**Auto-pause: The Effect of Moderating the Content Delivery Rate in Online Instructional Videos on Task Completion by Older Adults**

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**Additional Keywords and Phrases:** Insert comma delimited author-supplied keyword list, Keyword number 2, Keyword number 3, Keyword number 4

ACM Reference Format:

First Author’s Name, Initials, and Last Name, Second Author’s Name, Initials, and Last Name, and Third Author’s Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock ’18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1. Introduction

Prior research has shown that older adults can have difficulty learning to use new technology [1][16][27]. As a result, they only use them in the limited ways they have learned or they abandon them entirely. One of the reasons is they lack the support needed for learning the new technology. Although friends and family can help them overcome challenges they face with some of the new technology, they may lack access to people with the right expertise at all times. Second, they lack the self-confidence to use the new technology properly [7][27]. Finally, they often face difficulties using written product instructions [3][14].

Increasingly, older adults have begun to leverage online instructional videos to complete many tasks on their own. Pew Research has shown that 39% of American older adults watch or download online videos. Twenty-three percent (23%) of that content is educational or instructional material [30]. However, many older adults suffer from age-related declines in cognitive abilities--such as working memory capacities, processing speed, spatial abilities, attention focusing, and reasoning--which make it hard for older adults to understand rapid speech and recall details about what they have seen or heard recently (even for those with normal hearing) [6][23], and negatively affect their visual processing rate and reaction time to visual stimuli [8][31]. Because online videos are often created with a general audience in mind, older adults can find it difficult to follow and comprehend existing online video content delivered at a rate that is inappropriate to them. E.g., content on YouTube typically has a speech rate faster than the average speech rate of 150 wpm [32], however, older adults struggle to comprehend and recall content that is delivered faster than 150 wpm [2][4][5][12].

Many prior works have investigated the effect of moderating audio and/or video playback rate on older adults’ ability to recall, recognize and comprehend visual or audio materials. They report that older adults perform better in terms of their ability to recall, recognize and comprehend the material at a uniformly slower rate than they did at a uniformly faster rate, while the playback rate had little effect on younger adults’ performance [2][4][5][8]. Beyond applying a constant slowing factor, Holland and Fletcher showed that inserting extra pauses at sentence endings of audio recordings of stories gives served as an effective alternative for moderating the rate at which the story was delivered [12].

To date, how to help older adults better understand and follow instructional videos remains under-explored. In this paper, we study the effect of moderating the rate at which content in instructional videos is delivered on older adults’ ability to complete related tasks. We compare two methods for moderating the content delivery rate: uniformly slowing the video or automatically pausing the video.

We show that , automatically pausing the instructional videos was found to be more helpful than uniformly slowing down the instructional videos and it was more beneficial to older adults than no moderation at all after older adults have become sufficiently proficient with the method. . Furthermore, older adults were generally satisfied with the automatic pausing of the instructional videos. Overall, our work shows that automatically pausing is a promising method of moderating the content delivery rate of online instructional videos to help older adults complete tasks efficiently.

1. Related work
   1. The benefits of instructional videos to older adults

Prior research has shown that audiovisual presentations of instructional materials can mitigate the negative effects of cognitive declines [10]. They prevent unnecessary visual search between mutually dependent, and physically separated information, such as a diagram and its caption. Additionally, they make use of both the visual and auditory components of working memory, thereby minimizing the chance of overloading either memory. Furthermore, they enable information to be encoded both verbally and nonverbally, which leads to high quality and durable knowledge. Other than the age-related declines in cognitive abilities, the lack of self-efficacy also plays a major role in deterring older adults from independently and completing a technology-related task. When presented with new technology, many older adults may feel anxiety, discomfort, and a lack of confidence in their ability to use the technology (or a lack of self-efficacy) [7][13][21][27]. Results from a 2017 survey by Pew Research Center shows that American adults older than 65 years old were largely “digitally unprepared” (not confident in their digital skills and in their ability to find trustworthy information online) and would seek another person for help when given a new electronics device [30]. Instructional videos could increase older adults’ self-efficacy [11]. This characteristic of video instructions is closely tied to the concept of video modeling and observational learning (also known as vicarious learning), a powerful learning technique. According to the Cognitive Theory of Bandura [33], one can acquire certain knowledge and build up competencies just by observing other people’s outcomes. Learners may gain self-efficacy by successfully imitating the model’s interaction steps.

Empirically, multiple experiments [15][20][25] have shown that older adults perform tasks faster or more accurately when following video-based instructions than other types of instructions. For example, Sierra, Fisk, and Rogers found that the application of audiovisual presentation as opposed to audio-only presentation enhanced performance (better accuracy) and reduced the influence of increased task difficulties (a simple assembly task)[25]. This result confirms a prior theory that videos (with audios) facilitate the spatial and working memory demands of a task, which older adults often have trouble dealing with [19][28]. It is worth noting that this positive effect also applies to the younger adult group in their experiment. Mykityshyn, Fisk, and Rogers found that older adults who were given instructional videos demonstrated faster and more accurate task performance (calibrating a glucose meter) to ones who were given text-based user manuals, while there was no difference for younger adults tested under the two conditions [20]. They argued that training with the user manual required users to visualize, imagine, and infer the task sequence, which was more challenging to older adults, who suffered from declines in cognitive abilities. Video training was helpful because it explicitly demonstrated the task sequence, thereby minimizing the reliance on working memory and reading comprehension. Lin and Hsieh [15] attempted to investigate if the principle of multimedia learning and dual encoding, proposed by Richard Mayer [17][18], could be applied to older adults. In their experiment, older adults were trained to use a digital camera by three types of training media: animated visuals, narration, and static visuals. The result showed that training with animation and narration resulted in significantly faster task completion than static visuals when the task was difficult. They provided a few explanations for the difference between the animated visuals and the static visuals: 1) Older adults respond more actively to dynamically displayed visual stimuli. 2) Animation enables older adults to draw connections between procedures. 3) Animation makes the mechanism of the device clearer and helps older adults develop a mental model. Their experiment highlighted the importance of “animating” graphic instructions, which was not emphasized in Mayer’s theory.

