both one *original* instructions and one *modified* instructions. The order of the two types of product instructions was counterbalanced so that half of the participants would use the *original* product instructions first. Among the four participants shown in Figure 1, two (P_1 and P_4) used the *original* instructions first and the other two (P_2 and P_3) used *modified* instructions first. The study design also counterbalanced the order in which participants used the two devices. Among the four participants shown in Figure 1, two (P_1 and P_2) used the first device (d1) first and the other two (P_3 and P_4) used the second device (d2) first.

We designed the study in this manner to examine what problems participants would encounter when using the instructions for each product, how participants would modify the instructions to address these problems, and whether these changes can help others use the instructions more effectively. Having more than one participant use and modify the original product instructions

Fig. 2. A participant writing her modifications on the margin of alarm clock instructions.

allowed us to discover whether different participants would identify the same problems and gain an understanding of different ways that potential problems in the instructions could be addressed. We could then examine if these modifications improved the instructions. Alternatively, we could have designed the study such that all participants would have continued to improve the previous participant's modifications to both product instructions instead. However, results collected with such a design would have been heavily influenced by the early modifications to the instructions. We could also have designed the study such that all of the participants would use and modify the original product instructions. Such a design could still allow us to identify common problems that older adults would encounter when using the instructions. The design could not, however, test whether the modifications would make the instructions easier to use for other older adults.

After the participant finished both tasks, we conducted a short interview to learn about the problems that the participant encountered, what modifications to the instructions were made by the participant, and for what reasons. Figure 2 illustrates one participant modifying the instructions for one of the products used in the study.

Participants used a pencil to make modifications to the instructions. After each participant finished the study, we then used a computer to apply the changes as suggested by the participant to the product instructions that she used. Handwritten changes were typed into the reformatted instructions, but the exact wording and spelling used by the participant were preserved. This is necessary because our study validates whether the specific wording and spelling chosen by one participant are effective for another participant and if they elicit further modifications if needed. After we reformatted the instructions, we printed them out so that they resembled the original.

3.5 Analysis

Using open coding, both authors analyzed modifications made by participants to the product instructions. To code a modification, each researcher identified the problem that the modification tried to address and the solution that it provided.

Both authors coded all modified instructions independently. We adopted a "negotiated agreement" approach [7] for reconciling our codes and arriving at the final version of codes in which all discrepancies were resolved. Specifically, we met and discussed our coding for each modification. For any modification that we disagreed on, we presented and discussed the rationale for our code. After discussion, we created a new code that was a better representation of the modification.

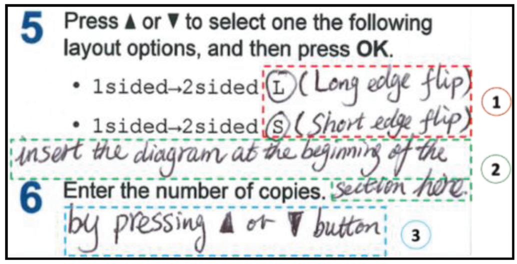

Fig. 3. Three example modifications made by a participant: (1) explaining that "L" means "Long edge flip" and "S" means "Short edge flip"; (2) indicating that the diagram at the beginning of the section should be inserted here; and (3) adding extra information "by pressing ▲ or ▼ button."

Table 2. The Problems and Solutions Identified for the Modifications in Figure 3 During the Coding Process

ID	The Problem Addressed	The Solution Provided
1	Technical terms/concepts (i.e., "L," "S") were unexplained.	Provide explanations for the technical terms/concepts ("L," "S") using plain language.
2	The diagram explaining the terms was not presented in the right place.	Include the diagram that explains the technical terms from the beginning of the instructions to the step where the diagram is immediately needed.
3	The step (Step 6) did not contain information about how to complete the required actions	Provide sufficient instructions for completing the required actions in a step.

Because creating new codes can potentially affect previously coded data, we went through all our codes again and adjusted them accordingly. We went through the coding process multiple times until no further changes were made to the codes. With this approach, both coders reached complete intercoder agreement on the final set of codes generated. Figure 3 shows three example modifications that were made by a participant. Table 2 shows the problems and solutions that we coded for these three modifications.

Next, the first author used the affinity diagramming method to organize the codes into groups based on their similarities. After the groups were formed, the second author reviewed these groupings, pointing out those that may not be representative of the data. Groups were further changed, removed, and merged, and additional groups were formed until the final set of groupings was agreed on by both authors. The themes of the final groups of codes formed the basis of the guidelines for creating senior-friendly product instructions, which will be discussed in detail in Section 3.6.2.

3.6 Results

3.6.1 Number of Modifications. To understand whether participants were able to identify and reduce the number of problems in the instructions, we analyzed the number of modifications that were made to the *original* instructions and the *modified* instructions that were used in the study, respectively.

In total, participants made 253 modifications to all of the product instructions used in the study. The average numbers of modifications to the two types of instructions (*original* and *modified*) are

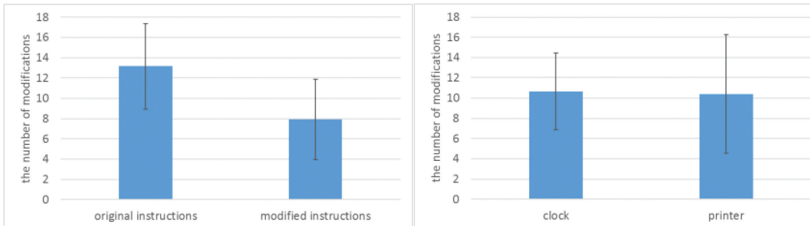

Fig. 4. (Left) the average numbers of modifications to two types of instructions; (right) the average numbers of modifications to two devices. Error bars show standard deviations.

as follows (see Figure 4 left): *original* instructions ($M = 13$, $SD = 4$) and *modified* instructions ($M = 8$, $SD = 4$). We performed Wilcoxon signed rank test on the numbers of modifications to each type of instructions. Results show that there was a significant effect of the type of instructions on the number of modifications ($Z = -2.8$, $p = .005$).

Because of the exploratory nature of the study, different participants used different versions of the *modified* instructions created by other participants as per the study design (see Section 3.4), which should be taken into account when referring to the exact numbers of modifications. However, the result shows that, on average, older adults were able to identify problems in the instruction manuals and, further, that the modifications they made were able to reduce the number of these problems. In sum, this implies that it is reasonable to derive guidelines for creating senior-friendly product instructions based on older adults' modifications.

Additionally, we also tested whether the number of modifications differed between the two devices used in the study (see Figure 4, right). The average number of modifications made for the alarm clock's instruction manual was 11 ($SD = 4$), and, for the copier, it was 10 ($SD = 6$). There was no statistically significant difference in the number of modifications to the instructions of the two devices ($Z = -.05$, $p = .959$). This suggests that device differences did not significantly impact the number of modifications made by participants.

We further analyzed the modifications that participants made to instructions that were previously modified by a participant. Specifically, we divided the number of modifications in these instructions into two categories: Modifications that were made to parts that already were changed by the previous participant (category 1) and those that were made to parts that were unchanged by the previous participant (category 2). The average number of changes made to these two categories were 4.3 ($SD = 3.3$) and 3.5 ($SD = 2.6$), respectively. The difference was not statistically significant ($Z = -.564$, $p = .573$). This result suggests that while participants felt that parts of the instruction manuals that had already been modified by another participant were clear enough to begin with, they also felt that improvements could still be made to the instructions because they proposed new changes in unaltered parts.

3.6.2 Problems and Guidelines. Using the final groups of codes produced from the open coding and affinity diagramming analysis process described in Section 3.5, we developed 11 guidelines for creating senior-friendly product instructions from the sets of solutions learned from participants in Study 1. Table 3 shows these guidelines. We present the problems that each guideline aims to address and example solutions that we created to realize each guideline in the rest of the section.

Guideline 1: Provide an overview of the elements that will be used later. Participants had difficulty with steps that refer to parts of the products that must be used to complete the tasks. To become familiar with these parts, participants needed to search the instructions for texts and figures that explained these parts. Rather than placing the burden on them to locate information about the

Table 3. Guidelines for Creating Senior-Friendly Product Instructions

1	Provide an overview of the elements that will be used later.
2	Increase the legibility of all content.
3	Create instructions as self-contained steps.
4	Include all the information that is relevant at each step.
5	Remove irrelevant content.
6	Include the goal for any steps that have substeps.
7	Establish and use consistent language.
8	Label key elements in image figures.
9	Explain technical terms and concepts using plain language.
10	Show the post-action state for every step.
11	Provide references to similar tasks before the instructions.

relevant parts of the product, participants recommended instead including such information before the instructions are given. In sum, guideline 1 recommends that writers provide an overview of the elements related to the product that will be used in the rest of the steps (see Figure 5 for an example). This allows the user to become familiar with the parts of the product that are relevant to the task. The information can then be quickly located and consulted later as the user is performing the task, rather than needing to search through the entire instructions.

Guideline 2: Increase the legibility of all content. Participants encountered several problems related to the legibility of the instructions, such as font sizes being too small and a lack of contrast in images causing in-figure text to be indiscernible. Participants also reported difficulties in identifying the step to which a particular piece of information, such as a figure, pertained. For instance, participants were often misled to associate text and images with unrelated instructions due to erroneous formatting and padding, or when they appeared visually similar (e.g., font size, color, type, etc.) to nearby instructions. In general, participants expressed a desire to easily distinguish between relevant and irrelevant information by having unrelated content appear visually distinct.

