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Effects of Cueing with Videotutorials for Software Training

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Abstract

Videotutorials considerably support demonstration-based training where the main goal is to boost procedural knowledge by observing various comprehensible examples of accomplishing a task. Although videotutorials are fashionable nowadays, little attention is given to the design features of an instructional tutorial. Two empirical studies investigated the effects of a cueing strategy on the learning, and mental effort of learners who studied three videotutorials about video editing techniques. A one-way factorial repeated measures design with two levels of cueing (no cueing vs cueing) was used. Participants were students from two departments in a Greek university. The students (N=118) in Study 1 had high levels of prior experience in ICT, whereas the students (N=114) in Study 2 had moderate levels of prior experience. The results revealed main effects of cueing on learning in Study 2, compared to those in Study 1. The discussion proposes several alternatives for improving the effectiveness of videotutorials.

Keywords: cueing, multimedia learning, videotutorials, mental effort, prior experience

Introduction

Over the past thirty years, everyday life has become gradually saturated and mediated by software (Kitchin & Dodge, 2011). For instance, editing a video on YouTube or designing a multimedia app are examples of actions that are enabled by a subset of software which called media software (Manovich, 2013). Therefore, many users are seeking tutorials to gain more information and consequently become literate in media software.

Video tutorials are a popular learning tool that presents how-to information about software tasks (van der Meij & van der Meij, 2013). They are rendered through a screen capture with synchronized narration. Today, popular video-sharing websites, such as YouTube and Vimeo, host thousands of informal video tutorials for performing numerous complex software-related tasks such as video editing. A question that arises is what type of software applications can be characterized as complex? According to HCI studies (Leutner, 2000), complex software applications involve a lot of related entities to accomplish complex workflows. As the number of entities rises, the degree of complexity would grow and therefore users should put more mental effort to know and understand all of them.

Since the acceptance of video tutorials has been exponentially increasing, there have been two theoretical foundations for designing instructional videos. The Cognitive Theory of Multimedia Learning (CTML; Mayer, 2001) and the Cognitive Load Theory (CLT; Sweller, 2005) (1) take into consideration the limitations of human working memory capacity while processing information simultaneously, and (2) interpret how the features of the working memory influence cognitive processes. The CLT and CTML have proposed a set of guidelines for effective dynamic representations (i.e. videos). For example, people learn more from words and pictures than only words (multimedia principle) or people learn better when words are presented as speech rather than on-screen text (modality principle). Several studies have explored the contribution of multimedia principles in learning with low prior knowledge users (Kalyuga, 2014). Also, Mayer (2001) argues that multimedia design

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principles may be more beneficial for learners with low prior knowledge than for high prior knowledge learners. Therefore, research on the effectiveness of these principles for high prior knowledge learners has received little attention. This study contributes to literature by exploring cueing with two different domain populations who had different levels in ICT but novices in the specific sub-field -video editing software.

Theoretical background

Cueing literature

The cueing (or signaling) principle (Mayer, 2001) postulates that people learn better when non-content information (e.g., visual cues) guide user attention to the critical points of the learning material or emphasize the organization of the learning material. Cueing is operationalized in many ways, i.e., colour, shapes, zoom, luminance. The question that arises is how cueing improves task performance and, therefore, facilitates learning. A recent meta-analysis of 29 experimental studies (Alpizar et al., 2020) on cueing indicated the following. Firstly, cues may be valuable for learners in terms of guiding the user's attention to the key points of a multimedia presentation. Secondly, cueing allows learners to organize and integrate relevant information with prior knowledge. Third, cueing can reduce the visual-search time, thereby releasing working memory assets.

