**Auto-pause: The Effect of Moderating the Information 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

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1. Introduction

Prior research has shown that older adults can have difficulty learning to use new technology [1][17][28]. 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. First, friends and family can help them overcome challenges they face with the new technology, but they may lack access to people who are available and with the right expertise at all times. Second, they lack the self-confidence to use the new technology properly [7][28]. Finally, they often face difficulties using written product instructions [3][15].

Increasingly, older adults have begun to leverage online instructional videos to gain new knowledge and solve problems. 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 [31].

Instructional videos explain to viewers how to complete many tasks on their own. 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][24], and negatively affect their visual processing rate and reaction time to visual stimuli [8][32]. Because online videos are often created with a general audience in mind, older adults could 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 [33], however, older adults might 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 information delivery rate on older adults’ ability to recall, recognize and comprehend visual or audio materials. They reported that older adults performed 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 delivery rate had little effect on younger adults’ performance [2][4][5][8]. Additionally, other than applying a constant slowing factor there is more than one way to moderate the information delivery rate. Holland and Fletcher showed that inserting extra pauses at sentence endings of audio recordings of stories gives served as an effective alternative to uniformly slowing down the audio [12].

However, little literature has examined how to help older adults better understand and follow instructional videos. In this paper, we study the effect of moderating the information delivery rate of instructional videos on older adults’ ability to complete associated tasks. We compare two methods for moderating the information delivery rate: uniformly slowing the video or automatically pausing the video.

Through a repeated measure within-subject study with 18 older-adult participants, followed by a within-subject study with 12 participants, we showed that automatically pausing the instructional videos as a way of slowing down the information delivery rate was more beneficial to older adults than no intervention at all after older adults have become sufficiently proficient with the intervention methods. Additionally, automatically pausing the instructional videos was found to be more helpful than uniformly slowing down the instructional videos. Furthermore, older adults were generally satisfied with automatically pausing the instructional videos. Towards the end, we build upon our findings and propose several research directions.

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

prior research has shown that audiovisual presentations of instructional materials could mitigate the negative effects of cognitive declines [10]. They prevented unnecessary visual search between mutually dependent, buy physically separated information, such as a diagram and its caption. Additionally, they made use of both the visual and auditory components of working memory, thereby minimizing the chance of overloading either memory. Furthermore, they enabled information to be encoded both verbally and nonverbally, which led 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 would feel anxiety, discomfort, and a lack of confidence in their ability to use the technology (or a lack of self-efficacy) [7][14][22][28]. Results from a 2017 survey by Pew Research Center showed 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 [31]. 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 [34], one could acquire certain knowledge and build up competencies just by observing other people’s outcomesLearners could gain self-efficacy by successfully imitating the model’s interaction steps.

Empirically, multiple experiments [16][21][26] have shown that older adults performed 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 decreased the influence of increased task difficulties (a simple assembly task)[26]. 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 [20][29]. It is worth noting that this positive effect also applied 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. 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 [21]. Lin and Hissed [16] attempted to investigate if the principle of multimedia learning and dual encoding, proposed by Richard Mayer [18][19], 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. Additionally, the significance is mainly derived from the difference between animation and static visuals. They provided a few explanations for this result: 1) Older adults respond more actively to dynamically displayed visuals stimuli. 2) Animation enables older adults to draw connections between procedures. 3) Animation makes the mechanism of the device more clear and helps older adults develop a mental model. Their experiment highlighted the importance of “animating” the 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 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 found that older adults performed less well at the faster presentation of 200 wpm compared with 120 wpm when given auditorially presented information[5]. Furthermore, Bergmanshowed 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. reported that a slow speech rate (uniformly reduced by 15%) was 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 [27]. Overall the prior findings suggested that older adults performed better at a slower information delivery rate, as long as they were no suffering from a severe neurological disorder like Alzheimer’s disease.