Guideline 2 recommends that writers increase the legibility of all content included in the instructions. This includes text as well as images and figures that users must consult. Examples of important ways to enhance the legibility of the instructions include using font sizes and colors that can be read with ease, using padding to separate unrelated information, making references to interface elements stand out, and numbering steps. Additionally, writers should label figures so that annotations are added to images using a high-contrast color. Figure 6 shows an example implementation of guideline 2.

Guideline 3: Create instructions as self-contained steps. Participants had difficulty completing some steps when it was assumed that the user had prior knowledge about certain parts of a product. It was common for instructions to include references to other sections of the manual; in such cases, participants were required to refer back to these sections. Naturally, the information contained in these sections would not be specific to the task at hand, forcing participants to infer how to apply them for their specific cases. When instruction manuals are presented in such a way—requiring readers to refer to several sections of a manual to carry out a single step and placing the burden on them to interpret instructions because they lack specificity—it imposes cognitive load and may impede one's ability follow through on a set of instructions. Thus, participants expressed a desire for self-containment. Guideline 3 recommends that writers create self-contained steps by including within them all pertinent details (see Figure 7).

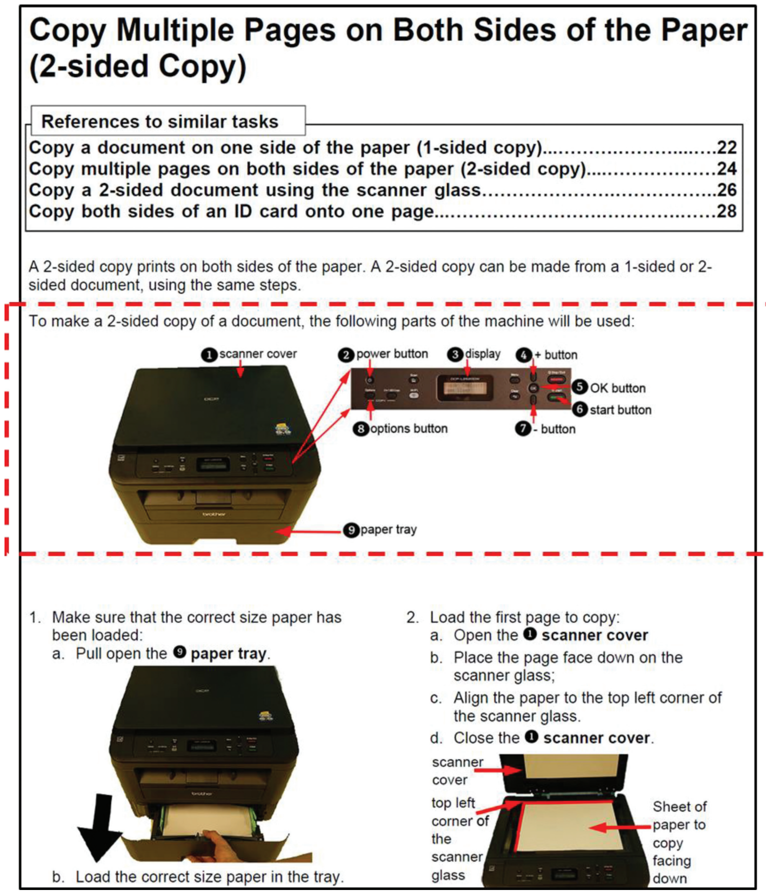

Fig. 5. An example implementation of guideline 1: The dashed rectangle highlights the overview of all the interface elements that a user will use in the following set of instructions for making two-sided copies.

c. Close the ❾ **paper tray**.

2. Load the first page to copy:
   a. Open the ❶ **scanner cover**
   b. Place the page face down on the scanner glass;

Fig. 6. An example implementation of guideline 2: Adding space properly between two steps, numbering steps and substeps, making references to interface elements stand out by using bold font.

Guideline 4: Include all the information that is relevant at each step. Guideline 3 recommends that writers create self-contained steps by including within them all pertinent details, but it does not suggest where the information should be presented within steps. When information was not presented in proximity to the associated step, participants felt confused and had a tendency to ignore such information. Consequently, they encountered problems in subsequent steps where the information was needed (see Figure 8, right).

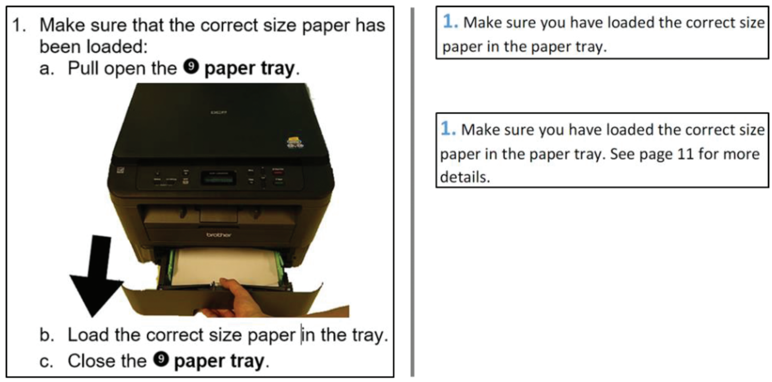

Fig. 7. (Left) an example implementation of guideline 3; (right) two examples that writers should avoid in creating product instructions for older adults.

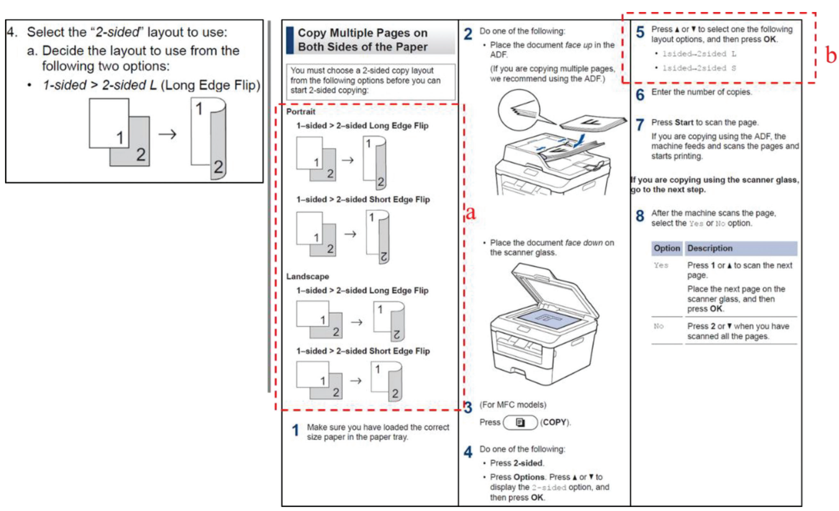

Fig. 8. (Left) an example implementation of guideline 4, which presents information (i.e., the explanation of the "long edge flip") in the step where it is needed; (right) an example to avoid, which presents information needed for a step (b) at a separate location (a).

Participants suggested presenting relevant information at the step where it is needed. Additionally, participants also wanted to know about information they would come across at each step. For example, P5 commented on the benefit of knowing all options that she would see when following a step so that it would help her understand how to perform steps properly: *"If I don't know what options are, then I don't know how many options I have to pass before I reach my target. I have to pause at every option and wonder 'is this the one?' It's a hide-and-seek kind of thing. Just tell me what options are, and I can go through them quickly and confidently, so it'll be more efficient."* Guideline 4 recommends that writers include in each step all relevant information (see Figure 8, left).

Guideline 5: Remove irrelevant content. Participants made mistakes when the instructions included information that did not apply to their specific context. For example, the copier manual contained instructions for two different models in each step. The first instruction presented in each

7. Copy the rest of the pages:
   a. Press the ❹ + button;
   b. Open the ❶ **scanner cover**;
   c. Remove the page from the scanner glass;
   d. Place the next page face down on the scanner glass as done for the first page;
   e. Align it to the top left corner of the scanner glass as done for the first page;
   f. Close the ❶ **scanner cover**;
   g. Press the ❺ **OK** button;
   h. Repeat the above steps a-g if you have additional pages to copy.

Fig. 9. An example implementation of guideline 6: The step presents its goal at the very beginning and then lists all the substeps.

step was for a different model of the copier from what the participants were using. Participants realized the instructions were not meant for their device only after they had actually mistakenly followed some of the directions. Inevitably, this led them to feel frustrated and annoyed. For example, P6 commented, *"I understand it (having instructions for multiple models written in one manual) is a cost-saving feature probably, but reading through all kinds of stuff that I don't care about really annoys me. Instructions should be in sequence for each model separately, so I don't read any stuff that I don't need to know."* Guideline 5 recommends that writers remove any irrelevant content that does not apply to the intended task.

Guideline 6: Include the goal for any steps that have substeps. Participants needed to understand why they were performing different steps. They were particularly confused when the instructions included steps that involved many actions but did not describe what these sequences of steps attempted to accomplish. Without knowledge of the purpose of a sequence of actions, participants had trouble keeping track of what they were doing. In practice, creating instructions involves performing a task decomposition, breaking down a high-level goal into lower level goals and steps for accomplishing those goals. Guideline 6 encourages writers to include the high- and low-level goals for the task to explain what the user will be trying to accomplish before presenting a sequence of actions (see Figure 9).

