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Kurt Kraiger

*Department of Management, University of Memphis*

Thomas M. Cavanagh

*Barowsky School of Business, Dominican University of California, thomas.cavanagh@dominican.edu*

Collin M. G. Willis

*Department of Psychology, Colorado State University*

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Why Do Cognitive Prompts Hurt Learning in Older Adults?

Kurt Kraiger<sup>1</sup>

Thomas M. Cavanagh<sup>2</sup>

Colin M.G. Willis<sup>3</sup>

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<sup>1</sup> Department of Management, University of Memphis; email: Kurt.Kraiger@memphis.edu

<sup>2</sup> Barowsky School of Business, Dominican University of California

<sup>3</sup> Department of Psychology, Colorado State University

## Abstract

The purposes of the present investigation were to attempt to replicate the negative effects for learning prompts in older adults reported by Cavanagh, Kraiger, and Peters (2016), determine if the impact of learning prompts depends on type of prompt, and investigate the two possible explanations of the negative impact of prompts – increased cognitive load and higher negative affect. Learning prompts refer to short text inserted into training content to encourage trainees to rehearse new content or engage in meta-cognitive activity. While learning prompts generally lead to greater learning in training, Cavanagh et al. reported a negative impact for prompts on measures of recall and transfer. Using similar training materials and learning outcome measures, we conducted two studies using both elaboration and meta-cognitive prompts in online training. In the first, older adults (N=194 between 55 and 70 years) and younger adults (N=218) were randomly assigned to either a meta-cognitive, elaboration, or no prompts (control) condition. Older adults learned less and reported greater mental effort than younger learners, but these effects were not moderated by prompt condition. In the second N=57 older adults were randomly assigned to the same three prompts conditions. Older adults learned less *with* prompts than without, but there was no difference between conditions in mental effort or negative affect. In sum, negative effects for learning prompts in older adults in one of two studies and we found no evidence to suggest that these effects were due to either increased cognitive load or greater negative affect.

### Why Do Learning Prompts Hurt Learning in Older Adults?

Changing demographics are generating increasing interest in training older workers. According to the Bureau of Labor Statistics, the percentage of the civilian workforce age 55 or over grew from 11.9% in 1996 to 22.4% in 2016, and is expected to rise to 24.8% in 2026 (U.S. Department of Labor, 2017). Due to factors such as organizational downsizing or increasing use of technology, older workers may find they need to learn new roles and acquire new skills to stay in the workplace (Beier, 2008). However, compared to younger adults, older adults on average take longer to complete training and learn less (Kubeck, Delp, Haslett, & McDaniel, 1996). The challenges of training older adults may be exacerbated by the ongoing rise in the use of various forms of technology distributed instruction (TDI; Association for Talent Development, 2017). Research consistently shows that older adults perform worse in computer-based training environments than do younger adults (e.g., Carter & Beier, 2010; Wolfson & Kraiger, 2011).

There have been multiple sets of recommendations for designing training to be more effective for older learners (e.g., Kraiger, 2017; Truxillo, Cadiz, & Hammer, 2015; Wolfson, Cavanagh, & Kraiger, 2014; Young & Beier, 2017). While Truxillo et al. and Young and Beier recommended training interventions that take into account potential cognitive and affective challenges of older learners, Wolfson et al. instead called for research on training interventions that produce ordinal interactions with age – smaller (or non-negative) effects for younger learners and larger positive effects for older learners. The authors suggested that these are “reasonable recommendations in most situations where there is a chronologically diverse mix of learners” (pg. 27). One such intervention is the insertion of learning prompts into the instructional material. Learning prompts refer to short text inserted periodically into TDI to encourage trainees to rehearse new content (elaboration prompts) or engage in meta-cognitive

activity (meta-cognitive prompts). Learning prompts have been shown to facilitate learning in both experimental (Berthold, Eysink, & Renkl, 2009; Berthold, Nückles, & Renkl, 2007) and workplace contexts (Sitzmann, Bell, Kraiger, & Kanar, 2009). Prompting facilitative self-regulatory activity may be particularly useful for older adults since research shows they are less likely to self-initiate cognitive strategies, but can successfully use them if encouraged to do so (Hertzog & Dunlosky, 2009; Touron & Hertzog, 2004).

Cavanagh, Kraiger, and Peters (2016) tested the effectiveness of learning prompts in online training with a sample of 131 adults aged 55 to 70. The researchers examined whether prompts previously used successfully by Berthold et al. (2007) reversed the effects of age-related stereotype threat. Stereotype threat occurs when performance may be comprised if individuals feel themselves at risk of conforming to stereotypes about their identify group. That is, they induced stereotype threat expecting it to inhibit learning in older adults, and hypothesized that reductions in learning would be less when cognitive prompts were used. Instead, Cavanagh et al. found that the use of prompts negatively affected learning and accentuated the detrimental impact of stereotype threat. The authors speculated on potential reasons for the surprising negative effects of cognitive prompts and encouraged caution before implementing learning prompts into training for older adults.

The purpose of the present study is to replicate and extend the study by Cavanagh et al. (2016) to better understand why learning prompts undermine learning in older adults. The question explored here is why did an empirically-supported training intervention fail with older adults? Our research makes three contributions to the literature. First, we attempt to replicate the negative effects of learning prompts on learning *in older adults*. The positive effects of prompts are robust in the literature, to our knowledge all prior studies were done with younger adults. It is

important to understand whether one negative effect is an outlier or can be attributed to learner age. Second, we test two explanations for why learning prompts may negatively affect older learners – increasing cognitive load or increasing negative affect. Third, we investigate whether elaboration v. meta-cognitive prompts had differential effects on learning on older adults.