* 1. Adjustments to the playback of multimedia content

***Uniformly slowing down multimedia playback***

Researchers have examined the effect of uniformly slowing down the playback of speech on older adults’ comprehension. Compared to younger adults, older adults’ ability to comprehend information is much more susceptible to the rate at which the information is being delivered due to a slower information processing rate. For example, Calero and Lazzaroni have found that increasing the speech rate (from 140 wpm to 350 wpm) affected older adults’ intelligibility of the speech disproportionately more than the younger adults [4]. Similarly, Cohen have found that older adults performed less well at the faster presentation of 200 wpm compared with 120 wpm when given auditorily presented information[5]. Furthermore, Bergman has shown that distortions in speech, such as reverberation, overlapping, interruption, or a simple increase in words per minute, resulted in a much worse speech intelligibility score for older adults than the younger ones[2]. However, these findings might not apply to older adults with severe working memory impairment. For example, Small et al. have reported that a slow speech rate (uniformly reduced by 15%) is beneficial only for the subject with the most working memory (WM) capacity and detrimental for the subject with the most severe WM impairment among all three older adults with Alzheimer’s disease because the decline in WM would counteract any benefits derived from a reduction in speech rate [26]. Overall, the prior findings suggest that older adults performed better at a slower content delivery rate, as long as they were no suffering from a severe neurological disorder like Alzheimer’s disease.

***Pausing multimedia playback***

Pauses can be inserted in certain places of the speech to bring down the pace of the speech, as another way to slow down the content delivery rate, other than applying a constant factor. Holland and Fletcher argue there is no virtue in simply uniformly slowing the input and what needed to be done is to provide meaningful input for one cycle and then allow time for it to be processed before the next input arrives [12] to avoid “traffic jam” in memory. They show that inserting pauses at natural boundaries of auditorily presented stories enhances older adults’ recognition and recall of the story content. Although Holland and Fletcher propose an alternative to uniformly slowing, they did not compare the effects of uniformly slowing and inserting pauses in their experiment. In our work, we aim to compare both methods.

Pauses can be used to support learning new knowledge and gaining new more information from videos. For example, in an experiment related to acquiring cultural knowledge from a feature film, Ogan et al. developed a pause-predict-ponder system that pauses at the moment of high cultural interests, asks students to predict what will happen next, and asks them to ponder if their prediction is correct after watching the rest of the clip [22]. The results indicate that the addition of such a system guides students in acquiring cultural knowledge and significantly increases students’ ability to reason from an intercultural perspective. They noted that a pause in the video can focus the students’ attention, which can help them understand particular declarative knowledge components. Encelle et al. showed that extending the existing pauses of a video could help transmit more audio descriptions for viewers with visual impairments [9]. Doing so does not cause much discomfort, and viewers quickly adapt to the videos with extended pauses. These works showed that leveraging pauses at carefully selected places boost knowledge transfer and do not disrupt the viewing experience much. In our work, we chose an automatic approach to generate pauses because the manual approach might not generalize well to the vast number of online videos.

Pauses have been shown to be valuable when watching instructional videos. For example, Pongnumkul et al. developed a novel system “Pause-and-Play” that supported learning design software (e.g., Photoshop). When there was a tool change in the video the system checked whether the user’s active tool matched the current video tool with computer vision. If not, the video would automatically stop, wait for the user to catch up, and display an annotation informing the user how to proceed [24]. The system saved the user the manual effort of constantly switching between interacting with the video tutorial and working on the software task, allowing them to focus on the task at hand. No significant difference was found in completion time or error rate, but user feedback showed that the system was helpful and improved the user experience. Our implementation of the automatic pausing condition contrast Pause-and-Play in two ways. First, our approach pauses a video based on speech characteristics because unlike the tool change event in Photoshop, other instructional videos might not have visually identifiable boundaries for each step. Second, we let older adults decide whether to resume the videos because in this way the older adults could have more control over their task progress.

Understanding why users pause the video would provide important insights to content creators. For example, Tuncer and Lindwall identified four different ways in which the simple pause button was used by users when viewing online how-to videos: finding the task object, turning to action, pausing to catch up, and fixing problems [29]. Based on the different types of pausing, they made several suggestions to improve a video’s viewing experience, for example, having the content creators highlight the important frames within the videos or annotate different steps of actions within the video ahead of time. By studying pauses, their findings contributed valuable suggestions on how to make the instructional videos more informative from the perspective of content creators, while our work focused on investigating how moderating the content delivery rate might affect older adults’ ability to complete tasks.

1. Hypotheses

The prior literature suggests that older adults’ ability to comprehend online instructional videos can be affected by whether the content is presented too fast or not. Thus, in this paper, we study the effect of moderating the content delivery rate in instructional videos on older adults’ ability to complete associated tasks. We explore two methods for moderating the content delivery rate: uniformly slowing down the playback of a video and automatically pausing the video. Specifically, we will test the following two hypotheses:

*H1: Moderating the content delivery rate in instructional videos would be beneficial to older adults.*

Prior literature has shown that older adults perform better with audio and visual materials that are played at a slower content delivery rate. Therefore, we hypothesize that older adults would require less time to complete tasks when watching an instructional video with a slower content delivery rate, because she would be able to recognize, understand, and retain more of the content during each playthrough of the video and would need to rewatch the video fewer times.

*H2: Automatically pausing the video would be more helpful to older adults than uniformly slowing down the video.*

Prior literature argue that providing meaningful input in one cycle of the articulatory loop and allowing time for it to be processed helps older adults more than simply slowing down the input. We hypothesize that uniformly slowing down the video might cause distorted audio that can negatively affect the user experience. We believe that, on the other hand, older adults would prefer the automatically pausing of the videos because it can help them focus on one portion of the video at a time.

1. Approaches for moderating an instructional video’s content delivery rate

In this section, we describe how we implemented the two approaches for moderating the instructional video’s content delivery rate: uniformly slowing down the playback and automatically pausing the playback.

* 1. Uniformly slowing down the playback

Prior literature reported that older adults performed better in terms of their ability to recall, recognize and comprehend the material at a uniformly slower rate (120 WPM,140 WPM, and 150 WPM) than they did at a uniformly faster rate (175WPM, 200 WPM, and 350 WPM) [2][4][5][8]. Therefore, we conservatively adjusted the playback speed of all videos to have a speech rate of 120 WPM. We used the following process to uniformly slow down the playback:

1. We counted the number of words in the video’s transcript and divided that by the video length to get the average speech rate of the entire video.
2. We divided 120WPM by the video’s average speech rate to get the slowing factor.
3. If the slowing factor is less than 1.0, then we applied the slowing factor to the video.