Guideline 7: Establish and use consistent language. Participants encountered several problems due to inconsistent presentation of instructions. For example, participants found it hard to identify the steps that they had to perform when the directions combined and presented both the actions to perform and other information. This is made more difficult because of different sentence structures describing the actions that users would need to complete in different steps. P8 explained the issue as follows: "*When people read instructions, they want to know what they need to do. Like "slide function selection slider..." tells them exactly what they need to do right away. But if you write it differently, then you increase the burden of processing it.*" Moreover, participants also faced difficulties following the instructions when the descriptions of the interface elements in the written text were not consistent with the labels on the actual device. Thus, guideline 7 encourages writers to use consistent language. Examples of important ways to keep instructions consistent include distinguishing steps that only provide information from those requiring actions (see Figure 10), using the same sentence structure for instructions requiring actions, and using actual labels on the device when referring to parts that the user needs to interact with.

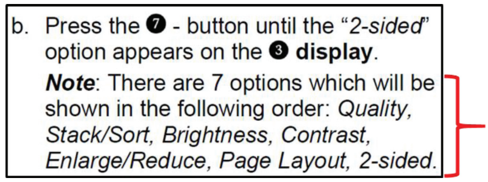
b. Press the ❼ - button until the "*2-sided*" option appears on the ❸ **display**.
Note: There are 7 options which will be shown in the following order: *Quality, Stack/Sort, Brightness, Contrast, Enlarge/Reduce, Page Layout, 2-sided.*

Fig. 10. An example implementation of guideline 7: Distinguishing the steps that only provide information from those requiring actions by presenting them in a different format (e.g., putting them visually separate as a note).

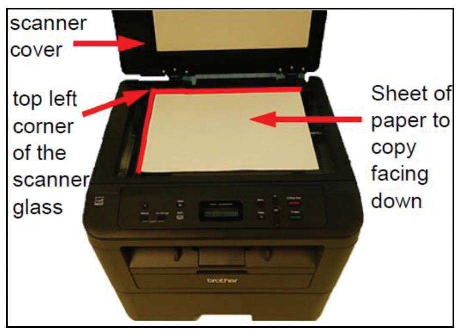

Fig. 11. An example implementation of guideline 8: Pointing out the parts of the image that the user must pay attention to (using red lines and arrows).

Guideline 8: Label key elements in image figures. Participants had difficulty with images that did not label key information properly. For example, participants spent a lot of time searching an image for a particular label when labels were not numbered or numbered randomly. Participants also encountered problems because important parts of an image were not emphasized. For example, participants misplaced the paper on the copier's scanner glass because the image in the original copier's instructions did not clearly emphasize that the paper must be aligned with the top left corner of the surface. Thus, guideline 8 recommends that writers label key elements in image figures, emphasizing specific part(s) of the interface that the user must pay attention to when completing a step (see Figure 11), and number the parts in a logical order (e.g., clockwise).

Guideline 9: Explain technical terms and concepts using plain language. Participants often could not understand the meaning of certain jargon and abbreviations used in the instruction manuals. For example, participants had a hard time understanding the meanings of the "long edge flip" and "short edge flip" terms when using the copier's instructions. To mitigate such problems, guideline 9 proposes that writers explain technical terminologies in an easy-to-understand, clear, and concise way and make use of analogies to help users understand the necessary information for following instructions (see Figure 12).

Guideline 10: Show the post-action state for every step. Participants found it hard to know whether they had completed a step correctly or not. In certain cases, they were unaware of a mistake that they made in a step and carried the problem forward. When participants eventually realized that a mistake had been made, they were not able to determine when the problem occurred and how to resolve it. Often, this resulted in participants repeating steps several times to guess where the problem may have occurred. To enable users to validate whether a step was completed correctly, guideline 10 suggests providing the post-action state for every step (see Figure 13).

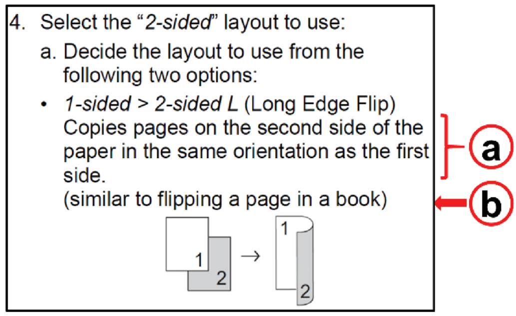

Fig. 12. An example implementation of guideline 9: Defining the technical term ("Long Edge Flip") by explaining it in plain language (a) and using an analogy (b).

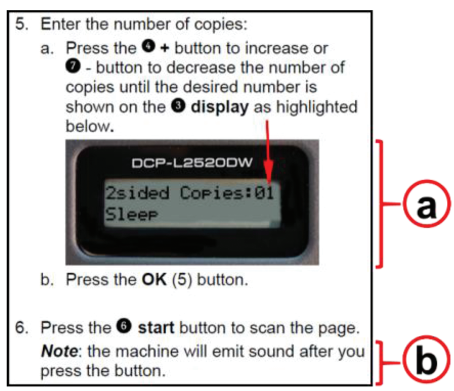

Fig. 13. An example implementation of guideline 10: Providing visual (a) or textual (b) description(s) of the state of a step when its required actions are successfully completed.

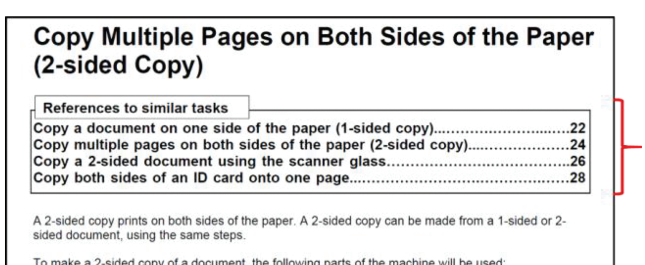

Fig. 14. An example implementation of guideline 11: Adding a mini "table of contents" that only lists the references to instructions for similar tasks at the beginning of a set of instructions.

Guideline 11: Provide references to similar tasks before the instructions. For the copier machine, headings were often uninformative for tasks that were similar as these sections were titled in a similar fashion. As a result, participants would study sections of the manual for the wrong task. Participants proposed adding a mini "table of contents" containing references to the instructions for similar tasks. Thus, guideline 11 recommends that writers provide references to similar tasks before presenting the actual instructions (see Figure 14). This will enable users to assess whether or not they are consulting the appropriate section.

Table 4. The Demographic Information of the Study 2's Participants

ID	Gender	Age	Education	Retired	Occupation
1	F	70	Master's degree	Yes	IT project manager
2	M	65	Master's degree	No	Marketing consultant
3	F	76	College degree	Yes	Project manager
4	M	61	Master's degree	Yes	Software developer
5	F	65	College degree	Yes	Teacher
6	F	72	Master's degree	Yes	Administrative assistant
7	M	73	Master's degree	Yes	Teacher
8	F	62	College degree	Yes	Accountant
9	F	66	College degree	Yes	Nurse
10	F	62	College degree	Yes	Accountant
11	F	61	College degree	Yes	Teacher
12	M	62	College degree	No	Internet marketer
13	M	65	College degree	No	Sales associate
14	M	77	High school	Yes	Building manager
15	M	68	Master's degree	Yes	Police officer
16	M	65	College degree	Yes	Sales representative
17	F	82	College degree	Yes	Journalist
18	M	66	High school	Yes	Accountant
19	F	68	High school	Yes	Customer service representative
20	M	72	College degree	Yes	Teacher
21	M	60	College degree	No	Background performer

4 STUDY 2: VALIDATION OF THE GUIDELINES FOR CREATING SENIOR-FRIENDLY PRODUCT INSTRUCTIONS

4.1 Goals

In Study 2, we validated the guidelines for creating senior-friendly product instructions that were identified from Study 1. We evaluated the usability and effectiveness of the guidelines in terms of instruction writers' ability to apply them to produce manuals that senior adults find easy to use.

4.2 Participants

Two types of participants were involved in the validation study: writers who modified existing product instructions using either the guidelines or their prior research experience with older adults and older adults who used these product instructions to carry out tasks for various devices.

We recruited 21 older adult participants (10 females and 11 males) from a metropolitan area of a major city in North America via flyers posted around senior community centers, advertisements posted in online forums, and snowball sampling. Their ages were between 60 and 82 ($M = 68$, $SD = 6$). They had varying educational backgrounds. Seventeen of them (81%) were retired. Participants also came from a diverse range of occupations in accounting, consulting, management, nursing, law enforcement, customer service, and teaching. Their demographic information is shown in Table 4.