***Pause in multimedia***

Pauses could be inserted in certain places of the speech to bring down the pace of the speech, as another way to slow down the information delivery rate, other than applying a constant factor. Holland and Fletcher argued there was 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 further showed that inserting pauses at natural boundaries of auditorially presented stories could enhance older adults’ recognition and recall of the story content. Although Holland and Fletcher proposed an alternative to uniformly slowing, they did not compare the effects of uniformly slowing and inserting pauses in their experiment. In our work, we sought to evaluate 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 [23]. The results indicate that the addition of such a system seems to guide students in acquiring cultural knowledge and significantly increases students’ ability to reason from an intercultural perspective. They emphasized that a pause in the video can focus the students’ attention, which can help them understand particular declarative knowledge components. Benoît Encelle et al. showed that extending the existing pauses of a video could help transmit more audio descriptions for viewers with visual impairments [9]. Most importantly, doing so did not cause much discomfort, and viewers quickly adapted to the videos with extended pauses. These works showed that leveraging pauses at carefully selected places could boost knowledge transfer and not disrupt the viewing experience too much. In our work, we chose an automatic approach to generate pauses because we believed the manual approach might not generalize well to 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 change 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 [25]. The system saved the user the trouble 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 pausing condition contrasted Pause-and-Play in two ways. First, we paused a video based on the 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 automatically resuming would require the video player to collect the older adults’ interaction data with the target software, which might present a privacy issue if the older adults were handling private and sensitive materials when watching online videos.

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 [30]. Based on the different types of pausing, they made several suggestions to improve a video’s viewing experience, for example, having 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, while our work focused on investiging how moderating the information delivery rate might affect older adults’ ability to complete tasks.

1. Hypotheses

The prior literature suggested that older adults’ ability to comprehend online instructional videos could be affected by whether the information presented in it is delivered too fast for them. Thus, in this paper, we study the effect of moderating the information delivery rate of instructional videos on older adults’ ability to complete associated tasks. We compare two methods for moderating the information delivery rate: uniformly slowing down the playback of a video or automatically pausing the video. Specifically, we will test the following two hypotheses:

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

Prior literature has shown that older adults performed better with audio and visual materials at a slower information delivery rate. Therefore, we hypothesized that a slower information delivery rate instructional videos, which are composed of visual and auditory elements, could offer benefits to the older adults. For example, older adults might spend less time completing the tasks while watching a video with a slower information delivery rate, because he or she would recognize, understand, and retain more information during each playthrough of the video and spend less time rewatching the video.

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

Prior literature argued that for speech processing providing meaningful input for one cycle of articulatory loop and allowing time for it to be processed would be more helpful to older adults than simply slowing down the input. Automatically pausing the videos could serve a similar role. Additionally, the inserted pauses in the video can potentially help focus older adults’ attention on the video. Furthermore, uniformly slowing down the video might cause distortion in audio and distorted audio might negatively affect user experience.

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

In this section, we implemented the two approaches explored in this paper for moderating the instructional video’s information 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, to be safe, we conservatively adjusted the speed of all videos to the slowest speech rate of 120 WPM. More specifically, 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 video speed of the entire video. 2. We divided 120WPM by the average video speed to get the slowing factor. 3. We applied the slowing factor to video. We were aware that this approach would accelerate the videos that were slowere than 120 WMP, but in the process of finding the instructional vdieos on YouTube we did not run into any videos that were slower than 120WPM so this approach had a consistent slowing effect.

* 1. Automatically pausing the playback

[**Insert a figure in here**]

We also explored automatically pausing the instructional video when the information delivery rate exceeds a particular threshold. We used the following process to identify points in the video when pauses should be inserted: First, we identify a set of potential pause points by locating silences in the audio stream, where the noise level is lower than 30 decibels (same as level as a whisper[35]) for longer than 0.25 second (typical pause duration in a conversation[36]). Second, we computed the speech rate for each sound segment separated by gaps of silence. If that sound segment had a speech rate that was higher than the average speech rate of the entire video, we would insert a pause at the end of the sound segment. Finally, we filtered out pauses which were too close to each other as pausing too frequently could disrupt the viewing experience. Ideally, we would like to only include pauses at the sentence endings and exclude pauses occurring in the middle of a sentence, but there lacks an automated method for reliably detecting sentence endings in a continuous speech. As a result, we opted to filter out pauses that occurred within a certain time duration after the previous pause to avoid more than one pause per sentence. We used to following process to apply the filter:

1. We computed the average video speed for each video. For example, 155 WPM (2.6 words per second) was the video speed for the first instructional video of study 1.
2. Assuming the average word count for a sentence in the video transcript was 15 words, the average word count in English[37][38][39], we divided 15 by the average video speed to estimate the average time duration for a sentence in the video. For example, 15/2.6 = 5.8 seconds for the video mentioned above.
3. We filtered out pauses that occurred X seconds after the previous pause. X = 5.8 for the video mentioned above.
4. StudY 1: the effect of slowing down the information delivery rate ininstructional videos on older adults’ task performance
   1. Goal

In Study 1, We tested if moderating the instructional video’s information delivery rate would be help participants complete tasks (H1). This study also enabled us to examine if adding automatic pauses was more effective 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 needs to be run remotely due to the Covid 19 pandemic, we required our participants to 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

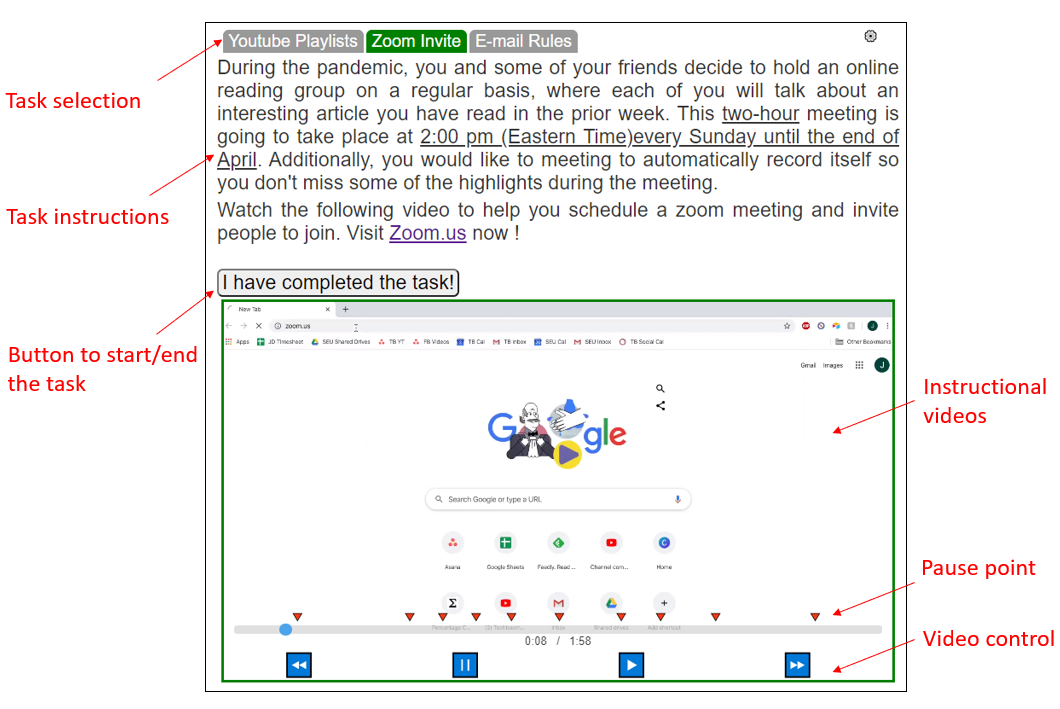


Figure 1. The figure shows a participant playing the instructional video on the Web-based study interface

*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 see 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 collects relevant data for each task in the background: 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 applications 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.

In this study, we asked participants to perform three web tasks. For each task, 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 which would show them how to complete the task.

* + 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 email in Outlook

How to create a Music playlist on youtube

We selected videos rendered at 1080p resolution or more. After editing out portions that were irrelevant to the task (e.g, promotions), each video was around 2 minutes long.

* + 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 and determine how to apply that information 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. The minimum number of steps to complete our scenarios ranges from 10-13: 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 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 for these three music videos. You are to name this playlist, “My Favourite Songs”.