This approach does not take into consideration that there are parts of the video which may still be faster than 120 WMP after the slowing factor has been uniformly applied to the whole video.

* 1. Automatically pausing the playback

We also explore automatically pausing the instructional video when the content delivery rate exceeds a particular threshold. We use the following process to identify points in the video when pauses should be inserted:

We segmented the video by locating silences in the audio stream, where the noise level is lower than 30 decibels (same as level as a whisper[34]) for longer than 0.25 second (typical pause duration in a conversation[35]).

We compute the average speech rate of the whole video.

We compute the speech rate for each sound segment separated by silent gaps.

If a sound segment has an average speech rate higher than the average speech rate of the video, we would add the end of the sound segment to the list of potential pause points.

We remove pause points that are too close to each other because pausing too frequently could disrupt the viewing experience. Ideally, we would like to only pause at the end of a sentence and exclude pauses in the middle of a sentence; however, there lacks an automated method for reliably detecting sentence endings in continuous speech. As a result, we use the following steps to filter out pauses that occurred within a certain time duration after the previous pause to avoid pausing more than once per sentence:

We compute the average time duration of a sentence (seconds per sentence) in a video by dividing the average number of words in an English sentence (15 words per sentence) by the average speech rate (words per seconds) for that video.

We filter out pauses that would be less the computed average time duration for a sentence after the previous pause.

1. StudY 1: EVALUATING THE AUTO-PAUSING AND SLOWING METHODS FOR Moderating Content delivery rate
   1. Goal

In Study 1, we tested if moderating the instructional video’s content delivery rate would be help participants complete tasks (H1). This study was designed to also enable us to examine if adding automatic pauses or uniformly slowing down the video was more effective (H2).

* 1. Participants.

We recruited 18 older adults (age 65+, 10 males, and 8 females) to participate in our study, without regard for a particular educational background or a profession, to ensure diversity. Because the study needed to be run remotely due to the Covid 19 pandemic, we recruited participants who own at least one internet-enabled desktop computing device to interact with the study software on their end. For the recruitment, we relied on word-of-mouth, posting flyers on community notice boards, and distributing recruitment ads on social media platforms like Facebook and Kijiji.

* 1. Apparatus

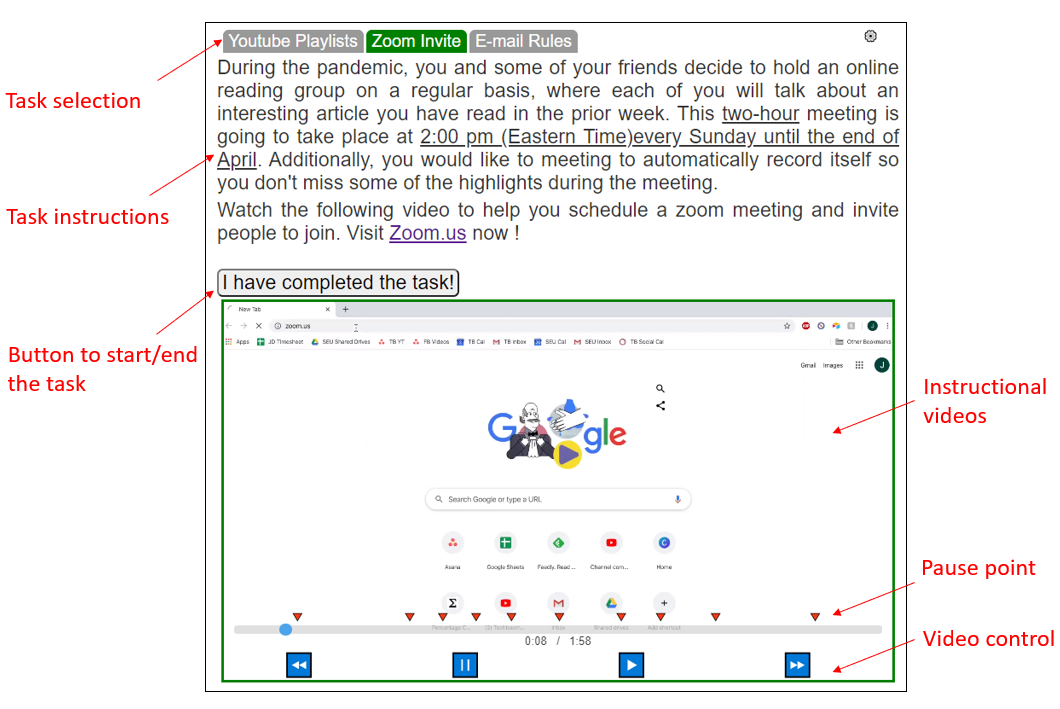


Figure 1. The figure shows a participant playing the instructional video on the Web-based study interface

*Web-based study interface.* We developed a web page hosted on *GitHub Pages* to act as the study interface, shown inFigure 1**.** The study interface allowed participants to load the three tasks they were asked to perform in the study. For each task, the interface showed the scenario that participants were asked to complete and an instructional video which participants were asked to watch and follow. The web page automatically logged data in the background, such as: when the participant begins to watch the video, the task completion time, and the number of pauses.

*Web applications*. In this study, we asked participants to perform web-related tasks. We selected 3 different web applications: Zoom, Outlook, and YouTube. For each application, we created an account for the participants to use so that they would not have to create accounts or use their personal ones.

*Video conferencing software*. We used Zoom to carry out the entire study remotely due to the Covid-19 pandemic. During the study, we asked participants to share the screen to allow us to observe their actions as they perform the tasks. With the participants’ consent, we audiotaped the interview phase of the study, but no video data was recorded to protect their privacy.

* 1. Tasks.

Participants performed three web-related tasks. For each task, we asked participants to watch a related instructional video and to complete the goals presented to them in a scenario.

* + 1. Instructional videos

We used existing instructional videos found on YouTube. The videos showed how to complete specific web tasks:

How to schedule a Zoom meeting

How to create rules to move emails in Outlook

How to create a Music playlist on YouTube

We selected videos that met the following criteria: the video length is around two minutes, rendered at 1080p resolution or more.