4.3 Materials and User Tasks

In Study 2, we used three devices—a radio alarm clock (*Electrohome EAAC201*), a coffee machine (*De'Longhi BCO264B*), and a universal remote control (*RCA RCRN03BR*) (see Figure 15). We chose

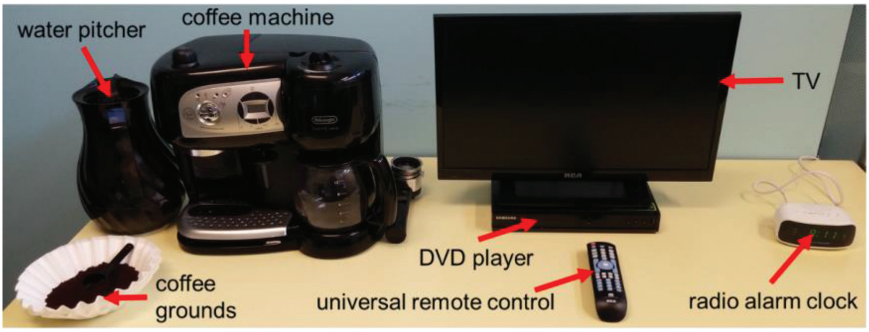

Fig. 15. Three devices used in the validation study: Radio alarm clock, coffee machine (with coffee grounds and water in the pitcher on the side), and universal remote (with a DVD player to control and a TV to show the content on the DVD).

these devices because older adults may have different levels of familiarity using them and may find that certain devices are more difficult or easier to use than others. The radio alarm clock is a common device, and older adults likely have used one in their daily life. It can be confusing to use because it has a number of functions (setting alarms using different sounds and playing the radio) that participants must figure out how to use. The coffee machine used in this study is a moderately complex multifunction device that makes three types of coffee: drip coffee, cappuccino, and espresso. It can also be programmed to make coffee for a preset time. Last, the universal remote control is a less common device and must be programmed, making it potentially harder to use. To create a realistic use scenario for the universal remote control, we also provided a DVD player and a TV.

For each device, we asked participants to perform a task that related to its primary function. Table 6 provides further details about these tasks.

4.4 Study Design and Procedure

Study 2 was designed to compare the effectiveness of three types of product instructions (*original, guidelines-based,* and *experience-based*) in helping older adults to complete tasks with different products. Details about how *guidelines-based* and *experience-based* product instructions are created will be explained in Section 4.4.1. In a nutshell, *original* product instructions are those provided with the commercial products. *Guidelines-based* product instructions are those created by applying the guidelines identified in Study 1 to the original instructions. *Experience-based* product instructions are those that interaction design researchers created by modifying the original instructions using insights learned from their research experience with older adults. We include the *experience-based* product instructions as a test condition to understand (1) whether experience gained from doing research with older adults could be used to identify and resolve problems that other older adults might encounter and (2) how older adults perceive and use *experience-based* instructions compared with those that are *guideline-based.*

4.4.1 Creation of Different Types of Product Instructions. To create the *guidelines-based* product instructions, we enlisted three graduate students (two females and one male), who are referred to as *guideline users* in the remainder of this article. They majored in computer science and were in their second year of graduate study. They did not have any prior research or work experience with older adults. We first asked each guideline user to follow the *original* product instructions that accompanied a device to complete the corresponding task (see Table 6) because doing so could aid in identifying issues in the original instruction manuals [13, 39]. Afterward, each guideline user was required to modify the instructions by applying the guidelines.

We provided each guideline user with the following aids to assist them with the creation of modified instructions:

1. a booklet containing the guidelines and examples;
2. an example set of product instructions that was modified using the guidelines;
3. the original product instructions that the guideline user used;
4. images extracted from the original instructions and photos taken from the actual device;
5. a digital camera to capture additional images if needed; and
6. a printer to print out the modified instructions.

The first aid, namely, the booklet containing the guidelines and examples, was curated by modifying the instructions of a copier device using the guidelines. For each design guideline, we selected snippets from the modified instructions as examples to illustrate good practices and snippets from the original copier instructions to illustrate bad practices. These examples were then compiled into the booklet.

After creating the *guidelines-based* instructions, these guideline users were given a hard copy of their modifications and were asked to identify the guideline(s) that they applied to each modification. To assess the usability of the guidelines from the guideline user's perspective, we asked guideline users to rate two statements about their experience of using the guidelines on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). The two statements were as follows: 1: *it was easy to follow the guidelines in general;* 2: *the examples provided to illustrate the guidelines were helpful.* Inspired by the severity ratings for usability problems, which are proposed to rate how urgently the discovered usability problems must be fixed [36], we designed questions to assess the effectiveness of the guidelines in addressing problems with various levels of severity. To do so, we asked the guideline users to rate three statements about each guideline on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). The three statements were as follows: the guideline addresses problems in the instructions that (1) *frequently appeared*, (2) *would have impacted the successful completion of the task*, (3) *would have persisted through the task*.

To create *experience-based* product instructions, we enlisted three *interaction design researchers* to use the insights that they gained from research with older adults. At the time of the study, they were a postdoctoral fellow who had been studying the impact of architectural design on the psychosocial well-being and health of older adults with dementia for her Ph.D. and continued to work in the same research area, a third-year Ph.D. student with a master's degree who had been focusing on serious game design for the assessment of executive function in older adults, and a second-year master's degree student who had been studying communication technology adoption among older adults. All had hands-on experience interacting with older adults in their research and had at least two peer-reviewed publications as a leading investigator. We included them as *experience-based* instruction writers because their experience could potentially help them understand the problems that older adults might encounter while using technologies.

These interaction design researchers followed the same procedure mentioned earlier except that they were not provided with the guidelines and had to modify the original instructions using only their research experience with older adults. To understand how they modified the original instructions, we asked them to write down the rules and strategies that they used in making their modifications in a post-task questionnaire.

All guideline users and interaction design researchers worked on the assigned task at their own pace and spent 1.8 hours on average ($SD = 0.9$). Given the length of time required to produce a set of modified instructions, each guideline user and interaction design researcher was asked to

Table 5. The 3 × 3 Latin Square Used in Study 2 to Counterbalance the Three Types of Instructions for Three Different Devices

Instruction Type for the First Device	Instruction Type for the Second Device	Instruction Type for the Third Device
Original	Guidelines-based	Experience-based
Guidelines-based	Experience-based	Original
Experience-based	Original	Guidelines-based

Table 6. The Devices Used in Study 2 and the Corresponding Tasks

Device	Task
Radio alarm clock	Set the alarm for 8 a.m. and use the radio as the alarm's ringtone/sound.
Coffee machine	Program the coffee machine to make two cups of strong flavor drip coffee at 8 a.m.
Universal remote control	Program the universal remote control to control the DVD player.

modify one instruction manual. Specifically, the three guideline users developed three *guidelines-based* instructions, and the three interaction design researchers developed three *experience-based* instructions, resulting in two modified manuals produced per device—one that is *guidelines-based* and one that is *experienced-based.*

4.4.2 Study Procedure. After the *guidelines-based* and *experience-based* product instructions for the three testing devices were created, we conducted the validation study with older adult participants (see Section 4.2). In the study, we first provided each participant with a device, its instructions, and the task to complete. The device and its instruction types were determined by a within-subjects design so that each participant used all three types of instructions.

To remove potential learning effects between conditions, the three types of instructions were used with three different devices. We counterbalanced the order of the three types of product instructions that participants used with a reduced 3 × 3 Latin Square design[1] (see Table 5) in order to guarantee that each instruction type appears first, second, and last at least once. The 3 × 3 Latin Square was repeatedly administered to every three participants.

We chose not to counterbalance the order of the three devices that each participant used because they are commercial products for unrelated household tasks. As such, there was little foreseeable learning effects among them, and task performance was likely to differ between devices. That said, we acknowledge that this study design entailed performing statistical analyses for each device separately to measure the interaction between device and instruction type. Alternative study designs that treat both *device* and *instruction type* as independent variables would have allowed for statistical tests that may be more robust, such as such as a two-way ANOVA, which would better protect against type I errors.

Each participant was given 30 minutes to complete the task. We did not provide participants with any help while they attempted to follow the instructions to complete the task. After a participant completed the task or when the allocated time was up, we checked whether the task was completed

[1]Other designs, such as balanced Latin Squares, can be used to reduce the first-order carryover effect. We opted to use a reduced 3×3 Latin Square study design because there exists little foreseeable carryover effect between the conditions. Participants had no knowledge that we were studying their use of three different types of instructions in the study.

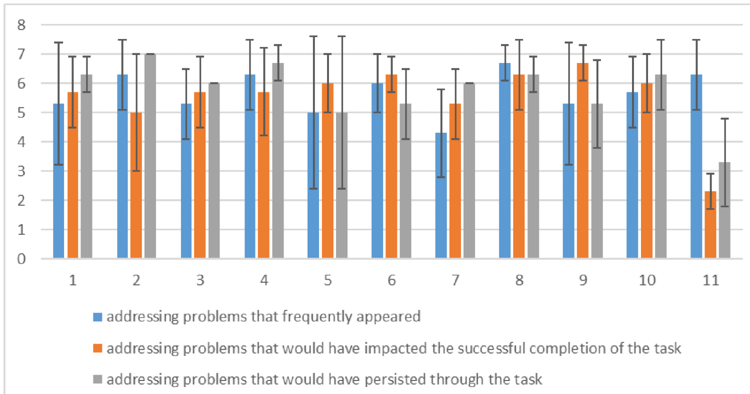

Fig. 16. Guideline users' average ratings of the three statements about each guideline in helping to address problems in original instructions. Error bars show standard deviations.

correctly and asked the participant to fill in a post-study questionnaire. To assess the usefulness of the instructions, we designed four statements in the post-study questionnaire that asked each participant to rate his or her agreement on the statements using a Likert scale from 1 (strongly disagree) to 7 (strongly agree). The statements were as follows: (1) *the instructions were helpful*, (2) *the instructions were easy to follow*, (3) *the instructions were complete*, (4) *the instructions were concise and of the appropriate length.*

We then followed the same procedure to ask the participant to use the other two devices and their product instructions to complete corresponding tasks. After each participant completed all three tasks for the three devices, we asked them to rate their experiences of using the three types (*original, guidelines-based,* and *experience-based*) of instructions on a Likert scale of 1–7 (1: strongly dislike, 7: strongly like). Afterward, we conducted a short interview to learn about any issues that they may have encountered and any additional thoughts and feelings that participants may have had about their experiences.