* 1. Conditions

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

|  |  |  |  |
| --- | --- | --- | --- |
| 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 experiment, we compared three information delivery methods: control, slowing, and pausing. Under the *control* condition, we present the instructional videos to the participants with the information delivery rate unaltered.Under the *slowing* condition, we present to the participants the instructional videos with video speed slowed down by an adjustment factor. Under the *auto-*pausing condition, we presented to participants the instructional videos with automatic pauses inserted within the video. Figure 1 showed an example of the study interface presenting an instructional video using the pausing method; the red upside-down triangles indicated where automatic pauses that 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 on with the video. On average, there were 9.6 pauses per video and a video automatically paused about every 12.6 seconds in this study.

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 for 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 experiment and informed them of the data we were planning to gather (e.g., recording of the interview phase).

During the experiment, participants were assigned to different conditions, as shown in Table 1, and asked to perform the corresponding task as instructed by the task instructions 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 would mark the trial as “failed” had participants gone over 20 minutes.

Towards 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

| Information delivery method | Completion Time (secs) | Number of 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 pauses  Satisfaction rating | Auto-Pausing < Slowing & Control \*  Control < Auto-Pausing & Slowing \* |

All participants completed the tasks successfully. 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 information 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). Although there was no significant difference between two methods for moderating the information delivery rate and the Control condition (M = 619.94, SD = 129.76), the difference between the Auto-Pausing and Slowing conditions are trending towards near-marginal significance (p=0.124). 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 information delivery method × task scenario interaction effect was not significant ((F (4,45) = 1.50, p=0.217, = 0.095)).

*The number of pauses*. The analysis showed that there was a significant main effect of the information 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 information 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 uinformation delivery method with a Friedman test. In this study, participants rated each information 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 information delivery rate of the instructional videos.13 participants believed that the two methods for moderating the information 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, 4 participants pointed out some drawbacks of these two methods. 2 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…” 2 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

The results from study 1 only partially supported H1 (moderating the information delivery rate in instructional videos will be beneficial to older adults) but did support H2 (automatically pausing the video will be more helpful to older adults than uniformly slowing down the video). In particular, 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. However, we observed only a marginally significant difference between participants’ completion time with the Auto-Pausing condition and the Control condition (report p-value), and no significant difference between the Slowing and Control conditions.

We hypothesized that there was only a near-marginally significant difference between participants’ completion time with the Auto-Pausing condition and the Control condition (p=0.124) due to the novelty effect of the Auto-Pausing condition. We conjecture that perhaps participants’ task completion time could be significantly faster with the Auto-Pausing condition than with the Control condition, once they have more experience with the method and become more efficient with using it. To test this hypothesis, we separated the participants into two groups: those with a faster than average completion time for each condition, and those with a slower than average completion time. For example, if a participant spent less time than the average completion time in the Control condition, this participant would be assigned to the “faster than average” group, otherwise she would be assigned to the “slower than average” group in the Control condition. We repeated the process for the Slowing and the Pausing condition. By chance, for each condition, 10 participants were assigned to the ‘faster than average’ group, and 8 participants were assigned to the ‘slower than average’ group, but they were a different set of people for each condition. 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 (10) | Slowing (10) | Auto-Pausing (10) |
| 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 (8) | Slowing (8) | Auto-Pausing (8) |
| 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 information delivery method on the completion time (F (2,27) =9.05, p <0.05,=0.40). More specifically, a post hoc analysis showed that the completion time (in minutes) for the Auto-Pausing condition (M = 6.38, SD = 2.04) was significantly less than the Control (M = 10.03, SD = 2.89) and the Slowing condition (M = 12.35, SD = 4.18). Additionally, the effect of the information 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 efficient 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 information 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 = 4.30, SD = 1.25) was significantly less than that for the Slowing condition (M = 6.50, SD = 2.07), but two conditions were not significantly different from the Control condition (M = 5.70, SD = 1.70).