### **Background and Hypotheses**

**Cognitive Prompts Are Usually Effective.** At a general level, learning prompts are queries inserted into the training program that do not provide any new content but encourage meta-cognitive activity or elaboration and active processing of previously presented content (Cavanagh et al., 2016). Examples of learning prompts are: “Which main points have I already understood well?” (meta-cognitive prompt) and “Can you think of any links between the contents of the video and your knowledge from school and everyday experience?” (elaboration prompt). Interestingly, research on cognitive prompts begins with the assumption that they *should work* and worries less about the underlying theoretical mechanisms. Cognitive prompts may work by promoting focused processing (Renkl & Atkinson, 2007) – enabling learners to learners should focus on core concepts and principles. Helping learners direct their time on central content is also central to cognitive load theory (CLT; Merriënboer & Sweller, 2005). Additionally, learning prompts should encourage self-regulation (Sitzmann et al., 2009) and assist in linking newly presented information to prior knowledge (Berthold et al., 2007). Self-regulation occurs when individuals modify their thought, affect, and behavior to guide their goal-directed activities in learning contexts.

The use of learning prompts is generally effective. For example, Berthold et al. (2007) found that both elaboration prompts and meta-cognitive prompts following a video presentation improved learning relative to a no-prompt control condition. Berthold et al. (2009) showed that

prompting self-explanations of training content (see Roy & Chi, 2005) improved both procedural knowledge and conceptual understanding compared to no prompts. Bannert, Hildebrand, and Mengelkamp (2009) found that learners who provided meta-cognitive prompts during instruction performed better on a post-training transfer tasks than participants not provided prompts. Bixby and Land (2010) embedded both procedural or elaboration prompts and meta-cognitive prompts into a college course on information science and technology. Relative to a no-prompts section, students receiving prompts performed better on measures of problem representation, developing solutions, making justifications, and monitoring and evaluation. In one of the more impressive demonstrations, Sitzmann et al. (2009) embedded meta-cognitive prompts into 10 hours of training on a course management system for college instructors and showed a significant impact over time (compared to no prompts) on measures of both declarative and procedural knowledge.

**When Cognitive Prompts Do Not Work in Older Adults.** Cavanagh et al. (2016) found that for a sample of older learners, the inclusion of a mix of elaboration and meta-cognitive prompts resulted in lower scores on measures of recall and transfer<sup>4</sup> than in a no-prompts condition. They also reported a significant interaction with stereotype threat - surprisingly, the deleterious effects of prompts were worse when negative age stereotypes were evoked than when they were not. The researchers speculated that the injection of the prompts may have added to the cognitive load of the older adults. Cognitive load theory proposes that because humans have a limited working memory capacity, instruction should be designed so that the brain is not overtaxed during learning (Merriënboer & Sweller, 2005). Cognitive load is imposed by both

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<sup>4</sup> Transfer in Cavanagh et al. (2016) and in this study is operationalized as it was in Mayer, Heiser, and Lonn (2001) and is often done in studies in cognitive or educational psychology – performance on a task immediately after instruction, on materials that are different but similar in form to the instructional content. As Kraiger (2002) noted, this operationalization of transfer is very different than how the construct is used in the workplace learning literature, where transfer refers to successful application and generalization of learning content to a novel workplace context after training concludes.

intrinsic factors such content difficulty and learning-irrelevant extraneous factors in the instructional interface. When training older adults (who have lesser working memory than younger adults; Bopp & Verhaeghen, 2005), care should be taken to reduce extraneous load and optimize germane load – the active processing of instructional content. In theory, learning prompts should facilitate learning by optimizing germane load through focusing attention on relevant content. However, it is possible that the prompts in Cavanagh et al. may have had the opposite effect, encouraging older learners to switch their attention from the primary learning task to thinking about (responding to) the prompts.

To support this proposition, Cavanagh et al. (2016) cited a study by Berthold, Röder, Knörzer, Kessler, and Renkl (2011) on university students in their twenties. Those researchers found that the introduction of prompts increased levels of cognitive load reported by participants; learners expended more effort answering the prompts at the cost of cognitive resources devoted to the primary learning task. However, the impact of learning prompts on the cognitive load – or mental effort – of older adults has not been tested.

A related argument is that responding to the prompts appeared as a secondary task to learners, serving to distract them and/or consume cognitive resources. Van Gerven, Paas, Merriënboer, and Schmidt (2002) recommended that, since aging adults have diminished cognitive abilities, instructional design should be structured so that “optimal use is made of remaining cognitive resources” (pg. 87). Specifically, because older adults have slower cognitive processing speeds (Salthouse, 1996), they are at a disadvantage in two ways. First, they are less likely to have completed processing of information presented immediately before the prompt. Second, they are less capable of simultaneously processing mutually-referencing information elements. In other words, while prompts may be handled as concurrent processing tasks in



younger adults, they become sequential tasks in older adults. Older adults are generally less able to task-switch (turn attention from one task to another) than younger adults (Zwarun & Hall, 2014), suggesting that attending to the prompts interfered with older adults' ability to return to learning the primary content. With respect to prompts as a distraction, Connelly, Hasher, and Zacks (1991) compared college-aged adults to adults in their 60s on their ability to ignore distractions to the central message in text and found that the older participants were more easily distracted than younger adults. Similarly, Darowski, Helder, Zacks, Hasher, and Hambrick (2008) argued that attention regulation abilities necessary to ignore distractions and focus on primary learning tasks becomes less efficient with age, such that distractions – here, learning prompts – reduces or prevents the processing of central information.