* + 1. Scenarios

For each video, we designed a scenario with goals that aligned with what the instructional video taught. However, the goals would require participants to consider what is shown in the video and to apply that knowledge for a different situation. We also wrote the scenarios to include high-level goals (which participants would need to satisfy when performing the task) but did not include steps for how the goals should be completed. Finally, we created the scenarios such that the goals were not presented in the same order that they would be covered in the instructional videos. We showed each scenario to the participants before they were asked to watch the video and complete the task (see Figure 1). This allowed the participants to understand what the goals were before they started the task. The minimum number of steps to complete the scenarios range between 10 and 13: 13 for creating a zoom meeting, 10 for creating an e-mail rule, and 11 for creating a YouTube playlist.

*Scenario 1: Creating a Zoom meeting*. During the pandemic, you and some of your friends decide to hold an online reading group on a regular basis, where each of you will talk about an interesting article you have read in the prior week. This two-hour meeting is going to take place at 2:00 pm (Eastern Time) every Sunday until the end of this month. Additionally, you would like the meeting to automatically record itself for later reference.

*Scenario 2: Creating an Outlook e-mail rule*. Facebook has been sending you emails on a regular basis. You would like to have all emails from Facebook go automatically into its own folder called "Facebook" instead, including both the future and the current emails.

*Scenario 3: Creating a YouTube playlist*. You came across three music videos on YouTube: *Sara Bareilles-Gravity, Taylor Swift-Love Story*, and *Katy Perry-Roar Official*. You really liked them. Now you have decided to find these three music videos and create a playlist with these three music videos. You want to name this playlist, “My Favourite Songs”.

* 1. Conditions

Table 1. The 3x3 Graeco Latin square design used for Study 1

|  |  |  |  |
| --- | --- | --- | --- |
| Participants | Trial 1 | Trial 2 | Trial 3 |
| P1, P4, P7, P10, P13, P16 | Control (Task 1) | Slowing (Task 3) | Auto-Pausing (Task 2) |
| P2, P5, P8, P11, P14 | Slowing (Task 2) | Auto-Pausing (Task 1) | Control (Task 3) |
| P3, P6, P9, P12, P15, P18 | Auto-Pausing (Task 3) | Control (Task 2) | Slowing (Task 1) |

In this study, we compared three content delivery methods: control, slowing and auto-pausing. Under the *control* condition, we present the instructional videos to the participants with the content delivery rate unaltered.Under the *slowing* condition, we present to the participants the instructional videos with video speed slowed down by an slowing factor. Under the *auto-pausing* condition, we presented to participants the instructional videos with automatic pauses inserted within the video. Figure 1 shows an example of the study interface presenting an instructional video using the *auto-pausing* method; the red upside-down triangles indicated where automatic pauses had been inserted into the video. Upon an auto-pause, participants could choose to engage with the task while the video stayed paused or continue with the video. On average, the system inserted 9.6 automatic pauses per video and the pauses happened about every 12.6 seconds.

We used a 3x3 Graeco-Latin Square study design with two blocking factors, shown in Table 1, to counter-balance the conditions and the task scenarios. We repeated this counterbalancing of conditions and task scenarios every three participants. It is worth noting that we treated task type as an independent variable in the analysis because some participants might find a task more difficult than the other.

* 1. Dependent variables

For each task, we measured the completion time and the number of pauses. The completion time was defined as the total time it took for the participants to watch and complete the tasks. The number of pauses was defined as the number of times the participants manually paused the video. We also collected the participants’ preference rating of each condition as additional subjective measures for comparison.

* 1. Procedures

After connecting participants to the video chat, we introduced them to the purpose of the study and informed them of the data that would be collected (e.g., recording of the interview phase).

During the study, we assigned participants to different conditions, as shown in Table 1, and asked them to read and complete the task scenario while watching the instructional videos. They were free to pause, replay, rewind and fast-forward the video as they would in real life. We assigned 20 minutes to each participant to complete a task. We marked a trial as “failed” if the participant had not completed the task within 20 minutes.

At the end of the study, we conducted a short semi-structured interview to learn about any issues that they may have encountered, and any thoughts participants may have about their experience.

* 1. Results

Table 2. Completion time, number of pauses, and satisfaction ratings for each condition

| Content delivery method | Completion Time (secs) | Number of manual pauses | Satisfaction ratings (median) |
| --- | --- | --- | --- |
| Control  Auto-Pausing  Slowing | 619.94 (129.76)  545.83 (220.76)  726.33 (262.66) | 5.83 (1.85)  4.21 (1.01)  6.0 (2.63) | 1  2  2.5 |

Table 3. Summary of comparison results (\* indicates significance)

| Variable | Result |
| --- | --- |
| Completion time | Auto-Pausing < Slowing \* |
| Number of manual pauses  Satisfaction rating | Auto-Pausing < Slowing & Control \*  Control < Auto-Pausing & Slowing \* |

All participants completed the tasks successfully under 20 minutes. We used a General Linear Model (multi-factor ANOVA) with two independent variables (delivery rate and task type) to analyze the task performance data. In this section, we report the results (summarized in Table 2 and Table 3) and discuss findings from the first user study.

*Completion time*. The results showed that there was a significant main effect of the content delivery methods on the task completion time (F (2,45) = 3.58, p<0.05, = 0.11). A post-hoc pairwise comparison using Fisher LSD method revealed that the completion time for the Auto-Pausing condition (M = 545.83, SD = 220.76) and the Slowing condition (M = 726.33, SD = 262.66) were significantly different (p=0.011). There was no significant difference between the two methods for moderating the content delivery rate and the Control condition (M = 619.94, SD = 129.76). No significant effect of the task scenario on the completion time was observed ((F (2,45) = 2.55, p=0.089, = 0.081)). Furthermore, the content delivery method × task scenario interaction effect was not significant ((F (4,45) = 1.50, p=0.217, = 0.095)).

*The number of manual pauses*. The analysis showed that there was a significant main effect of the content delivery method on the number of pauses (F (2,45) = 6.16, p<0.05, = 0.18). A post-hoc pairwise comparison using Fisher LSD method showed that the number of pauses for the Auto-Pausing condition (M = 4.21, SD = 1.01) were significantly less than that for the Control (M = 5.83, SD = 1.85) and the Slowing (M = 6.0, SD = 2.63) conditions. The results suggested that at least some of the automatic pauses in the Auto-Pausing condition overlapped with participants’ intended pause location and participants needed to pause less manually. No significant effect of the task scenario on the number of pauses was observed ((F (2,45) = 0.62, p=0.542, = 0.02)). Additionally, the content delivery method × task scenario interaction effect was not significant ((F (4,45) = 2.55, p=0.052, = 0.12)).