For participants slower than average with the Slowing condition, there was a significant effect of the information 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 = 8.53, SD = 5.07) than the Slowing condition (M = 15.67, SD = 3.97), 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 analysis showed that Auto-pausing instructional videos potentially can help participants who are efficient with the method complete tasks faster than slowing down the video or watching it a normal speed. In contrast, it also showed that participants who were faster than average with the Control condition were not significantly faster than when they completed tasks with the Slowing or Auto-Pausing conditions; similarly participants who were faster than average with the Slowing condition were not significantly faster than when they completed tasks with the Control or Auto-Pausing conditions. These results suggested that indeed perhaps participants’ task completion time could be significantly faster with the Auto-Pausing condition than with the Control condition, once they had more experience with the method and became more efficient with using it.

1. Study 2: Looking into the effect of automatically pausing instructional videos on task performance for older adults with proper knowledge
   1. Goal

In study 2, we investigate specifically whether there would be a signi significant difference between participants’ completion time with the Auto-Pausing condition and the Control condition (report p-value) as participants become more familiar with the Auto-Pausing method after multiple exposure to it.

* 1. Participants

We invited all 18 participants from the first study to participate in this follow-up study. From the original participant pool, 12 older adults (age 65+, 8 males, and 4 females) enrolled in the second study.

* 1. Apparatus

In study 2, we employed the same Web-based study interface and video conferencing software as we did in Study 1. However, we now asked participants to perform 4 new web-related tasks. We selected 4 different applications web applications: 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 which would show them how to complete the task.

* + 1. Instructional videos

Again, 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 email messages to different folders in Outlook Office 365; and

How to create a playlist on Youtube

How to…

* + 1. Task scenarios

Similar to study 1, four similar tasks were created to test the participants’ ability to complete tasks. The minimum number of steps for completing each task is 9 for creating a folder, 8 for setting an auto-reply, 9 for measuring distance, and 10 for setting a reminder.

*Scenario 1: 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 are going to share it with her. Additionally, you need to make sure Celine can view and edit the folder so she can upload her pictures later.

*Scenario 2: 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 to do is to use the vacation responder feature on Gmail to automatically reply to any incoming e-mails. The subject for your auto-reply is going to be "On vacation. Back on 7-15" and the message itself is going to be "Please e-mail Alice at alice@hotmail.com".

*Scenario 3: Measuring distance.* You plan to do some construction work in your backyard. To do this, you need to find out the perimeter of your backyard so your estimate the cost. You are going to search and find your building at [some address] on Google Maps and use the distance measurement feature of Google Maps to gauge the perimeter of the backyard.

*Scenario 4: 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 plan to set a reminder on Google Calendar to remind your 2 hours before the appointment.

* 1. Conditions

Table 6. Counterbalancing of the tasks for study 2

|  |  |  |  |
| --- | --- | --- | --- |
| **Auto-Pausing** | | **Control** | |
| Task 1 | Task 2 | Task 3 | Task 4 |
| Task 1 | Task 3 | Task 2 | Task 4 |
| Task 1 | Task 4 | Task 2 | Task 3 |
| Task 2 | Task 1 | Task 3 | Task 4 |
| Task 2 | Task 3 | Task 1 | Task 4 |
| Task 2 | Task 4 | Task 1 | Task 3 |
| Task 3 | Task 1 | Task 2 | Task 4 |
| Task 3 | Task 2 | Task 1 | Task 4 |
| Task 3 | Task 4 | Task 1 | Task 2 |
| Task 4 | Task 1 | Task 2 | Task 3 |
| Task 4 | Task 2 | Task 1 | Task 3 |
| Task 4 | Task 3 | Task 1 | Task 2 |

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 Section 4.2. In the end, on average 11 pauses were generated for each video and the video would automatically pause every 12.7 seconds.

In the second study, we asked each participant to complete four different tasks under two conditions: two tasks under the Auto-Pausing condition and another two under the Control condition. We counterbalanced the order of the four tasks, as shown in Table 6. We did not counterbalance the order of the conditions because at this point the participants should already be very familiar with both pausing and control conditions so there would be little learning effects between the two conditions. In the end, each of the 12 participants got a unique ordering of the tasks.

* 1. Dependent variables

Other than completion time, the number of manual pauses, we include three additional variables in the second study: the number of switches, the number of replays, and the replay time.

*The number of switches*. We defined the number of switches as the number of times a participant left the instruction page that hosted the instructional videos and started working on the application web page. We designed our experiment in such a way that each participant could not view the instruction page the application 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 inches), and splitting these screens in half might make the instructions too small to be illegible. We were interested in finding out whether the pausing condition would result in more 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.