In summary, we believe that the learning prompts in Cavanagh et al. (2016) may have hurt the learning of older adults because they either directly created cognitive load or served as a distraction and prevented the processing of relevant information. Note that both the cognitive load and distraction explanations make similar propositions – greater mental effort by older adults and diminished learning of training content. Because younger learners generally have greater working memory capacity and faster processing speeds than older learners, the same prompts would not be expected to interfere with cognitive processing and should facilitate learning (as shown in most previous learning prompts studies). Because Cavanagh et al. did not compare the effectiveness of learning prompts in older *and younger* adults, we include both in an exploration of when learning prompts do not work. Based on our reasoning above, we predict:

*Hypothesis 1: Older adults will perform worse than younger adults on an online learning task.*

*Hypothesis 2: There will be an interaction of prompts condition and learner age on learning such that the use of learning prompts will result in lower scores on measures of learning than in a control condition for older adults but not for younger adults.*

*Hypothesis 3: There will be an interaction of prompts condition and learner age on reported mental effort such that the use of learning prompts will result in greater mental effort than in a control condition for older adults but not for younger adults.*

**Type of Prompts May Matter.** We argue above that learning prompts may inhibit the learning performance of older adults by drawing away cognitive resources available to the primary task either by increasing cognitive load or by distracting attention. By either mechanism, the type of prompt may matter - that is, some prompts may reduce cognitive resources more than others. Berthold and colleagues (Berthold et al., 2007, Berthold et al., 2009; Berthold et al., 2011) distinguished between several types of prompts. Berthold et al. (2007) differentiated meta-cognitive prompts from what they refer to as “cognitive prompts.” The former trigger monitoring and self-diagnosing cognitive activity, asking learners to reflect on progress towards a learning goal (Koriat, 2007) Examples include: Which main points have I already understood well? Which main points, in my opinion, were not as sufficiently clarified by the video? By cognitive prompts, Berthold et al. (2007) meant both “organizational prompts” (helping the learner organize learning material, e.g., “What are the main points in your opinion”) and “elaboration prompts” (encouraging deeper processing of the content, e.g., “Which examples can you think of that illustrate, confirm, or conflict with the learning contents?”). In contrast to meta-cognitive prompts, which are self-focused, these latter prompts focus attention on the training content. Meta-cognitive prompts should improve learning by encouraging self-regulation, while organizational or elaboration prompts trigger more active engagement in the training content.

Berthold et al. (2011) introduced the concept of “conceptually-oriented explanation prompts” which build on the elaboration prompts in Berthold et al. (2007). These are prompts that encourage learners to generate explanations for the training content (e.g., “Does the thin-cap rule differentiate between interests that are paid to their shareholders by a co-entrepreneurship and interests that are paid to a bank by a corporation?” pg. 71). These are prompts that do not provide additional learning content, but are intended to “induce... focused processing and further processing after reading” (pg. 71). Berthold et al. (2011) however warned that doing so could reduce cognitive resources necessary for “sustaining germane activities,” particularly for complex material. In other words, certain types of prompts may be a “double-edged sword,” focusing attention, but draining cognitive resources. In a study involving university tax students (presumably with above average levels of cognitive ability), Berthold et al. (2011) found that compared to a no-prompt condition, the use of self-explanation prompts resulted in higher scores on a measure of declarative knowledge, but also higher levels of reported mental effort.

There has been little research so far exploring differential effects of prompt types on both learning and mental effort. And, no research has examined these effects in older learners. Therefore, rather than forming a priori hypotheses, we explored whether potential deleterious effects of prompts in older learners depends on prompt type. In this study, we explicitly compare meta-cognitive prompts to elaboration prompts.

Returning to our two proposed explanatory mechanisms for the negative effects of learning prompts in older adults - increased cognitive load and distraction - we consider here whether differential effects for prompt type might inform this question. Elaboration prompts are intended to engage the learner in the content, but they may require greater mental effort. Accordingly, if the data suggest that older adults perform worse on a learning task with

elaboration prompts than meta-cognitive prompts *and* report greater mental effort under those conditions, this would support the cognitive load explanation. Meta-cognitive prompts are intended to initiate the executive functions of monitoring and self-diagnoses, and we argue above that older adults may struggle switching attention between this and the primary task. Thus, a pattern of results in which older adults perform worse and report more mental effort with meta-cognitive prompts than elaboration prompts would provide support for the distraction explanation. Because we can argue the direction of effects in either way for both types of prompts, we propose the following research questions:

*Research Question 1: If there is a negative impact for learning prompts on learning in older adults, is it greater for elaboration prompts or for meta-cognitive prompts?*

*Research Question 2: Is reported mental effort for older adults greater for elaboration prompts or for meta-cognitive prompts?*

*Research Question 3: Given the answers to the first two questions, do the results inform the questions as to whether the negative effects of learning prompts are due to increased cognitive load or distracting learners?*

## **Study 1**

### **Participants and Design**

412 individuals participated in the study. Older adults (N=194) ranged in age from 55 to 70 years ( $M = 62.0$ ,  $SD = 5.0$ ); this was the same age range as in Cavanagh et al. (2016). Younger adults (N=218) ranged in age from 17 to 49 ( $M = 19.0$ ,  $SD = 2.9$ ). All participants reported either having a high school degree (33.3%) or some college training (66.7%).