*Subjective feedback.* We analyzed the satisfaction ratings for each content delivery method with a Friedman test. In this study, participants rated each content delivery method on a three-point scale: 1 - Not satisfied, 2 - Neutral, and 3 - Satisfied. A significant difference in ratings was found among the three conditions ( ). A followed up post-hoc pairwise comparison showed that the rating for the Auto-Pausing (median = 2) and the Slowing (median = 2.5) conditions were significantly higher than the Control condition (median = 1). No significant differences were found between the Auto-Pausing and the Slowing condition. The results suggested that participants preferred the two methods for moderating the content delivery rate of the instructional videos. Thirteen participants believed that the two methods for moderating the content delivery rate gave them more “time to react” to the video content. For example, P5 told us that “…slowing down helps me catch up because my reaction is slow.” P9 commented that “…auto-pause gives me time to think and reflect…sort of like a buffer.” However, four participants pointed out some drawbacks of these two methods. Two of them complained that the video speed was too slow in the Slowing condition. For example, P1 noted that “…the speaker speaks in a very drawn-out manner. It makes me fall asleep.” Two did not agree with the locations of the automatic pauses. For example, P2 felt that” …sometimes the video stopped in the wrong place…it’s better for us to choose where to pause.”

* 1. Summary & Discussion

We observed that participants found the Auto-Pausing and Slowing conditions more satisfying than the Control condition, but we did not observe a significant difference in participants’ rating between Auto-Pausing and Slowing. Performance-wise, participants needed to manually pause the video playback less often with the Auto-Pausing condition than with the Slowing and Control conditions. Additionally, participants completed the tasks faster with the Auto-Pausing condition than the Slowing condition. . Thus, the results from Study 1 only partially supported H1 (moderating the content delivery rate in instructional videos would be beneficial to older adults) but did support H2 (automatically pausing the video would be more helpful to older adults than uniformly slowing down the video).

While participants were faster with the Auto-Pausing condition than the Control condition, we did not observe a significant difference between the two conditions (p=0.124). This is perhaps due to the novelty of the Auto-Pausing condition, and participants might be able to complete tasks significantly faster with the Auto-Pausing condition than the Control condition once they are more experienced and proficient with the method. To test if those who are proficient with the Auto-Pausing method do complete tasks significantly faster in the Auto-Pausing condition than the other ones, we performed an additional analysis on the performance data. For each condition, we separated the participants into two groups: those who completed the tasks faster than the average completion time for that condition, and those with a slower than average completion time. By chance, for each condition, 10 participants belonged to the ‘faster than average’ group, and 8 participants belonged to the ‘slower than average’ group. However, but they were a different set of people for each condition. With the data organized in this way, we then performed tests to determine if those who were proficient with a particular method were able to complete tasks significantly faster with that method over other methods; and in a similar vein, we also performed tests to determine if those who were not proficient with a particular method yet were able to complete tasks significantly faster with other methods over that method. The results are summarized in Table 4 and Table 5.

Table 4. Summary of comparisons for participants who were faster than average with each condition (\* indicates significance)

|  | Condition | | |
| --- | --- | --- | --- |
| Variable | Control (n=10; px, px, px, px, px, px, px, px, px, px) | Slowing (n=10; px, px, px, px, px, px, px, px, px, px) | Auto-Pausing (n=10; px, px, px, px, px, px, px, px, px, px) |
| Completion time  Number of pauses | n.s.  Auto-Pausing < Slowing \* | n.s.  n.s. | Auto-Pausing < Slowing & Control \*  Auto-Pausing < Slowing & Control \* |

Table 5. Summary of comparisons for participants who were slower than average with each condition (\* indicates significance)

|  | Condition | | |
| --- | --- | --- | --- |
| Variable | Control (n=8; px, px, px, px, px, px, px, px) | Slowing (n=8; px, px, px, px, px, px, px, px) | Auto-Pausing (n=8; px, px, px, px, px, px, px, px) |
| Completion time  Number of pauses | n.s.  n.s. | Auto-pausing < slowing \*  Auto-pausing < slowing \* | n.s.  n.s. |

For participants who were faster than average with the Auto-Pausing condition, there was a significant effect of the content delivery method on the completion time (F (2,27) =9.05, p <0.05,=0.40). A post hoc analysis showed that the completion time for the Auto-Pausing condition (M = 382.81, SD = 122.48) was significantly less than the Control (M = 601.82, SD = 173.45) and the Slowing condition (M = 742.88, SD = 250.83). Additionally, the effect of the content delivery method on the number of pauses was also significant (F (2,27) =5.33, p = <0.05,=0.28), and the number of pauses for the Auto-Pausing condition (M = 5.40, SD =1.58) was significantly less than that for the Control (M = 5.40, SD =1.58) and the Slowing (M = 5.9, SD = 1.91) conditions. This suggests that for participants who were proficient with the Auto-Pausing condition, they were able to complete the task faster and manually paused the video less with Auto-Pausing than with Slowing and Control. We also examined the effect of the content delivery method on the completion time and the number of pauses for participants who were faster than average with the Slowing condition and then similarly with the Control condition. We observed that for participants who were faster than average with the Control condition, the number of pauses (F (2,27) =4.25, p <0.05,=0.24) for the Auto-Pausing condition (M = 258.79, SD = 75.01) was significantly less than that for the Slowing condition (M = 390.73, SD = 124.22), but the Auto-Pausing and Slowing conditions were not significantly different from the Control condition (M = 342.06, SD = 102.13).

For participants slower than average with the Slowing condition, there was a significant effect of the content delivery method on the completion time (F (2,21) =6.28, p = <0.05,= 0.38) and the number of pauses (F (2,21) =6.71, p <0.01,=0.39). The Auto-Pausing condition resulted in a significant faster completion time (M = 511.81, SD = 304.3) than the Slowing condition (M = 940.25, SD = 248.27), it also resulted in significant a smaller number of pauses (M = 3.75, SD = 0.70) than the Slowing condition (M = 7.25, SD = 2.695).