*The replay time*. We define the replay time as how long a participant spends rewatching parts of the video she has already viewed.

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  Number of pauses  Number of switches  Number of replays  Replay time  Satisfaction (median) | 7.91 (1.97)  8.88 (2.76)  12.58 (2.65)  6.13 (2.13)  1.98 (0.48)  7 | 6.37 (2.84)  0.79 (0.88)  12.21 (3.70)  2.29 (1.12)  1.61 (0.25)  4 | Auto-Pausing < Control \*  Auto-Pausing < Control \*  n.s.  Auto-Pausing < Control \*  Auto-Pausing < Control \*  n.s. |

Once again, we used a General Linear Model (multi-factor ANOVA) with two independent variables (information delivery method and task scenario) to analyze the task performance data. We reported on our findings (results in Table 7).

*Completion time*. The results indicated that there was a significant effect of the information delivery method on the completion time (F (1,40) =5.02, p = <0.05,= 0.09). More specifically, the completion time for the Auto-Pausing condition (M=6.37, SD = 2.84) was significantly less than that for the Control condition (M=7.91, SD = 1.97). The task scenario had no effect on the completion time (F (3,40) =0.96, p = 0.42,= 0.053). The information delivery method × task scenario interaction effect was not significant (F (3,40) =0.159, p = 1.82,= 0.10).

*The number of pauses*. The results showed that the effect of the information delivery method on the number of pauses was significant (F (1,40) =185.58, p =<0.01,= 0.80). The number of pauses for the Auto-Pausing condition was significantly smaller than the number of pauses for the Control condition. The task scenario had no effect on the number of pauses (F (3,40) =0.75, p = 0.529,= 0.0097). Moreover, the information delivery method × task scenario interaction effect was not significant (F (3,40) =1.11, p =0.356,= 0.014). Similar to Study 1, the auto-pauses reduced the number of manual pauses the participants would have to make.

*Number of switches*. No significant effect of the information deliverymethod (F (1,40) =0.19, p =0.68,= 0.003) and the task scenario (F (3,40) =2.29, p =0.092,= 0.13) on the number of switches was found.

*The number of replays*. A significant effect of the information delivery method on the number of replays was found (F (1,40) =54.68, p = <0.01,= 0.57), but the effect of the task scenario was not observed (F (3,40) =0.18, p = 0.900,= 0.0056). The number of replays in the Auto-Pausing condition (M = 2.29, SD = 1,12) was significantly less than in the Control condition (M=6.13. SD = 2.13). Additionally, the information delivery method × task scenario interaction effect was not significant (F (3,40) =0.57, p = 0.64,= 0.009). The results indicated the auto-pause system reduced the number of times that participants needed to rewatch any part of the video.

*Replay time*. The effect of the information delivery method on the replay time was significant (F (1,40) = 9.96, p <0.01,= 0.19), while the effect of the task scenario was not significant (F (3,40) = 0.18, p = 0.909,= 0.0056). The Auto-Pausing condition (M = 1.61, SD = 0.25) took significantly less replay time than the control condition (M=1.98, SD=0.48). Also, the delivery rate x task interaction was not significant (F (3,40) =0.29, p = 0.83,= 0.033). 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, but no significant effect was found between the two delivery methods ( ). It was likely the result was caused by smaller population size in the second study. Furthermore, in the second study, 3 out of 12 participants gavex= a lower rating to the pausing condition than the control condition. These 3 participants were amongst the 4 participants in the first study who gave a lower rating to the methods for moderating the information delivery rate than the Control condition.