Among older learners, 23.8% reported either some high school training or a high school degree, 25.3% reported some college training, 36.1% reported a college degree, and 14.9%

reported a post-graduate or professional degree. 77.3% reported their ethnicity as White and 10.8% as Asian-American. 56.2% were female and 42.3% were male. Among younger learners, 70.6% reported their ethnicity as White, 11.9% as multi-racial, 6.9% as African-American, and 6% as Hispanic. 82.6% were female, and 17.0% were male. There were no significant differences among conditions in education ( $\chi^2 = 7.565, p = .477$ ) or gender ( $\chi^2 = 4.108, p = .128$ ). However, there was a significant difference in ethnicity ( $\chi^2 = 34.845, p = .002$ ), with Asian-Americans more represented in both prompt conditions (10.7% combined across age groups) than in the control condition (4.9%)

The study employed a 2 x 3 factorial design, with both older and younger learners assigned to either a meta-cognitive, elaboration, or no prompts (control) condition. Participants in the meta-cognitive condition saw the following three prompts inserted within the training video: “Which main points have I already understood well?” “Which main points haven’t I understood yet?” “Which questions, in my opinion, were not sufficiently clarified by the lecture video?” Participants in the elaboration condition saw these three prompts: “Which aspects of the learning materials do you find interesting, useful, convincing, and which not?” “Which examples can you think of that illustrate, confirm, or conflict with the learning content?” and “Can you create any links between the contents of the presentation and your knowledge from everyday experience?” Participants in the control condition saw three instances of the following prompt: “Please wait for the presentation to continue. The presentation will auto-advance in 30 seconds.” There were no other differences between treatment conditions.

### **Recruitment**

Older adults are notoriously difficult to recruit for psychological research (McHenry, 2015). We chose two methods to recruit older participants. First, we recruited 28 participants by

offering undergraduate business majors extra credit for recruiting older friends and family to participate in the study. Undergraduate research pools are common in psychological research and make up the majority of participants in psychological studies in toto (Wintre, Northe, & Sugar, 2001). We contend that older adults recruited by undergraduates should be similar to the undergraduates themselves in terms of demographic characteristics (with the exception of age). The remaining participants were recruited through a Qualtrics study panel (<https://www.qualtrics.com/online-sample/>), which are effective for recruiting hard to reach participants (Ibarra, Agas, Lee, Pan, & Bутtenheim, 2018). Samples collected through Qualtrics have been shown to be demographically and politically representative as compared to national benchmarks (Baos, Christenson, & Glick, 2018). Qualtrics participants were paid for participation, although the company does not release information on exact payments.

Among older adults, there were no significant differences between the friends/relatives and Qualtrics samples on either age ( $F_{(1,194)} = .326, p = .569$ ) or the linear composite of learning scores ( $F_{(1,194)} = .001, p = .973$ ), nor was there an interaction of sample and experimental condition on age ( $F_{(1,190)} = .968, p = .326$ ) or learning scores ( $F_{(1,190)} = .007, p = .936$ ).

## **Procedure**

After providing informed consent, participants answered two Likert-type questions indicating their familiarity with automotive and four stroke internal combustion engines; the average of these two responses was considered as a potential covariate, prior knowledge (Towler et al., 2008).

Participants were then randomly assigned to conditions and watched the same six-minute narrated, animated video describing the components and fundamental principles of how a four-stroke, internal combustion engine works. Participant instructions and the video was identical to

that used in Cavanagh et al. (2016), which in turn was closely adapted from Berthold et al. (2007; 2009). Following completion of the video, participants rated their mental effort, answered six recall and transfer questions, then provided demographic information.

Participants accessed all pre-measures, the training video, and post-measures online.

## Measures

Mental effort was rated by a single item, “Please rate your level of mental effort for this lesson,” with a nine-point Likert-type rating scale ranging from *1=extremely low mental effort* to *5=neither high nor low mental effort* to *9=extremely high mental effort*. Paas, Merriënboer, and Adam (1994) presented supportive evidence of the reliability and validity of this single-item measure of mental effort.

Participant learning was measured with one open-ended recall and five open-ended questions. The recall question was identical to that used by Cavanagh et al. (2016), while the transfer questions were identical or similar in focus. The recall question asked simply: “Please explain how a four-stroke, internal combustion engine works. Describe the main parts of the engine as necessary.” The transfer questions required participants to apply their learning to new problems, e.g., “What would most likely happen if one or both of the valves stayed open during the compression?” and “Often, internal combustion engines experience problems at extremely high altitudes, where air pressure is substantially lower than at sea level. According to the presentation, what could be the cause of these problems?” Questions similar to these are often used frequently in the assessment of multi-media training (e.g., Mayer et al. 2001).

An answer key for all six questions was developed by the developer of the training video. Using the key (and blind to condition), the first and second authors independently scored all responses by participants. Any disagreements in initial scoring were identified and resolved, so

that participants' final scores on the six learning measures reflect perfect consensus. A confirmatory factor analysis indicated that a model with the six learning scores loading on a single factor fit the data extremely well ( $\chi^2 = 304.294$ ,  $p = .000$ ;  $GFI = .990$ ;  $TFI = .979$ ;  $RMSEA = .043$ ). Accordingly, the six learning scores were added to form a single score of learning performance.

### Study 1 Results

Table 1 shows means and standard deviations for learning performance and mental effort for the two (age) by three (condition) design are shown. Pre-test knowledge was uncorrelated with learning and transfer ( $r = .09$ ,  $p = .087$ ), but gender was significantly correlated ( $r = .15$ ,  $p = .003$ ). Because women in general are less familiar with automotives (e.g., Mays, 2014) and the proportion of women differed substantially between the younger and older learners, subsequent investigations of hypotheses and research questions controlled for participant gender.