4.5 Results

In the first two subsections, we report the feedback from the *guideline users* and *interaction design researchers* who created the *guidelines-base*d and *experience-based* instructions, respectively. In the next two subsections, we report quantitative and qualitative results about the validation study in which older adults participated.

4.5.1 Guideline Users' Experiences of Using the Guidelines to Create Guidelines-Based Instructions. We analyzed guideline users' labels about the guidelines that they used to make modifications and found that each guideline user applied all guidelines in their modified instructions. Their responses to the two statements about their experiences of using the guidelines on a 7-point Likert scale (the bigger the number, the better the experience) showed that *it was easy to follow the guidelines in general* ($M = 5.7$, $SD = 2.3$) and *the examples provided to illustrate the guidelines were helpful* ($M = 6$, $SD = 1$). With respect to the effectiveness of the guidelines in addressing problems with different levels of severity, guideline users expressed that the majority of the guidelines were effective in addressing frequent, important, and persistent problems (see Figure 16). They rated guideline 11 ("*provide references to similar tasks before the instructions*") the lowest. The guideline user who modified the alarm clock instructions explained that guideline 11 was not as important

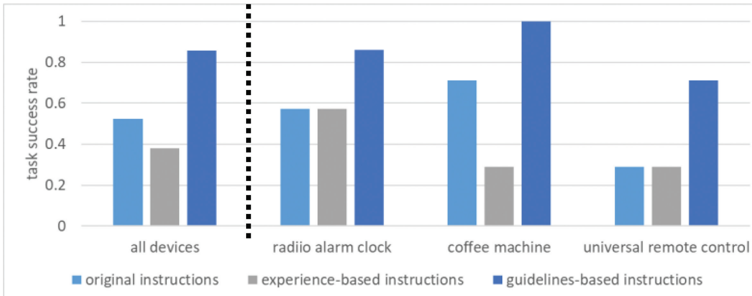

Fig. 17. Task success rates when using three types of instructions for all devices and each device respectively.

as others for short instructions like the one he modified because there were not many similar tasks in the instructions. However, he agreed that guideline 11 would be very helpful for devices with many similar functions.

Guideline users also provided their concerns and difficulties when following the guidelines. First, given that there are so many guidelines, it is difficult for participants to retain them in memory and recognize when a particular aspect of an instruction should be modified to adhere to a certain guideline. Consequently, they expressed a tendency to constantly refer back to the guidelines when making their modifications. Second, although guideline 3 ("*create instructions as self-contained steps*") helps users avoid searching for related instructions themselves, it may introduce redundant content. Third, it is hard to show the post-action state for a step that does not result in a noticeable state change after the required actions were completed (guideline 10). Last, it can be difficult sometimes to determine exactly whether or not a term used in the manual might require further elaboration (guideline 9).

4.5.2 Interaction Design Researchers' Feedback About Creating Experience-Based Interactions. In the post-task questionnaire, interaction design researchers mentioned the common strategies that they used in modifying the original instructions: (1) *increasing legibility by using different font, large font size, white-space, and colors; (2) inserting missing information based on their own experience of doing the task*; (3) *using both real and abstract images of the components with which users will interact*; and (4) *indicating the places in the images where users should focus attention.* Many of the modifications made by interaction design researchers were encompassed by our guidelines, particularly, 2, 3, and 8.

4.5.3 Quantitative Results About Using the Three Types of Product Instructions. In this subsection, we present quantitative results about the task success rates, the task completion times, and the perceived usefulness and preferences of the three types of instructions when used by older adults.

Task Success Rate. We computed the task success rate as the number of participants who completed the task successfully divided by the total number participants in a condition. Figure 17 shows the success rates of using three different types of product instructions on all devices together and on each device, respectively. Results show that the *guidelines-based* product instructions (1) contributed to the highest task success rate for every device respectively and (2) improved the task success rate 29% for the radio alarm clock task, 29% for the coffee machine task, and 42% for the universal remote control task compared with the *original* instructions; however, (3) the *experience-based* instructions did not improve the task success rates compared with the *original* instructions. The overall task success rates of using three types of product instructions for all

Table 7. The Adjusted Wald Confidence Interval for the Task Success Rate of Using Each Type of Instructions

Instructions Type	Task Success Rate	95% Adjusted Wald Confidence Interval	
Original	0.52	0.32	0.72
Experience-Based	0.38	0.21	0.62
Guidelines-Based	0.86	0.65	0.96

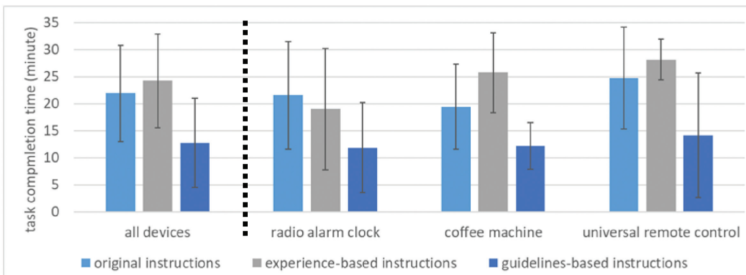

Fig. 18. Task completion time of three types of instructions for all devices together and each device. Error bars show standard deviations.

devices together are 52% (original instructions), 38% (*experience-based* instructions), and 86% (*guidelines-based* instructions).

We further computed the 95% confidence interval of the task success rate for each of the three types of instructions. We used the Adjusted Wald method to calculate the confidence interval to compensate for the small sample sizes used in usability testing [29, 42]. Table 7 shows the 95% Adjusted Wald confidence intervals for the task success rates of using three types of instructions.

Task Completion Time. We recorded the time that each participant took to complete each task. We used the maximum allocated time for each task (30 minutes) in cases where participants did not complete the task successfully ($N = 26$). Figure 18 shows the average task completion time of all participants when using each type of product instructions on all devices together and also on each device separately. The task completion time when using *guidelines-based* instructions ($M = 12.8$, $SD = 8.2$) was less than both using the original instructions ($M = 21.9$, $SD = 8.9$) and using the *experience-based* instructions ($M = 24.2$, $SD = 8.6$). In particular, the results show that the task completion time when using *guidelines-based* instructions was roughly 60% less than using *original* instructions and almost half of the time spent using *experience-based* instructions.

As the study followed a within-subjects design, we performed one-way repeated-measure ANOVA on the task completion time for using the three types of product instructions. Whenever a statistically significant effect was found, we followed up with post-hoc pairwise comparisons with Bonferroni correction. We applied the Greenhouse-Geisser correction whenever sphericity was violated (note that using the correction may result in a decimal degree of freedom). Partial eta-squared (η_p^2) was used as the measure of effect size for the subsequent statistical analysis. The partial eta-squared values for small, medium, and large effect sizes are 0.01, 0.06, and 0.14, respectively [12].

Results show that there was a significant main effect of the instructions type on the task completion time ($F_{2,40} = 13.09$, $p < .001$, $\eta_p^2 = .40$). Pairwise comparison results consistently show that the task completion time using *guidelines-based* instructions was significantly shorter than using either the *original* or the *experience-based* instructions ($p < .001$). No statistically significant

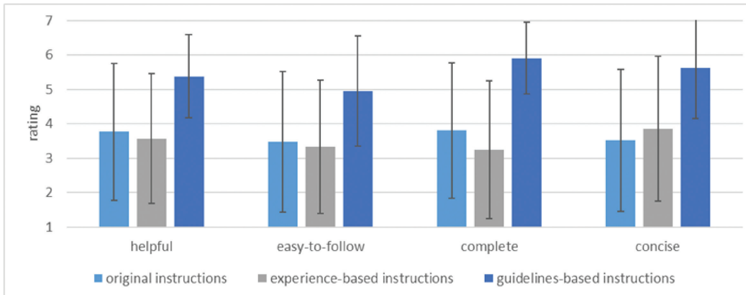

Fig. 19. The average ratings of four statements for using the three types of instructions. Error bars show standard deviations.

difference was found in task completion time between using the *original* instructions and using *experience-based* instructions.

We further examined the task completion time for each device respectively. In all cases, the task completion time while using *guidelines-based* instructions was consistently shorter than using the other two types of instructions (see Figure 18).