*Participant’s feedback*. The participants’ feedbacks towards automatically pausing the instructional videos were generally positive. Participants appreciated the auto-pause’s role as a “content divider.” For example, P3 noted that “…a video without auto-pauses is just like an article without paragraphs. An article broken in paragraphs will be easy for people to read and understand.” Similarly, P5 appreciated that “auto-pause divides the video into many parts so I only need to watch and remember a small part at a time.”). Participants had divided opinions on the proper number of auto-pauses in the video. For example, P7 wanted more frequent pauses and explained that ”the gap between every two pauses was way too long… I would prefer (auto) pausing more frequently. For example, one pause every 5 seconds.” On the other hand, some felt there were too many auto-pauses. P10 felt that ” manual pause is better because I can pause at any time if I don’t understand the video…I wish there could be fewer auto-pauses in the video.” One reason why participants preferred fewer auto-pauses is perhaps the effort involved with manually unpausing the video. P5 suggested “it would be great if the video could automatically resume after a few seconds instead of having me do it.” **[trust issue? Trust auto pausing? Why they trust and why they not trust the auto pause system?**]

*Participant sample*. Of the 12 participants in Study 2, 7 were amongst those who were already faster than average in Study 1 and 5 were amongst those who were slower than average in Study 1. To examine whether a potential subject selection bias affected Study 2 results, the participants were divided into two groups: A (those who were amongst the faster than average participants from Study 1) and B (those who were amongst the slower than average participans from Study 1). We treated the group affiliation (A or B) as an independent variable and performed a one-way ANOVA on the collected data. The results showed the effect of the group affiliation was not significant on the completion time (F (1,47) = 2.44, p = 0.125,= 0.050), the number of pauses (F (1,47) = 0.03, p = 0.866,= 0.0006), the number of switches (F (1,47) = 0.54, p = 0.465,= 0.012), the number of replays (F (1,47) = 2.32, p = 0.135,= 0.048) or the replay time (F (1,47) = 0.02, p = 0.894,= 0.0003).

Table 9. Summary of comparison results for group 1 and group 2 (\* indicates significance)

| Variable | Trial 1 | Trial 2 |
| --- | --- | --- |
| Completion time  Number of pauses  Number of switches  Number of replays  Replay time | 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 second trial (F (1,23) = 5.70, p <0.05,= 0.21). They spent less time with the Auto-Pausing condition (M = 5.68, SD = 2.98) than with the Control condition (M = 5.68, SD = 2.98). Taking Study 1 into consideration, this meant that participants became experts with the method by the third time they used it (once in Study 1 and twice in Study 2).

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 information 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 generating pauses might not apply to other videos. We observed that it was hard to identify where to insert pauses by only examining the audio stream. For example, some speakers read through their scripts with almost no natural pauses, which made it difficult for the algorithm to identify gaps of silence within the speech. Additionally, sentences might not always be 15 words long. Thus, always removing pause that occurred within 15 words after the previous one could potentially mean that playback was stopped in the middle of a sentence. Furthermore, the inclusion of background music in some videos only exacerbated the technical challenge. To address this limitation of solely relying on the audio components, future researchers should consider analyzing visual components of the instructional videos for generating pauses. For example, if the number of steps within a window of time exceeds a certain threshold, pauses could be inserted to allow the viewer to focus on a smaller number steps at a time. Additional research is needed to determine the proper number of steps that should be shown to older adults within a particular time window.

*Leveraging interaction data*. Alternative to the visual-based or audio-based approaches, which rely heavily on the image and audio quality of the video to work, future researchers could consider leveraging the power of the human crowd for generating pauses at the most appropriate locations. On average a how-to video on YouTube can get over 8000 views in its lifetime[40] and a large amount of interaction data (i.e., pause, rewind, resume and fast forward) generated by the viewers could potentially be leveraged to generate pauses. For example, if most viewers replayed a certain segment of the video several times, it might indicate to the system that a pause should be placed at the end of the segment. An advantage of this crowd-based approach is that the system should become very robust to the issues of low image/audio quality and different instructional styles (for example, speaking very fast with no pauses). Additionally, the data will be very cheap to obtain in terms of both financial cost and time, compared to other types of crowd-based video tools, for example, a crowd-based video annotation system[13]. However, questions still remain with such a system. First, the crowd might come from diverse age groups like high school students, working professionals, or older adults, and each age group might exhibit different video browsing patterns than other age groups, as designers how could we resolve the conflict in the data generated by the crowd? Should a simple majority suffice? Second, what is the difference between crowd-generated pauses and auto-generated pauses? If the two pause patterns were significantly different, then which of the two would be more helpful to the older adults? The results could shed insights on how to design a better intervention method in the future. For example, if the crowd-generated pauses are proved more helpful than auto-generated pauses, then a future intervention method could start with auto-generated pauses initially and then replace them with crowd-generated pauses after collecting sufficient crowd data.