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Insert Table 1 About Here  
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Prior to running our analyses, we also identified potential outliers by calculating the semi-studentized residual for each participant for the full factorial ANCOVA model, then eliminated outliers with residuals greater than 2.0. This led to the removal of 11 participants for analyses of learning performance, and 24 for analyses of mental effort.

### Tests of Hypotheses

The first hypothesis was that older adults would perform worse on the learning outcomes measure than would younger adults. As seen in Table 1 and across conditions, older adults



scored significantly lower than did younger adults ( $M_{old} = 4.86$ ,  $SD_{old} = 3.81$ ,  $F = 46.14$ ,  $p < .001$ ,  $\eta^2 = .11$ ). Thus, the first hypothesis was supported.

Our second hypothesis was that there would be an interaction between learning prompts and age, such that the use of prompts would hurt the performance of older learner, but not younger learners. We found a significant interaction of age and prompts ( $F = 3.46$ ,  $p < .033$ ,  $\eta^2 = .03$ ), but not of the form we predicted. As seen in Table 1, means for older learners were lower than for younger learners, but did not differ by condition ( $M_{Meta-cognitive} = 6.47$ ,  $SD_{Meta-cognitive} = 4.87$ ;  $M_{Elaboration} = 5.88$ ,  $SD_{Elaboration} = 4.28$ ;  $M_{Control} = 5.97$ ,  $SD_{Control} = 4.02$ ). Fisher's Least Significant Difference (LSD) test (Williams & Abdi, 2010) confirmed that there were no significant differences between conditions for older adults. In contrast, for younger learners, learning performance in the meta-cognitive prompt condition ( $M = 8.16$ ,  $SD = 4.97$ ) was significantly higher than in the elaboration condition ( $M = 6.56$ ,  $SD = 4.60$ ;  $p = .027$ ) and marginally significantly higher than in the control condition ( $M = 6.88$ ,  $SD = 3.95$ ;  $p = .085$ ). Thus, Hypothesis 2 was not supported. Related to Research Question 1, there is no difference in learning performance in older adults by prompt type.

Our third hypothesis proposed an interaction of type of prompts and learner age on mental effort, such that the use of mental prompts resulted in greater mental effort than in the control condition for older adults, but not for younger adults. As can be seen in Table 2 and Figure 1, there was a significant main effect for learner age on rated mental effort ( $F = 16.34$ ,  $p < .001$ ,  $\eta^2 = .04$ ). Across conditions, older adults ( $M = 5.63$ ,  $SD = 1.92$ ) reported greater mental effort than did younger adults ( $M = 5.06$ ,  $SD = 1.51$ ). However, there was no interaction between age and prompt type ( $F = .27$ ,  $p = .765$ ,  $\eta^2 = .00$ ). Therefore, Hypothesis 3 was not supported.

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Insert Table 2 and Figure 1 About Here

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Related to Research Question 2, Fisher LSD tests revealed a significant difference in the mental effort of older adults in the meta-cognitive v. elaboration prompt conditions ( $p = .013$ ), with older adults reporting less mental effort when experiencing meta-cognitive prompts.

### **Study 1 Brief Discussion**

The purpose of Study 1 was to replicate and extend the study by Cavanagh et al. (2016) who found that the use of learning prompts hurt the training performance of older adults. We specifically tested the effect of prompts on both learning performance and mental effort in the same online training program used by Cavanagh et al. We speculated that learning prompts could increase mental effort in older adults because they either increase cognitive load or they are distracting. We also investigated whether effects differed depending on the type of prompt.

### **Summary of Study 1 with Implications**

On a brief online learning task, older learners (ages 55 to 70) performed significantly worse on a composite measure of learning and transfer than did younger learners ( $M_{age} = 19.0$ ). This replicates previous effects found in computer-based training environments (Carter & Beier, 2010; Wolfson & Kraiger, 2011) and the broader experimental and training literature (Kubeck et al., 1996). We caution that nearly all studies that demonstrate greater learning performance for younger adults do so in environments with fixed training intervals (Kraiger, 2017) and call for additional research that examines age effects in learning when both groups have longer or unlimited periods in which to master content.

With respect to the effects of learning prompts in general on training performance, our study failed to replicate the findings of Cavanagh et al. (2016). Whereas Cavanagh et al. found

that the use of prompts hurt the learning performance of adults aged 55 to 70 (under conditions with and without stereotype threat), using essentially the same training materials, in the present investigation, we found no interaction of age and prompts condition, older adults scored similarly across prompts conditions. We say “essentially the same” because the Cavanagh et al. training videos began by prompting participants that they would be soon tested on their “memory ability” (in the stereotype-threat condition) or “information-processing ability” (in the non-stereotype-threat condition), while the present videos began immediately after collecting the pre-test knowledge items. Therefore, in this study, participants may not have been sufficiently primed that they were to learn the material, or they may not have understood how responding to the prompts was advantageous. Additionally, in the current study we included a text box in which participants could type notes in response to each prompt, whereas the prompts only encouraged reflection (but no production) in the Cavanagh et al. study. Either small difference could explain the differences in the effects for prompts. On the other hand, the failure to replicate suggests two important implications: 1) we should be careful before concluding that learning prompts are deleterious for older learners; and 2) there is a need for additional studies that seek to replicate the earlier findings.