Given that each participant only used one type of instructions for a particular testing device, the study was a between-subjects design when we only analyzed the data for a particular device. Thus, for the data related to each device, we performed a one-way ANOVA on the task completion time. We applied a Welch ANOVA instead of a one-way ANOVA when the homogeneity of variances was violated. Whenever a statistically significant effect was found, we followed up with post-hoc tests with Bonferroni correction. In total, three ANOVA tests were performed for the three devices. Results for each device are as follows: (1) Coffee machine: There was a significant main effect of the instructions type on the completion time ($F_{2,18} = 7.27$, $p < .01$, $\eta_p^2 = .45$). Post-hoc tests revealed a significant difference in the task completion time between *guidelines-based* instructions and *experience-based* instructions ($p = .004$); no significant difference was found between any other pairs. (2) Universal remote control: There was a significant main effect of the instructions type on the completion time ($F_{2,9.72} = 4.51$, $p < .05$, $\eta_p^2 = .35$). Post-hoc tests revealed a significant difference in the task completion time between *guidelines-based* instructions and *experience-based* instructions ($p = .03$). No significant difference was found between any other pairs. (3) Radio alarm clock: No significant difference was found in the completion time of three types of instructions ($F_{2,18} = 1.82$, $p = .19$, $\eta_p^2 = .17$). Cases where no significant effects were found could be attributed to the following reasons: (1) There was a relatively small sample size for each device's related data; we only had seven participants who used each type of instructions for any given device. (2) Because the study was a between-subjects design for each device, individual differences among participants likely influenced the testing results when statistical tests were carried out on the data for each device separately. And (3), we assigned the task completion time to be the maximum allocated time (30 minutes) for those cases in which participants failed the task. In reality, it may take these participants longer to eventually accomplish the task or they may never succeed. Given the higher task success rate achieved with the *guidelines-based* instructions for each device compared to the *original* or *experience-based* instructions, significant difference might be found if longer times (e.g., >30 minutes) were assigned to those failed cases.

Usefulness of the Three Types of Product Instructions. The average ratings of the four statements regarding the usefulness of the three types of instructions (see Section 4.5) are shown in Figure 19. The ratings for the *guidelines-based* instructions were the highest among all three types of

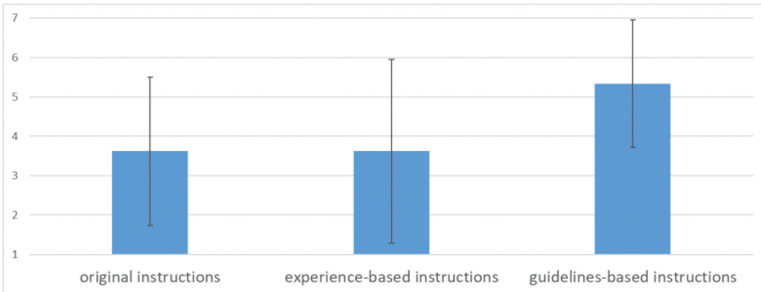

Fig. 20. The overall preferences of the three types of product instructions. The vertical axis shows the ratings: (1) strongly dislike and (7) strongly like. Error bars show standard deviations.

instructions (all ≥5 out of 7), which suggests that participants perceived the *guidelines-based* instructions to be the most helpful, easy-to-follow, complete, and concise in general.

We conducted a Friedman test on the ratings for each of the four statements. Results indicate a statistically significant difference in the ratings for each statement depending on the type of instructions ("*the instructions were helpful*": $\chi^2(2) = 12.68, p < .01$; "*the instructions were easy-to-follow*": $\chi^2(2) = 9.79, p < .01$; "*the instructions were complete*": $\chi^2(2) = 14.55,\ p < .01$; "*the instructions were concise and of appropriate length*": $\chi^2(2) = 11.55,\ p < .01$). Pairwise comparisons using Conover's F test at $\alpha = .05$ systematically showed statistically significant differences in the ratings of each statement between the *guidelines-based* instructions and the *original* instructions, and between the *guidelines-based* instructions and the *experience-based* instructions. No significant differences were found between the ratings of the *original* instructions and those of the *experience-based* instructions.

User Preference for Three Types of Product Instructions. Figure 20 depicts the overall ratings of preference for the three types of product instructions. The *guidelines-based* instructions received the highest ratings ($M = 5.3$, $SD = 1.6$). The *original* and the *experience-based* instructions had roughly the same average ratings. We applied a Friedman test on the ratings and found a statistically significant difference in the preference ratings depending on the type of instructions ($\chi^2(2) = 9.82,\ p < .01$). Pairwise comparisons using Conover's F test at $\alpha = .05$ show significant differences between the *guidelines-based* instructions and the *original* instructions, and between the *guidelines-based* instructions and the *experience-based* instructions. There were no significant differences in the preference ratings between the *original* instructions and the *experience-based* instructions.

Summary of the Key Findings. In summary, the quantitative results revealed a number of key insights:

- *Guidelines-based* product instructions helped participants achieve the highest task success rate compared with *original* and *experience-based* product instructions;
- *Guidelines-based* product instructions helped participants complete the tasks significantly faster than either the *original* or the *experience-based* instructions;
- *Guidelines-based* product instructions were perceived to be significantly more helpful, easier to follow, more complete, and of the most appropriate length than either the *original* or the *experience-based* instructions;
- *Guidelines-based* product instructions received significantly higher ratings of preference by older adult participants than either the *original* or the *experience-based* instructions;

- No significant difference in the task completion time was found between using the *original* and the *experience-based* product instructions;
- No significant difference was found between using the *original* and the *experience-based* product instructions for the ratings of four statements regarding the instructions' usefulness;
- No significant difference was found between using the *original* and the *experience-based* product instructions for users' preferences;
- There were mixed results for the effect of the *instruction type* when considering each device separately. The mixed results suggest that there might be an interaction effect between *instruction type* and *device*. Further investigations with a two-way factorial design and more participants are needed to assess the interaction between *instruction type* and *device* on the user's task performance, experience, and preference when using three types of instructions.

4.5.4 Qualitative Results on Using the Three Types of Product Instructions. In this section, we present the qualitative results that we learned from observations and interviews with the participants in the validation study.

Issues with Using Original and Experience-Based Instructions. In the validation study, we observed similar problems pertaining to poor legibility, lack of post-action state (feedback), and the separation of images from their corresponding textual instructions that we had observed earlier from Study 1. For example, participants disliked small font sizes and the lack of contrast in images in the *original* instructions for the radio alarm clock. When given poorly presented instructions, they were often uncertain about whether they had correctly performed certain steps (P14: *"… I was unsure how long buttons should be held down. I feel I should just take their words, but I was searching and testing yet nothing was happening. Eventually I was frustrated and gave up…"*). Further, participants expressed disapproval about the way figures in the coffee machine's manual were presented in that they were located separately from the textual instructions, forcing participants to constantly flip back and forth between pages. They also reportedly felt bombarded by the amount of text present on any given page when figures were not embedded with the instructions. The guidelines—namely 2, 10, and 4—were able to address all these issues in the modified manuals.

During the interview, some participants expressed feelings of frustration when the result of carrying out a step did not match their expectations. Due to being provided with poorly presented instructions that did not describe a subtle but necessary action (i.e., releasing a button after the display flashes), participants had issues with programming a preset time for the coffee machine. When the instructions improved to adhere to the guidelines, none of the participants encountered this issue. We suspect that guideline 10 ("provide the post-action state for each step") might also have helped guideline users consider implicit actions that must be done to reach the desired post-action state.

Issues with Using Guidelines-Based Instructions. There were three cases in which participants did not complete the tasks successfully when using the *guidelines-based* instructions. The first case occurred when using the radio alarm clock, and the remaining two occurred with the universal remote control. We will present the problems that participants encountered when using *guideline-modified* instructions and then discuss for each problem what to take into consideration when using the guidelines.

1. Insufficient plain-language explanation of technical terms. "Plain-language" explanation of technical terms from the writer's point of view was still difficult to understand for some older adults. In the universal remote control's instructions, a plain-language explanation ("*change from off to on, or from on to off*") was used to explain a technical term "*change state.*" One participant still found this explanation hard to understand. This suggests that simplified technical terms still need to be validated with older adults to ensure that they are understood.

2. Interference from interacting with instructions and devices. The act of reading a set of instructions distracts from the main task at hand. For example, certain actions must be performed within a specific time frame. If participants turn to their instruction manual for help, the device may time out, causing them to repeat previous steps to reactivate the device. Additionally, reading instruction manuals demands the use of one's body, such as to flip a page, and may physically impede one's ability to perform certain steps (P16: "*How am I supposed to flip a page [in the instructions] when both of my hands are in use on buttons of the device?*").

Furthermore, completing the required actions of a step can affect users' ability to carry out following steps. When composing the instructions, guideline users may not realize or may ignore the impact of executing one action on subsequent actions. For example, one step of the universal remote control instructions asks users to press the power button and then check if it is lit up. However, the button is occluded by the finger when pressed, causing difficulties for some participants in figuring out where to check if the button had lit up. Participants who failed to complete the step properly the first time noted that they had to intentionally press a corner of the button to give themselves a chance to check its status. This points to a need for instruction guideline users to take a user-centric approach by actually carrying out the instructions themselves in order to identify potential issues.

3. Lack of encouragement for self-diagnosis. The guidelines are meant to make the instructions better so that older adults will not run into problems when following them. In practice, they may still misunderstand instructions for unforeseen reasons. One approach that people commonly use to overcome an error is through trial-and-error. However, we observed that participants hesitated to do so due to potential negative consequences that may result from maloperations (P6: "*… in the early days, machines were mechanical. If you did not know what you were doing, you were likely to break the machine seriously…*"). Moreover, older adults may not think it is appropriate to continue to follow a few more steps to understand their current issue (P17: "*…I won't ignore it [the unexpected result of the current step] and continue because the device is new to me and I need to get every step right…*"). Compared with the older generation, the younger generation is more willing to experiment with devices by trial and error [28]. These additional explorations after encountering an unexpected result may provide younger adults with more information to diagnose what went wrong. If we can increase older adults' confidence that errors do not cause serious consequences, then they might be more willing to experiment [3]. It would be worth further exploring how product instructions could be improved to lessen the anxiety that older adults have toward experimenting with their devices.