*Notifying viewers of an incoming pause.* The two intervention methods (pausing and slowing) explored in this paper do not have to be mutually exclusive of each other. There could be ways of integrating both methods altogether in the same system to improve the overall user experience. For example, an older adult 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…”). To eliminate the element of surprise, we could potentially implement a gradual slowing effect a couple of seconds prior to an inserted pause and older adults could be more mentally prepared for an incoming pause. Notify participants of an incoming pause.

*Understanding different pauses*. Our method takes advantage of the natural pause in speech. We lack We lack a comprehensive understanding of the pauses made by the speakers. We need to perform a video analysis. Analyzing over 100 how to videos? Analyze how they pause and why they pause? Identify the different kinds of pauses made by the speaker in the video. Identify the how the speakers pace their videos with pauses. For example, video types and pauses. Video analysis of problems? What kind of problems? Needs, challenges and practices. Pause to catch up breath. For example, we observed. Natural Pauses to allow participants to catch up. Pauses to allow speaker to catch up to their thoughts like “umm” “Ah”. Natural pauses in their speech to allow time to demo the action and optimize for them accordingly.

*Allowing for 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 pausing in the wrong places sometimes. The feedback indicated that older adults desired a more personalized experience with the auto-pause method. Therefore, for future work we could have the system generated three different pausing schemes (from more to fewer pauses), corresponding to novice, intermediate, and expert level, and have older adults select the level that fits the result of their self-assessment. Alternatively, the auto-pause method could “learn” from the older adults’ video browsing patterns. For example, if an older adult skipped through an auto-generated pause several times, it might indicate that he or she finds this pause unnecessary and the system could remove it from the list of pauses. By doing so, the auto system could ensure each subsequent re-watching of the video will be smoother than the previous one. Learning from a user watching and using many videos and then applying that to new videos that a user watches in the future might make the most sense.Learn where users would pause. Use that data to generate future pauses.

* 1. Improving the slowing method for viewing instructional videos [Need to expand].

The results from the exerpiments suggested that uniformly slowing down the instructional videos was just as helpful to the older adults as the control condtion. It indicated that applying a constant slowing factor over the while video (like the slowing option on YouTube) might not be an ideal way of moderating the information deliver rate, in terms of reducing the task completion time. For example, there could be parts of 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 effective by exploring better ways of doing it, for example, applying a slowing factor to a locally fast-paced segment instead of applying the factor over the whole video. However, there are situations where slowing could be appropriate. Similar to the auto pause, if the number of steps exceed a certain threshold,we could apply a time warp effet to “slow down” the actions in that video segment. Time warp speech when it’s too fast, time warp steps when it’s too fast.

* 1. Encourage adoption on the video platform [Need to expand]

We were able to show that automatically pausing instructional videos as a method for moderating the information delivery rate was helpful to older adults in the second study. Our analysis showed that Auto-Pausing resulted in faster task completion time over the Control condition **after participants have used it a third time**. Thus, participants needed multiple exposure to the method before they achieved expert performance. However, if the method were to be deployed on an online video platform, further research and design work is needed to explore how to motivate users to continue to use the method enough times for them to become proficient with the method and not abandon it.

* 1. Limitation

Despite some promising results, the experiment design had several limitations. First, we only tested the effect of moderating the information 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 might bias the results towards older adults who possess a computer so the results might not apply to older adults viewing instructional videos with a smartphone or a tablet[42], which requires a completely different interaction modality.

1. Conclusion

In this paper, we examined the effect of moderating the information 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 information delivery rate beneficial to older adults? And 2. Is automatically pausing the video more effective than slowing it down? The results indicated that automatically pausing the instructional videos helps older adults complete tasks faster than when they watch the video at a normal or slowed down rate. Future research could look into ways of improving the auto-pause system for older adults, and develop a strategy that allows older adults to quickly adopt a novel intervention method on online video platforms.

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