While not the focus of Study 1, we note our results replicate and extend the prior findings of the use of learning prompts with younger (college-aged) adults. A planned comparison showed that the mean learning scores for the combined meta-cognitive and elaboration prompts conditions was significantly higher than that of the control group ( $p = .043$ ). The use of brief prompts inserted periodically within training material enhances performance on measures of learning and transfer. As shown in Table 1, this effect was primarily driven by performance in the meta-cognitive group. The benefits on learning of meta-cognitive prompts in *younger*

*learners* is consistent with a large number of prior studies (e.g., Bannert et al., 2009; Berthold and colleagues, 2007; 2009; 2011; Bixler & Land, 2010; Hübner, Nückles, & Renkl, 2006; Kramarski & Friedman, 2014; Sitzmann et al., 2009; Stark & Krause, 2009). As these are easy to insert in instructional material (e.g., Sitzmann et al., 2009), an implication is that they should be used more frequently in the design of online training.

Self-rated mental effort was much lower for the meta-cognitive condition than for the elaboration condition. This supports the untested assumption by Berthold et al. (2011) that prompts which elicit elaboration may impose costs related to greater cognitive load.

Returning to the older adults, because we did not find a negative effect for learning prompts on learning outcomes, we could not directly test whether these effects were due to greater mental effort in the form of greater cognitive load or more distraction. However, our results also showed that there were no differences in rated mental effort across prompts conditions; relative to younger learners, older learners reported higher mental effort regardless of condition. We suggest that if we had found a negative effect for providing prompts, we would not have been able to attribute this to either greater cognitive load or distraction.

### **Rationale - Study Two**

There are two purposes of Study 2. The first was to again try to replicate the negative effects of learning prompts reported by Cavanagh et al. (2016) and again try to see whether these effects differ by prompt type - meta-cognitive v. elaboration. Above, we noted two small procedural differences between Study 1 and Cavanagh et al. et al. study (specifically, not including a prompt that participants would be tested on memory or information-processing ability after the pre-test, and inclusion of a text box for note taking along with the cognitive

prompts). In the present study, we eliminate one of those. In Study 2, identical to Cavanagh et al., older adults in either prompts condition were unable to type responses to the prompts.

The second purpose was to explore a second explanation of the negative impact of learning prompts - the creation of negative affect (e.g., feelings of stress or anxiety). Just as Cavanagh et al. (2016) proposed that learning would be harmed by inducing stereotype threat, it is possible that the prompts - in the form of questions about the content - serve to create an evaluative context for older learners, and may result in stress or anxiety that hurt the mastery of the training content. Thus, in Study 2, we repeat the experimental conditions presented in Study 1 (but with only older learners) and add a measure of negative affect prior to assessing mental effort and learning performance.

## Study 2

There are several mechanisms by which learning prompts could create negative affect in older learners. The first is that the prompts themselves serve as a form of stereotype threat. Recall that in Cavanagh et al. (2016), the use of prompts *augmented* stereotype threat. While we often think of stereotype threats as emanating from the presentation of group-level negative images and/or text, Shapiro and Neuberg (2007) noted that there are multiple ways in which stereotype threats can be implemented. Older adults in an online learning study - sponsored by a research university - may perceive seemingly innocuous questions about their learning performance as a threat. Believing they may be judged negatively for failing to learn, these participants may have felt “apprehension ...when performing in a domain in which their group is stereotyped to lack ability” (Aronson & Inzlicht, 2004, p. 830). Along with apprehension, proposed affect-related mediators of the stereotype threat - performance relationship include arousal, anxiety, interfering thoughts, reduced working memory and reduced confidence

(Shapiro & Neuberg, 2007). Accordingly, seeing learning prompts interjected into training material may have aroused negative affect in older adults.

More generally, while usage of technology by older adults is increasing, older adults are still half as likely as younger adults to use the internet for education purposes (Olson, O'Brien, Rogers, & Charness, 2011). As such, when learning online, older adults may experience both computer anxiety and negative affect about the effort needed to use the technology (Wolfson et al., 2014). While this holds true for all forms of online learning, the use of learning prompts may augment self-awareness of these negative states. In general, learners demonstrate greater meta-cognitive awareness in the presence of prompts than without (Bannert & Reimann, 2012; Nückles, Hübner, & Renkl, 2009). Thus, the instructional prompts may stimulate reflection in older learners leading to the recognition that they are anxious about mastering the content.

That recognition of anxiety, in turn, may lead to negative effects on learning as it increases learners' vulnerability to intrusive thoughts (Sarason, 1988) and leaves them less able to inhibit task-irrelevant thoughts (Hasher & Zacks, 1988). It is then this task interference which interferes with cognitive performance. Although the negative effect of anxiety on learning is prevalent at all ages (Maloney, Sattizahn, & Beilock, 2014), effects should be strongest for older adults who, as a group, have diminished cognitive resources. Accordingly, we proposed:

*Hypothesis 4: Older adults will report greater negative affect in learning prompts conditions than with no prompts.*

Consistent with Study 1, we also proposed:

*Hypothesis 5: Older adults will perform worse on measures of recall and learning in learning prompts conditions than with no prompts.*

*Hypothesis 6: Older adults will report greater mental effort in learning prompts conditions than with no prompts.*

## Methods

### Participants

Fifty-seven older adults participated in the study, ranging in age from 55 to 70 years ( $M = 62.4$ ,  $SD = 4.5$ ). Participants were recruited through a Qualtrics study panel and paid for their participation. Data from an additional six participants were collected and dropped for analyses because of very fast completion times coupled with non-attempts to answer the recall and transfer questions.