This additional analysis showed that Auto-pausing instructional videos can potentially help participants who are proficient with the method complete tasks faster than slowing down the video or watching it at a normal speed. In contrast, it also showed that participants who were proficient with the Control condition or the Slowing condition were not significantly faster with those methods. These results suggested that indeed perhaps participants’ task completion time might be significantly faster with the Auto-Pausing condition than with the Control condition, once they have gained enough experience with the method and are proficient with it.

1. Study 2: EVALUATING EXPERT PERFORMANCE WITH THE AUTO-PAUSING METHOD
   1. Goal

In Study 2, we investigate specifically whether there is a significant difference between participants’ completion time with the Auto-Pausing condition and the Control condition once participants are familiar with the Auto-Pausing method after using it multiple times.

* 1. Participants

For recruitment, we followed the same procedures as in Study 1. For Study 2, we recruited 12 new participants for the study (age 65+, 8 males, and 4 females).

* 1. Apparatus

In Study 2, we employed the same Web-based study interface and video conferencing software as we did in Study 1. We asked participants to complete tasks with 6 different web applications: Outlook, YouTube, Google Drive, Gmail, Google Maps, and Google Calendar. Similar to Study 1, for each application, we created an account for the participants to use so that they would not have to create accounts or use their personal ones.

* 1. Tasks

As with Study 1, we asked participants to first read a scenario describing the goals which participants were asked to complete. Then, we asked participants to watch a related instructional video.

* + 1. Instructional videos

Again, we used existing instructional videos found on YouTube, with a length around two minutes each, and rendered at 1080p resolution or more. The videos used in Study 2 were:

How to create rules to move emails in Outlook

How to create a Music playlist on YouTube

How To Create and Share Google Drive Folders

How to Set Up a Gmail Auto Reply Message

How to Measure Distance on Google Maps

Setting Google Calendar Reminders Tutorial

* + 1. Scenarios

Similar to Study 1, we asked participants to complete containing goals presented to them in a set of scenarios that aligned with what the instructional videos taught. We reused 2 scenarios (*Creating an Outlook e-mail rule* and *Creating a YouTube playlist*) from Study 1 and created 4 new scenarios. The minimum number of steps for completing the scenarios range between 8 and 10: 10 for creating an email rule, 11 for creating a YouTube playlist, 9 for creating a Google drive folder, 8 for setting a Gmail auto-reply message, 9 for measuring distance on Google Maps, and 10 for setting a Google Calendar reminder. We excluded the Setting a Zoom meeting scenario from Study 1 because it required about 4 more steps than the new scenarios created for Study 2.

*Scenario 1: Creating an Outlook e-mail rule*. Facebook has been sending you emails on a regular basis. You would like to have all emails from Facebook go automatically into its own folder called "Facebook" instead, including both the future and the current emails.

*Scenario 2: Creating a YouTube playlist*. You came across three music videos on YouTube: *Sara Bareilles-Gravity, Taylor Swift-Love Story*, and *Katy Perry-Roar Official*. You really liked them. Now you have decided to find these three music videos and create a playlist with these three music videos. You want to name this playlist, “My Favourite Songs”.

*Scenario 3: Creating a folder*. You are planning to create a folder named "Trip photos" on Google Drive to store all the pictures you have taken during your last trip with your friend Celine. After creating the folder, you want to share it with Celine, so that she can view and edit the folder, as well as to upload her pictures there later.

*Scenario 4: Setting an auto-reply.* You are going on a trip from July 1st to July 15th and you have asked Alice to take over your work during your vacation. The next thing you want to do is to have Gmail automatically reply to any incoming e-mails. You’d like for people to easily see in the subject for your auto-reply that you’re on vacation and will be back on July 15. And if people read the message itself, you’d like to tell them to e-mail Alice at alice@hotmail.com if they need immediate assistance.

*Scenario 5: Measuring distance.* You plan to do some construction work in your backyard. To do this, you need to figure out the perimeter of your backyard for your home (*6107 Long St, Los Angeles, CA 90043*) so that you can estimate the cost.

*Scenario 6: Setting a reminder*. You have scheduled a regular medical checkup with your doctor at 11:00 am from June 28th to July 31st every week on Monday and Wednesday. In case you forget about it, you’d like to have your calendar to remind you about them 2 hours before each appointment.

* 1. Conditions

Table 6. Condition assignment used in Study 2. AP stands for “Automatic Pausing,” CTL stands for “Control,” and S stands for “Scenario.”

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 |
| P1 | S1×AP | S2×CTL | S3×AP | S4×CTL | S5×AP | S6×CTL |
| P2 | S1×CTL | S5×AP | S6×CTL | S4×AP | S2×CTL | S3×AP |
| P3 | S2×AP | S3×CTL | S1×AP | S5×CTL | S6×AP | S4×CTL |
| P4 | S2×CTL | S6×AP | S4×CTL | S5×AP | S3×CTL | S1×AP |
| P5 | S3×AP | S1×CTL | S2×AP | S6×CTL | S4×AP | S5×CTL |
| P6 | S3×CTL | S4×AP | S5×CTL | S6×AP | S1×CTL | S2×AP |
| P7 | S4×AP | S5×CTL | S6×AP | S1×CTL | S2×AP | S3×CTL |
| P8 | S4×CTL | S2×AP | S3×CTL | S1×AP | S5×CTL | S6×AP |
| P9 | S5×AP | S6×CTL | S4×AP | S2×CTL | S3×AP | S1×CTL |
| P10 | S5×CTL | S3×AP | S1×CTL | S2×AP | S6×CTL | S4×AP |
| P11 | S6×AP | S4×CTL | S5×AP | S3×CTL | S1×AP | S2×CTL |
| P12 | S6×CTL | S1×AP | S2×CTL | S3×AP | S4×CTL | S5×AP |

Similar to Study 1, the Control condition left the video speed unaltered, while the Auto-Pausing condition inserted automatic pauses in the instructional videos by following the two criteria discussed in Section 4.2. On average, the system inserted 10.7 automatic pauses per video and the automatic pauses happened about every 11.2 seconds.

In the Study 2, we asked each participant to complete six different scenarios under two conditions: three scenarios under the Auto-Pausing condition and another three under the Control condition. We counterbalanced the order of the six tasks, as shown in Table 6 ordering of the tasks (where AP stands for “Automatic Pausing,” CTL stands for “Control,” and S stands for “Scenario”).

* 1. Dependent variables

Beyond completion time, the number of manual pauses, we include three additional variables in the second study: the number of switches from the instructional video, the number of replays, and the replay time.