4. Inappropriate use of conceptual images. Participants often took the instructions as verbatim rather than applying them accordingly based on their situations. For example, an image in the universal remote controller's instructions depicted a device different from the one used in the task (i.e., a different DVD player). Because of this, one participant struggled with finding the "power key" at the exact position of the power key shown in the image. To resolve such issues, when using guideline 8 ("label key elements in image figures"), writers should also consider whether images depict an exact device or a conceptual one and add notes to help users understand when it the picture is just a general illustration.

5 DISCUSSION

5.1 Challenges with Applying the Guidelines

Study 2 results show that each writer applied all guidelines when creating *guidelines-based* instructions. Thus, all guidelines contributed to participants' improved performance when using

Table 8. The Length (Number of Pages) of Each Type of Instructions for the Devices Used in Study 2

Device	Instructions Type		
	Original	Guidelines-based	Experience-based
Radio alarm clock	2	6	18
Coffee machine	14	21	14
Universal remote control	6	9	20

guidelines-based instructions. However, we did not collect quantitative data to assess each individual guideline's contribution. The importance of an individual guideline can be relevant to instructions writers in some situations, such as when they are pressed for time and resources and must prioritize. However, the importance of each guideline may vary depending on the product instructions that writers are writing or modifying. Consequently, even controlled studies that only implement one guideline at a time may not be sufficient to objectively assess the importance of each individual guideline in general. As such, we recommend that instructions writers apply and take into consideration as many guidelines as possible when composing product instructions. However, we acknowledge that there might be potential challenges, as follows.

Writers had access to the guidelines, both physically and digitally, when creating the *guidelines-based* instructions in Study 2. However, they still felt that it was difficult to remember all guidelines at the same time when applying them. One approach to assisting their writing process is to build computational tools that can suggest possible guideline(s) to follow based on their completed content at the moment. Additionally, identifying places in their written instructions that may violate guidelines could also be very useful for them to revise the document if they chose.

Applying guidelines may increase the overall length of the instructions. Table 8 shows the number of pages of the three types of product instructions used in Study 2. The increased length can be caused by several guidelines. For example, following guideline 2 ("increase the legibility of all content"), the font sizes were increased in the *guideline-based* instructions over those in the *original* instructions. Furthermore, the content was laid out with more space between lines of text and paragraphs in the *guidelines-based* instructions than in the *original* instructions. However, whereas some guidelines can increase the length of the instructions (e.g., guidelines 1, 3, 6, 9, 10, and 11), others could decrease it (e.g., guideline 5). In our current study, we did not ask guideline users to consider the length of their revised instructions but instead to focus solely on resolving potential problems by following the guidelines. Although there is little or no increase in the cost of product instructions that are provided to users in digital format (e.g., online manuals), an increase in the length of instructions could raise the cost of printing physical manuals. How to simultaneously increase the clarity of instructions while minimizing added length must be explored further. It might be worth considering ways to combine our guidelines with previous instructions design principles (e.g., minimal manual design [31]) that aim to manage the size of the instruction content.

Although, ideally, as many guidelines should be followed as possible, tensions may exist between those guidelines that require writers to make a trade-off between which to apply and how to do so. For example, guideline 9 requires guideline users to explain technical terms and concepts. However, it can be hard to determine which technical terms and concepts need to be explained. If technical terms and concepts are not explained to a sufficient degree, users may still encounter difficulty in understanding these terms and concepts. On the contrary, if every technical term or concept is explained in great detail, the instructions may become too verbose. This would then violate guideline 5, which advises writers to remove unnecessary content. Similarly, tensions may exist between guideline 3 and guideline 5, and between guideline 10 and guideline 5. It is important to consider how to minimize potential conflicts among different guidelines.

5.2 Comparison of the Guidelines with Existing Documentation Guidelines

Our guidelines were discovered from modifications made by older adults. Many of the guidelines follow common sense and existing principles for writing good documentation in general (i.e., do not focus on a specific population such as older adults). For example, guideline 2 is in line with what is recommended in the existing literature, such as using clear heads, providing visuals that are big enough, and using sufficient white space (see chapter 11 in *Technical Report Writing Today* [39]). This literature also suggests that writers should present a sequence of actions in the same order that a user would perform them and provides heuristics to identify such sequence (e.g., constructing a decision tree or flow chart to better organize a sequence of required actions) [39]. Once the sequence of actions is determined by following this suggestion, our guidelines can then be used to determine what information should be included for each step (guideline 4) and when the goal and post-action state for each step should be provided (guidelines 6 and 10).

Previous work has advocated keeping instructions simple. For example, Morell et al. found that simple step-by-step instructions were more effective in helping older adults learn to use computer software than the same instructions expanded with explanations [34]. Although our guidelines also advocate simplicity by suggesting that writers remove irrelevant content (guideline 5), they also point out that certain explanations must be added to simple step-by-step instructions, such as explanations for technical terms and concepts, the goal for steps that have substeps, and the anticipated post-action state for each step (guidelines 9, 6, and 10).

Although minimalist manuals have been shown to be effective, they can be hard to create. As a result, Meij and Carroll have proposed four principles and heuristics to aid in the design of minimalist instructions [31]. These principles are choose an action-oriented approach, anchor the tool in the task domain, support error recognition and recovery, and support reading to do, study, and locate. The first principle emphasizes that instructions should "invite users to act and to support their action." One approach to realizing this principle is to "begin [instructions] by giving the user less to read but more to do." Similarly, guideline 4 aligns with the "action-oriented" spirit of the first principle by requiring all information relevant to a step to be presented in that step instead of elsewhere (e.g., the very beginning of the instructions). The copier instructions used in Study 1 included a long explanation of two double-sided copying options before introducing any actionable steps. We observed that, without knowing how the information will be used, participants often had a hard time understanding the explanation. Some were worried that, without understanding it, they might make mistakes later and thus were reluctant to start the real steps. Some chose to skip the whole block of information. Such a design violate the first principle of minimalist instruction design because it does not provide "immediate opportunities for action" [31]. It also violates guideline 4 because the instructions did not place the information in the step where it is actually needed.

The second principle offers recommendations for choosing a set of tasks to include in the manual. For example, the tasks should "be recognized as genuine" by the target users. Because our studies only used one task per device, the guidelines offer few insights for selecting a set of tasks to create instructions for a manual. However, once the tasks are selected, guideline 11 requires guideline users to consider the similarity of the tasks and provide references to similar tasks before the instructions for a particular task.

Our guidelines align with the third principle (i.e., support error recognition and recovery). By providing a post-action state for each step (guideline 10), users can compare the current state of the product with the anticipated post-action state. This eliminates the possibility of carrying an error into the following steps. Thus, it supports error recognition. By including all relevant information at each step (guideline 4), users can easily access all required actions that must be performed to recover from an error.

Our guidelines also support Meij and Carrolll's last principle. The heuristics for the last principle are be brief and provide closure for chapters. Guideline 5 can make the instructions brief by removing any irrelevant content. Guideline 3 aims to make the instructions self-contained so that users do not need to search for unexplained content in other parts of the manual. This is consistent with the heuristic *provide closure for chapters*, which asks writers to make each chapter of the manual as independent as possible. However, as pointed out earlier, making instructions for a task self-contained can potentially lead to increases in the overall length of the instructions. Thus, how to make a trade-off between being self-contained and being concise should be considered in future work.

5.3 Other Approaches to Creating Senior-Friendly Product Instructions

Another way of creating senior-friendly product instructions is to have a senior review the product instructions (i.e., use and modify it). This can reveal problems that an older adult may actually encounter and potentially costs less time and effort than our approach. However, one older adult may not encounter the same issues that other older adults do. Furthermore, there is no feedback loop to examine the effectiveness of the senior's proposed modifications. Conversely, our research method addresses these two issues. First, it involves more than one older adult during the review of each set of product instructions. This design can discover a broader range of issues that older adults may encounter. Second, by asking older adults to use product instructions that were modified by other older adults, we can test if a modification is effective to other older adults and discover issues that were missed by any one older adult. The results of our first study demonstrated these two advantages. Participants still found issues in the nonmodified part of the instructions that another had not found and also modified another participant's modifications.

Another approach is to have interaction design researchers who have research experience with the older adult population review product instructions using their experience. Their experience with older adults may help them identify certain usability issues in the instructions without involving older adults. This approach saves the time and effort of recruiting and running studies with older adults, which can be challenging. However, we identified three disadvantages of this approach. First, it can take years of training to gain experience with the older adult population, and thus it may be difficult and expensive to find interaction design researchers with research experience related to the older adult population. Second, interaction design researchers may not experience the same issues that older adults could potentially experience and thus may not discover potential issues that older adults may face. Last, their experience with older adults may be highly specialized and may not be directly helpful in making product instructions better. We evaluated this approach in our validation study. Results show that although interaction design researchers' experience-based modifications (such as using bigger font sizes and high contrast color images) were consistent with some of our guidelines, the experience-based instructions were not better than the original product instructions. Moreover, interaction design researchers encountered difficulties in making effective changes to the instructions and were unsure about the quality of their created product instructions. For example, one interaction design researcher in Study 2 rated her performance as only neutral (4 out of 7) and commented that, "*The modifications were made based on my experience of using the product instructions and envisioned issues that older adults might have, but I still have the feeling that they might have problems. I don't know how to make more changes.*" Another interaction design researcher expressed her concerns, "*I am worried that the design might be too patronizing, yet I wanted to be as clear as possible. But I am not sure how that will work out.*"

In addition to methods that aim to improve the quality of the product instructions' content, such as our research approach and the two just described, researchers have also explored methods to improve the presentations of product instructions. For example, a multilayer interface approach, which shows users a simplified user interface first before the full-fledged one, has been shown to be helpful in improving older adults' performance in using new devices [8, 14, 17, 27]. Many approaches that optimize the presentation of instructions are beneficial in helping the general population to accomplish assembling tasks or learn computer software [1, 19, 26]. Our guidelines and these methods that optimize the presentation of instructions are complementary to each other. Instruction writers may first use our guidelines to create instruction content and then use these presentation optimization approaches to further reduce the complexity of instructions to end users.