Among participants, 19.3% reported either some high school training or a high school degree, 17.5% reported some college training, 42.1% reported a college degree, and 21.1% reported a post-graduate or professional degree. 66.7% reported their ethnicity as White, 14.0% as African-American, and 10.5% as Hispanic. 52.6% were female, and 47.4% were male. Participant gender was uncorrelated with learning ( $r = .06$ ,  $p = .645$ ) and not used as a covariate.

### Procedure

Participants accessed all pre-measures, the training video, and post-measures online. As in Study 1, participants provided informed consent and answered two Likert-type questions indicating their familiarity with automotive and four stroke internal combustion engines; an average of these two items was considered as a covariate but rejected because it was uncorrelated with learning performance.

Participants were then randomly assigned to either a meta-cognitive, elaboration, or no prompts (control) condition and watched the same six-minute video as used in Study 1 and

Cavanagh et al. (2016). Following completion of the video, participants rated their mental effort, answered recall and transfer questions, then provided demographic information.

Immediately after completing the videos, participants completed the 20-item Positive and Negative Affectivity Scale (PANAS; Watson, Clark, & Tellegen, 1988). Participants indicated their feelings *while watching the video* by using a 5-point Likert-type scale ranging from “Never” to “Almost Always.” Scores across the ten negative affect items (e.g., “irritated,” “afraid,” and “upset”) were averaged for form a negative affect scale ( $\alpha = .93$ ).

Given evidence in Study 1 of a single underlying factor on our open-ended questions, we eliminated two transfer questions. As in Study 1, the remaining recall question and three transfer questions were scored by the first and second authors who were again blind to condition. Any initial differences in scoring were identified and resolved through discussion so that final item scores represented consensus between scorers. As in Study 1, scores were summed across the four recall and transfer questions to form a single score of learning performance.

### **Study 2 Results**

Data were analyzed using a one-way ANOVA with three conditions (control, meta-cognitive prompts, elaboration prompts). Means and standard deviations for learning performance, negative affect, and mental effort by condition are shown in Table 3.

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Insert Table 3 About Here  
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The fourth hypothesis was a main effect for prompts on negative affect, such that negative affect would be greater when older adults receive prompts than when they do not.



Contrary to expectations, there was no main effect for conditions on negative affect ( $F = 0.78$ ,  $p = .456$ ,  $\eta^2 = .03$ ). Thus, Hypothesis 4 was not supported.

The fifth hypothesis was that the older learners would perform worse when provided prompts than when they weren't. As seen in Table 3, there was a significant main effect for condition on learning performance ( $F = 3.28$ ,  $p = .046$ ,  $\eta^2 = .11$ ). Further, the planned comparison revealed that the control group mean ( $M_{Control} = 8.35$ ,  $SD_{Control} = 4.63$ ) was significantly higher than the mean of the elaboration and meta-cognitive prompts combined ( $M_{Prompts} = 5.11$ ,  $SD_{Prompts} = 4.75$ ;  $t = 2.44$ ,  $p = .018$ ). Thus, Hypothesis 5 was supported.

The sixth hypothesis was that there would be a main effect for prompts on mental effort, such that cognitive load was greater in both the meta-cognitive and elaboration prompts condition. Contrary to expectations, there was no main effect for conditions on mental effort ( $F = 1.42$ ,  $p = .252$ ,  $\eta^2 = .05$ ). Therefore, Hypothesis 6 was not supported.

### **Study 2 Brief Discussion**

The purposes of Study 2 were: (1) again to try to replicate the effect found by Cavanagh et al. (2016) who found that learning prompts in online training hurt the performance of older adults; (2) again investigate whether negative effects (on learning) if found were due to high cognitive load (i.e., greater mental effort); and (3) investigate whether negative effects (on learning) if found were due to increased negative affect.

### **Summary of Study 2**

We found a strong and significant main effect for prompts on learning performance. With a sample of participants between the ages of 55 and 70, mean scores for learning were significantly higher without prompts than with either elaboration or meta-cognitive prompts. This is consistent with the findings reported by Cavanagh et al., but inconsistent with the

findings from Study 1. While our efforts meet recent calls for more replication in the psychological sciences (e.g., Roediger, 2012; Simons, 2014), the inconsistent pattern of results suggest that more research is needed before we conclude that learning prompts should not be used in online training for older adults.

With respect to effects of learning prompts on cognitive load, we found no main effect for condition on mental effort, a result consistent with the findings of Study 1. Together, these results suggest the negative effects caused by the use of learning prompts is not due to higher extraneous load created by the use of learning prompts.

Finally, we examined the effect of prompts on participants' negative affect, investigating whether the interruptions posed by the prompts increased older adults' feelings of being annoyed or bothered. We found no effect for prompts across conditions. Not only were there no differences between conditions, but scores across conditions ( $M = 2.55$  on a 10-point scale) suggested that participants experienced low negative affectivity in general. While the results do not support affect-related explanations for the disruptive effects of prompts, we do note that there are many ways of measuring moods and emotions (e.g., Betella & Verschure, 2016; Ekkekakis, 2013), and future researchers should explore alternative measures that may again be more sensitive to what older learners may be feeling when confronted with learning prompts.

### **General Discussion**

The purposes of the present investigation were to attempt to replicate the negative effects for learning prompts in older adults reported by Cavanagh et al. (2016), determine if the impact of learning prompts depends on type of prompt, and investigate the two possible explanations of the negative impact of prompts – increased cognitive load and higher negative affect.