*The number of switches from the instructional video*. We defined the number of switches from the instructional video as the number of times a participant left the study interface showing the instructional video and worked on the application web page. We designed our experiment in such a way that each participant could not view the study interface and the application web page at the same time (e.g., by splitting the screen) so they would have to switch between them. The rationale for this decision was that some of our participants had small computer screens (e.g., 12 inch laptops), and splitting these screens in half would make the instructions too small to be legible. In logging the number of switches from the instructional video, we would be able to test whether the automatic pausing condition would result in more or fewer switches if a participant followed our suggestion to switch to the task at each auto-generated pause.

*The number of replays*. We define the number of replays as the number of times a participant rewatched a portion of the video. In logging the number of replays, we would be able to test whether automatic pausing has an effect on how often the participants needed to rewatch any portion of an instructional video vs. when they viewed an instructional video without any method moderating the content delivery rate.

*The replay time*. We define the replay time as how long a participant spends rewatching parts of the video that she has already viewed. In logging the number of replays, we would be able to test whether automatic pausing has an effect on how much of an instructional video the participants needed to rewatch vs. when they viewed an instructional video without any method moderating the content delivery rate.

We again collected the participants’ satisfaction rating of each condition as a subjective measure. In Study 2, we used a 7 point scale, ranging from 1 (very dissatisfied) to 7 (very satisfied).

* 1. Procedures

We followed the same procedure used in Study 1.

* 1. Results

Table 7. Summary of comparison results for Study 2 (\* indicates significance)

| Variable | Control | Auto-Pausing | Comparison |
| --- | --- | --- | --- |
| Completion time  # of manual pauses  # of switches from instructional video  # of replays  Replay time  Satisfaction (median) | 579.05 (184.44)  10.28 (2.77)  8.69 (2.64)  7.14 (3.47)  151.33 (45.73)  6 | 495.52 (171.28)  2.33 (1.37)  8.53 (3.12)  4.02 (1.80)  120.58 (36.50)  6.5 | Auto-Pausing < Control \*  Auto-Pausing < Control \*  n.s.  Auto-Pausing < Control \*  Auto-Pausing < Control \*  Auto-Pausing < Control \* |

We use a General Linear Model (multi-factor ANOVA) with two independent variables (content delivery method and task scenario) to analyze the task performance data. We summarize on our findings (results in Table 7).

*Completion time*. The results indicated that there was a significant effect of the content delivery method on the completion time (F (1,60) =4.46, p = <0.05,= 0.057). More specifically, the completion time for the Auto-Pausing condition (M=495.52, SD = 171.28) was significantly less than that for the Control condition (M=579.05, SD = 184.44). The task scenario had no effect on the completion time (F (5,60) =0.94, p = 0.46,= 0.061). The content delivery method × task scenario interaction effect was not significant (F (5,0) =1.74, p = 0.14,= 0.1).

*The number of manual pauses*. The results showed that the effect of the content delivery method on the number of pauses was significant (F (1,60) =77.58, p <0.01,= 0.54). The number of pauses for the Auto-Pausing condition (M=2.33, SD = 1.37) was significantly smaller than the number of pauses for the Control condition (M=10.28, SD = 2.77). The task scenario had no effect on the number of pauses (F (5,60) =1.14, p = 0.349,= 0.0038). Moreover, the content delivery method × task scenario interaction effect was not significant (F (5,60) =1.70, p =0.149,= 0.056). Similar to Study 1, the auto-pauses reduced the number of manual pauses the participants needed to make.

*Number of switches from the instructional videos*. No significant effect of the content delivery method (F (1,60) =0.06, p =0.81,= 0.00085) and the task scenario (F (5,60) =0.54, p =0.74,= 0.041) on the number of switches was found.

*The number of replays*. A significant effect of the content delivery method on the number of replays was found (F (1,60) =26.42, p = <0.01,= 0.29), but the effect of the task scenario was not observed (F (5,60) =0.61, p = 0.70,= 0.032). The number of replays in the Auto-Pausing condition (M = 4.02, SD = 1.80) was significantly less than in the Control condition (M=7.14. SD = 3.47). Additionally, the content delivery method × task scenario interaction effect was not significant (F (5,60) =0.61, p = 0.69,= 0.035). The results indicated the auto-pause method reduced the number of times that participants needed to rewatch any part of the video.

*Replay time*. The effect of the content delivery method on the replay time was significant (F (1,60) =10.12, p <0.01,= 0.124), while the effect of the task scenario was not significant (F (5,60) = 1.82, p=0.123,= 0.11). The Auto-Pausing condition (M = 120.58, SD = 36.50) took significantly less replay time than the control condition (M=151.33, SD=45.73). Also, the content delivery method × task interaction was not significant (F (5,60) =0.89, p = 0.49,= 0.055). The results showed that the auto-pause method reduces the time the participants spent rewatching the video, which potentially contributed to the overall reduction in the completion time.

*Satisfaction rating*. A Friedman test was performed on the ratings, and a significant effect was found between the two content delivery methods ( ). The result suggested participants were more satisfied with the auto-pausing condition (Median = 6.5) than the control condition (Median=6).

*Participant’s feedback*. The participants’ feedbacks towards the automatic pausing of the instructional videos were generally positive. Similar to Study 1, the participants’ feedback echoed the auto-pause system role as a memory buffer. For example, P2 said “… (with auto-pause) I had more time to digest all the information and do the task.” Also, participants in Study 2 viewed the auto-pause system as a “highlighter” that marked many potentially important points in the video. For example, P5 commented “…to me the pauses are like the video’s highlights so I know where to look in the video…I could quickly find a particular step just by looking at the video’s timeline.” Additionally, the auto-pausing condition made watching the instructional videos less stressful. For example, P9 reported, “…Trying to keep up with the video at its regular speed stresses me out…auto-pause gives me some breathing room.” However, the auto-pausing conditions were not without problems. For example, participants had divided opinions on the suitable number of auto-generated pauses in the videos. P4 desired fewer pauses. She said, “…There are way too many pauses…I can memorize many of the steps so most of the pauses are unnecessary to me…I’d say five pauses are more than enough for a five-minute video.” In contrast to P4, P11 requested more pauses. He commented, “…I’d suggest adding more pauses… one for every single action like a mouse click or pressing a key.” Furthermore, the effort associated with manually unpausing the video after each pause might be a bit of an issue to the participants. For example, P8 commented, “…I wish the video could just auto-play after two seconds to save me some effort.”