5.4 Limitations and Future Work

While our validation study demonstrated that *guideline-based* instructions were better than *experience-based* instructions in terms of task success rate, task completion time, usefulness, and preference, it is also worth noting that there was a potential limitation of the study design. In the validation study, only one *guidelines-based* and one *experience-based* product instructions were created for each testing device. The quality of these instructions can potentially be influenced by their creators (i.e., guideline users and interaction design researchers). For example, if a guideline user did not implement the guidelines well, then the problems that older adults encounter when using their created *guidelines-based* instructions may not be because of the insufficiency of the guidelines but rather the quality of the implementation of the guidelines by the guideline user. Similarly, the interaction design researcher's ability to identify and resolve ambiguities in the *original* instructions can influence the quality of the *experience-based* instructions. One possible study design to alleviate this issue is to have multiple guideline users and interaction design researchers create multiple *guidelines-based* and *experience-based* instructions for the same device and then have participants use all of them. This design, however, may potentially demand a larger participant pool in order for each manual to be tested by several participants. An alternative study design is to choose representative *guidelines-based* and *experience-based* instructions from all available ones. It is, however, unclear which modifications should be considered as the most representative without knowing how well they fare in practice.

In this research, older adults modified existing product instructions in Study 1, and writers followed the guidelines to modify existing product instructions in Study 2. Hence, our guidelines were created and validated for modifying existing product instructions to make them more user-friendly for older adults. In theory, instruction creators should be able to use these guidelines to write product instructions from scratch as well. However, future research should examine the use of these guidelines for creating instructions from scratch and whether adaptations are needed. It is important to mention that future study designs must ensure that instruction writers have appropriate knowledge about the tasks prior to writing instructions for them. We ensured that participants had appropriate knowledge about the tasks prior to modifying instructions by requiring older adults in Study 1 and the guidelines users in Study 2 to perform the tasks themselves. Similarly, while creating instructions for a task from scratch, instruction writers should acquire knowledge about the task by either performing the task themselves or asking subject matter experts.

5.5 Out-of-Box Experience

Our studies simulated one's experience of using devices and their product instructions for the first time (i.e., out-of-box experience, or OoBE) to a certain extent. All participants used the testing devices for the first time. They were provided with the whole product manual and had to locate the relevant instructions for completing the tasks. Following the recommendations for training and studies with older adults [18], we did not make the length of the studies too long so that our participants could focus well on the tasks during the studies. As a result, we did not require them to set up and get familiar with the devices before working on the tasks, which are part of the OoBE. Although our study does not address the problem of setting up devices specifically, there is emerging interest in improving the OoBE, such as the "Out of the Box" design project [45]. The project guides a user to set up a mobile phone by placing it in a designed slot in the printed manual and then following the step-by-step instructions printed on each page around the slot, with pointers to the actual interface elements on the phone that the user needs to operate in each step.

Although these approaches may be promising in helping older adults set up devices on their own, older adults may not want to experience the OoBE alone. Burrow et al. show that more than half of older adult participants in their study avoided unpacking and setting up a new device by themselves [6]. However, older adults enjoy the co-experience of the OoBE with others, such as their family and friends. They viewed it as a chance to engage in social interaction [6]. Thus, an alternative way of improving OoBE is to explore how to support the co-experience of OoBE in the design of product instructions, such as dividing the instructions intelligently so that both older adults and their friends and family can work collaboratively.

5.6 Generalizability Across Different Devices and Older Adults

To test the generalizability of the guidelines, our study design considered a diverse range of devices that participants had varying levels of expertise in using. The results of the validation study on the task success rate, the task completion time, and the user experiences of using *guidelines-based* instructions demonstrate that, with reasonable generalizability, the guidelines improve the instruction quality of product manuals. Because the devices used in this work were physical devices, one interesting line of future work would be to explore whether such guidelines could be used for intangible products, such as a mobile app, as well.

Our study participants were randomly selected from a metropolitan area in North America, and all test trials were counterbalanced. Thus, the guidelines are expected to apply to other older adults who live in similar areas. Because all the testing materials were in English and all modifications were made in English, it remains an open question to what extent these guidelines are applicable to other languages because the way that ideas are conveyed in other languages may vary due to cultural differences.

Our participant pool consisted of healthy older adults with no motor, perceptual, or cognitive impairments that might have prevented them from coming to our lab and completing the studies on their own. Older adults who have motor, perceptual, or cognitive impairments may face a different set of issues when using product instructions. Therefore, further research should examine how the guidelines proposed herein could be adapted for this population.

6 CONCLUSION

Prior studies have shown that product instruction manuals that are well-designed can assist older adults in adopting and using new technologies. Yet developing effective instruction manuals remains a challenging endeavor. Devices often have dozens of functions and parts that need to be described, explained, visualized, and catered to an audience with disparate levels of knowledge. In this work, we derived and validated a set of guidelines for creating senior-friendly product instructions through a user-centered approach by identifying how older adults use product instructions, the problems that they encounter when using the instructions, and the kinds of modifications that they make to improve instructions.

In the first study, we requested each participant to modify the original product instructions for one device and the product instructions that had been modified by another participant for a second device (i.e., by the end of the study, the second device would have undergone two revisions). We presumed that more problem areas in a product manual would come up as a result since participants could build on top of each other's modifications. Results indicate that participants were mostly in agreement on where problem areas occurred in a product's manual because fewer revisions were made to the second device in comparison to the first. Yet participants still made additional alterations to instructions that the previous participant had modified.

The results of the second (validation) study show that guideline users who have no research or work experience with older adults can, using the guidelines, improve instruction manuals to assist older adults in using devices. Moreover, we also demonstrated that manuals adhering to these guidelines enable older adults to carry out tasks with greater success and efficiency than the originals and those modified by interaction design researchers, some of whom have research experience with older adults. The results further showed that there was no significant improvement made to instruction quality when manuals were revised by interaction design researchers. In fact, interaction design researchers reportedly felt uncertainty about what modifications should be made to the original instructions. These insights illustrate the challenge that arise in developing senior-friendly product instructions.

One limitation of the validation study is that the instruction manuals for each device were only modified once using the guidelines and once without. Although instructions adhering to the guidelines always outperformed the other two types of instructions across all devices, there were mixed results when considering individual devices, such as the task completion time. This might imply that the effectiveness of instructions may be influenced by differences inherent in a device or in a writer's skill level. Further studies employing more devices and more guideline users should be conducted to understand the impacts of these variables.

Many guidelines derived from this research align with existing principles for creating good documentation in general. For example, guideline 2 is in line with what is recommended by previous textbooks for technical communication (e.g., [39]). Guideline 10 ("show the post-action state for every step") and 4 ("include all the information that is relevant at each step) support error recognition and recovery, which is advocated by minimalist manual design [31]. As previous studies suggested, our guidelines also advocate simplicity, such as guideline 5 ("remove irrelevant content"). However, the guidelines also emphasize that certain information must be included, such as explanations for technical terms and concepts, the goal for steps that have substeps, and the anticipated post-action state for each step (guidelines 9, 6, and 10).

By identifying and validating a set of guidelines for creating senior-friendly instruction manuals, this work takes a step toward bridging the technology gap faced by older adult learners when they adopt and use new devices. Although guideline users are expected to follow all the guidelines when creating instructions for seniors, there are practical challenges that they must deal with. First, it is difficult for guideline users to retain the guidelines in memory and recognize when a particular aspect of an instruction should be modified to adhere to a certain guideline. One potential direction to investigate is to build a computational tool that analyzes the instructions and suggests relevant guidelines to apply. Second, guideline users were not required to consider the length of their revised instructions but instead to focus solely on resolving potential problems by following the guidelines. However, applying guidelines can increase the overall length of the instructions, which may increase printing cost if instructions are provided on paper. Consequently, guideline users may need to make a trade-off between clarity and the length of instructions. Further research is needed to explore how to maximize the clarity of instructions and minimize their length. Furthermore, although collectively the guidelines are effective in improving the quality of the instructions, their relative importance remains unknown. This can be relevant to guideline users when they are pressed for time or resources and must prioritize. Additionally, guideline users need to make trade-offs because tensions can exist between the guidelines.

The guidelines are expected to have reasonable generalizability when applied to the instructions of physical devices to make them easier to use for healthy older adults living in a North American or similar cultural context. It remains an open question the extent to which these guidelines are applicable to other languages and how they might need to be adapted when used in different cultural contexts or by older adults with special needs.

APPENDIX

The three types of product instructions used in the validation study (Study 2) can be accessed via http://mingmingfan.com/papers/TACCESS/appendix.html.

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