With respect to the first purpose, we found a negative impact on learning for prompts in Study 2, but not in Study 1. To analyze the overall impact of learning prompts on the performance of older adults in online training, we conducted a small meta-analysis, aggregating the effects across the three studies. To do this, we first combined the elaboration and meta-cognitive prompts conditions in both current studies, as prompt type did not have an impact on learning performance and because Cavanagh et al. (2016) combined both prompt types in their manipulation. We then computed a Cohen's  $d$  as the difference between the prompts and control group means, divided by the standard deviation of the control group. We then weighted each study  $d$  by its sample size and computed an overall mean.

The results show a negative effect for prompts,  $d = -.31$ ,  $N=300$ . This effect is considered moderate in size (Cohen, 1988) and indicates that older adults, ages 55-70, perform worse in online training when prompts are provided than when they are not. Notably, while we did not find a significant main effect for prompts in Study 1, the mean of the control group was still higher than the average of the two prompts conditions ( $d = -.14$ ). It should be noted that all three studies used virtually identical training materials, the length of the training was short, and participants were either volunteers or paid to participate. Additional research is necessary to determine if the obtained effects generalize to other training content, other training outcomes, and other training populations. Nonetheless an important implication for training professionals is that should be cautious implementing learning prompts in online training of older adults (Cavanagh et al., 2016).

We also examined whether differential effects were found for elaboration v. meta-cognitive prompts. The former require participants to make connections of new training content to existing knowledge or practical experiences, while the latter requires self-evaluation of

learning progress. We found no main effects for prompt type in learning in either study, and only a significant effect for prompt type on mental effort in Study 1 – older learners in the meta-cognitive prompt condition reported less mental effort than those in either the elaboration or control conditions. The latter finding might be due to the fact that elaboration prompts are intended to promote active engagement by the learner; however, this does not explain why older adults reported less effort in response to the meta-cognitive prompts than the neutral prompt in the control condition. At this point, we can only include that type of prompt does not seem to have a strong effect either on older learners' effort or learning performance.

### **Limitations**

The current study failed to find support for either increased cognitive load or negative affect as an explanation for negative effects of prompts on learning performance in older adults. This may in part be due to design choices we made. For example, the training video was short (six minutes) and both samples of older adults were well-educated (over 80% of Study 1 older participants and over 75% of Study 2 participants had at least some college education). Thus, we recommend continuing to explore the effects of learning prompts on cognitive load, but with longer training tasks and a more heterogeneous sample with respect to cognitive ability or education. Additionally, future research could consider alternative measures of cognitive load that may be more sensitive to the mental demands imposed by learning prompts (e.g., Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013).

In Study 2, there were no differences between conditions in reported negative affect. Again, this could be due to the sensitivity of the negative affect measure, future studies could use either a more specific measure of anxiety or stress, or use think-aloud protocols to uncover specific forms of negative affect that could be preventing participants from mastering content

when exposed to learning prompts. Additionally, while the negative affect scale mean was low, future studies could include both younger and older adults to see if the relative level of reported negative is high in the latter group.

Finally, we note that there may be other explanations besides those that we tested. A straightforward one is that older adults are simply penalized for slower processing speed (Salthouse, 1996). For example, when presented with new training content, younger learners may quickly integrate this with existing knowledge, so when the prompt appears, they can essentially use it to reflect on what is essentially now “previously-learned material.” Older adults may still be consolidating that same information, so the prompt distracts and disrupts active processing. One straightforward way to test this would be in a self-paced design in which prompts appear after learners signal they are ready to move on.

**Conclusion.** Two studies showed that the use of both elaboration and meta-cognitive prompts in online training materials resulted in lower levels of learning in older adults. We found no evidence to suggest that these effects were due to either increased cognitive load or greater negative affect. However, other research using different training materials and other measures (of cognitive load and negative affect) was encouraged.

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Table 1

*Means and standard deviations for learning performance by condition (Study 1)*

	Control		Metacognition		Elaboration		TOTAL	
	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>
Young	6.88	3.95	8.16	4.97	6.56	4.60	7.17	4.56
	<i>n</i> = 69 (82)		<i>n</i> = 68 (70)		<i>n</i> = 66 (79)			
Old	5.18	3.94	4.48	3.94	4.80	3.49	4.86	3.82
	<i>n</i> = 80 (81)		<i>n</i> = 58 (71)		<i>n</i> = 49 (51)			
TOTAL	5.97	4.02	6.47	4.87	5.88	4.28	6.10	4.38

Table 2

*Means and standard deviations for mental effort for each experimental group (Study 1)*

	Control		Metacognition		Elaboration		TOTAL	
	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>
Young	5.03	1.56	4.82	1.59	5.29	1.36	5.06	1.51
Old	5.74	1.93	5.15	2.08	6.07	1.56	5.63	1.92
TOTAL	5.40	1.79	4.98	1.83	5.58	1.48	5.32	1.73

Table 3

*Means and standard deviations for learning performance, negative affect, and mental effort by condition (Study 2)*

	Control		Metacognition		Elaboration		TOTAL	
	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>	<i>m</i>	<i>sd</i>
Learning	8.35	4.61	5.65	5.57	4.65	4.01	6.24	4.91
NA	2.73	.87	2.61	1.11	2.32	1.17	2.55	1.05
Mental effort	5.60	2.13	4.88	2.00	4.95	2.34	5.16	2.17

$N_{\text{Metacognition}} = 17$

$N_{\text{Elaboration}} = 20$

$N_{\text{control}} = 20$

Figure 1  
*Impact of condition on mental effort for younger and older participants*