Table 9. Summary of comparison results after the nth trial with each condition (\* indicates significance)

| Variable | Trial 1 | Trial 2 | Trial 3 |
| --- | --- | --- | --- |
| Completion time  Number of pauses  Number of switches  Number of replays  Replay time | n.s.  pause<control \*  n.s.  pause<control \*  n.s. | n.s.  pause<control\*  n.s.  pause<control \*  pause<control \* | pause<control\*  pause<control\*  n.s.  pause<control \*  pause<control \* |

*Expert performance*. The overall results indicated that it took the participants less time to complete the tasks in the Auto-Pausing condition than in the Control condition. To determine when participants became more proficient with the Auto-Pausing method than the Control condition, we compared the performance data based on their trial numbers for each condition. The results of a one-way ANOVA showed that the task completion time with Auto-Pausing only became significantly different from Control in the third trial (F (1,22) = 5.46, p <0.05,= 0.19), shown in Table 9. They spent less time with the Auto-Pausing condition (M = 452.50, SD = 118.41) than with the Control condition (M = 580.17, SD = 147.64). This meant that participants became experts with the auto-pausing method by the third time they used it.

1. Discussion and Limitation
   1. Improving the auto-pause method for viewing instructional videos

The results from the two studies indicated that automatically pausing the instructional videos as a method for moderating the content delivery rate was beneficial in helping older adults completing tasks and that it was more helpful than simply slowing down the instructional videos by a uniform factor. However, our current implementation of the auto-pause method had several limitations and could be improved in several different ways.

*Leveraging visual information*. Although the auto-pause method was effective with the videos used in the study, our approach for identifying where to insert automatic pauses might not generalize to other videos well. For example, some speakers may read through their scripts with almost no natural pauses or may speak with a lot of unintended pauses, which will make it difficult for the algorithm to accurately identify gaps of silence within the speech. Furthermore, the inclusion of background music in some videos will exacerbated the technical challenge. Thus, a natural way to improve upon our auto-pause method is to analyze other aspects of the instructional video beyond the audio stream, such as the visual components. For example, if the number of steps (and therefore changes on the screen) happening within a window of time exceeds a certain threshold, pauses could be inserted to allow the viewer to focus on a smaller number of steps at a time.

*Notifying viewers of an incoming pause.* Although the small triangles on the video seek bar were supposed to indicate a pause point to the older adults, the auto-generated pauses still surprised some of the participants during the video playback. For example, a participant in Study 2 complained about the auto-pause system stopping the video too suddenly (P5: “…sometimes when I was watching the video, all of a sudden, the video stopped, and it caught me off guard…”). One of the participants suggested adding some kind of notification ahead of an incoming pause (P7:” …It would be nice to have some kind of notification. Otherwise, I’d think there’s something wrong with my internet connection…”). To eliminate the element of surprise and help y prepare users for an upcoming pause, visual notifications should be included shortly before automatic pauses will occur.

*Supporting a personalized experience*. Although the older adults in our experiments were generally positive about the experience of the auto-pause method, some had divided opinions of the most appropriate number of pauses within a video (some requested more, and some requested for less) and some complained about the videos stopping in the wrong places sometimes. The feedback indicated that older adults desired a more personalized experience with the auto-pause method. Future implementations of the auto-pause method should allow the user to specify the amount of automatic pauses that they perceive will help them. Alternatively, machine learning techniques can be applied so that the auto-pause method could actively learn the older adults’ preference for pausing a video by analyzing their current browsing behaviors with instructional videos.

*Encouraging adoption of the auto-pause method.* Study 2 shows that automatically pausing instructional videos was helpful to older adults. Our analysis shows that Auto-Pausing resulted in faster task completion time over the Control condition after participants use it a third time. Thus, participants need multiple exposures to auto-pausing before becoming proficient with the method. However, if the method were to be deployed, it is possible that users might abandon the method after only trying it once or twice. Therefore, further research and design effort is needed to explore how to encourage users to continue to use the method enough times for them to become proficient with the method and adopt it.

* 1. Improving the slowing method for viewing instructional videos

Although the results from the experiments suggested that uniformly slowing down the instructional videos was not as helpful to the older adults in terms of reducing the task completion time, it did not mean that slowing down the instructional videos should be completely abandoned as a method for moderating the content delivery rate. The results merely indicated that applying a constant slowing factor over the whole video (like the slowing option on YouTube) might not be an ideal way of implementing the slowing condition. It is possible that there were parts of the video that might not have been slowed enough and other parts that were slowed too much. For future research, it could be worth revisiting whether just slowing down the video would be effective by exploring better ways of doing it. For example, one could consider applying a slowing factor to a locally fast-paced segment instead of applying the factor over the whole video.

Additionally, we believe there are also specific situations where slowing could be useful. For example, if a certain step (like the clicking of a button) was carried out too quickly, a “slow-motion” effect could be applied to the associated frames to give the older adults longer exposure to that step and a clearer view of the step.

* 1. Limitation

Despite some promising results, the experiment design had several limitations. First, we only tested the effect of moderating the content delivery rate on web-technology-related tasks for older adults. It is unknown how well this effect might apply to other types of tasks. Second, our recruitment process focused on older adults who possess a computer and therefore the results might be biased towards users who have a particular level of familiarity and knowledge with technology.

1. Conclusion

In this paper, we examined the effect of moderating the content delivery rate in instructional videos on older adults’ task performance. We explored automatically pausing the instructional videos and uniformly slowing down the instructional videos. We conducted two user studies to investigate: 1) Is moderating the content delivery rate beneficial to older adults? And 2) Is automatically pausing the video more effective than slowing it down? The results indicated that participants prefer auto-pausing over watching the video at a normal rate and that automatically pausing the instructional videos helped participants complete tasks faster than when they watch the video at a normal or uniformly slowed-down rate. When using the auto-pausing method for the first time, participants paused the video manually fewer times with the method than with normal playback and replayed the video less as well. When using the method for the second time, participants also needed to replay less of the content than when they watched it at normal speed. By their third time using the method, participants completed tasks faster with the Auto-Pausing condition than with the Control condition. Overall, auto-pausing can help older adultsfollow and use instructional videos to complete their tasks, and users can become proficient with the method after using it three times.

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