Some multimedia studies have reported that cueing can lead to improved task performance (Amadieu et al., 2011; De Koning et al. 2010) while others have found no effects on learning (Kriz & Hegarty, 2007). Previous research on cueing has also some limitations. First, the empirical studies have used self-paced animation or videos with static images and not on videos with a constant flow. Second, the video tutorials used in these studies targeted software with simple interfaces (i.e., word editing, web-based forms) rather than more complex ones (e.g., image or video editing). To the best of our knowledge, there was only one cueing study that has been conducted in the field of software training. Jamet and Fernandez (2016) integrated cueing in self-paced interactive multimedia tutorials that demonstrated how to fill out a web-based form. Cueing was empirically controlled and was implemented through green arrows pointing to elements of the interface. The participants in both conditions (no cueing vs cueing) had the opportunity to tackle each procedure in a step-by-step manner with the step names serving as labels. The results signalled that students in the cueing condition selected the relevant information more quickly compared to students in the no cueing condition. While this finding is consistent with CTML, cueing did not influence task performance.

Mediators of learning

Another issue that attracts further exploration is how individual characteristics such as prior experience and mental effort affect learning through multimedia videotutorials. Not all users have the same expertise; some of them are novices while others are knowledgeable. Multimedia research considering users' expertise differences has revealed that prior knowledge or prior experience is a crucial factor that influences various cognitive and affective measures. The expertise reversal effect postulates that effective strategies for novices can be redundant or even detrimental for knowledgeable users (Kalyuga, 2014). Empirical research has shown that users with low expertise give emphasis on salient elements of information, while users with high expertise may disregard the irrelevant information and focus on the essential elements of the material (Jarodzka et al., 2010).

Multimedia learning materials usually have an intrinsic level of difficulty, and learners often lack how to select the essential information in a limited time frame. In this context, the total cognitive load that learners experience can easily exceed the limited capacity of cognitive resources. According to CLT approach, cueing can prevent cognitive load; however, individuals thoroughly diverge in their processing capacity (Arslan-Ari et al., 2020). Experts have a high level of experience regarding a specific task which reduces the cognitive load associated with the task. On the contrary, novices lack experience or knowledge and thus confront higher cognitive load. In multimedia research, different techniques have been manipulated to measure cognitive load with mixed results. Mental effort indicates the amount of cognitive processing a person is engaged. This conceptualization of mental effort by Paas (1992) has been widely acknowledged in the field of learning and instruction because it has good reliability and validity.

The previous literature review suggests that cueing could potentially enhance task performance. This guideline seems to be beneficial for learning though it has been explored in combination with other design features. Thus, its possible unique contribution to learning from videotutorials has not been verified. The present study aims to bridge this gap by exploring the educational efficiency of videotutorials that was designed with cueing. Also, it measures task performance and mental effort considering two demographics population with different levels of ICT experience in the context of complex media software.

More specifically, the following research questions were investigated:

RQ1: What is the influence of cueing on the task performance of students studying videotutorials for software training?

RQ2: How does the use of cueing on videotutorials influence the mental effort?

Study 1

Participants and Research design

The sample consisted of 118 (90 males and 28 females) student volunteers who studied at an Informatics University Department in Central Greece. All study materials were fourth-year Computer Science students.

The study involved a single factor experiment repeated measures design. This factor included two levels: (a) no cueing and (b) cueing. Participants were randomly assigned to the no cueing (n = 60), cueing (n = 58) conditions.

Instructional materials

Three video tutorials were developed for the study. All three demonstrated how to perform common video editing tasks in Blender's VSE. More specifically, the tutorials covered fundamental video-editing operations such as navigating the interface, manipulating clips, and translating the positions of image and video clips.

Video #1 dealt with basic manipulations i.e., clip selection, change clip's position in timeline (3 min 26 s). Video #2 dealt with transform clips. It discussed complex procedures i.e., clip transformations such as scale and rotation (3 min 28 s). Lastly, Video #3 dealt with even more complex issues such as the Picture In Picture (PIP) effect using the actions that had been displayed in the former video (4 min).

Operationalization

The cueing strategy was operationalized with animated arrows, rectangles, and brightness. These cueing methods pointed the viewers' eye to look at the pertinent on-screen information such as menu items, icons, and popup windows and with highlights. Figure 1 shows a sample screen shot from the cueing videotutorial investigated in this study.

Figure 1 Sample screen shot from the cueing condition

Measures

The *Task Performance Test (TPT)* was partitioned in three types (declarative knowledge, procedural knowledge, and transfer knowledge). The declarative test comprised two closed-type items (Correct/Wrong and Multiple choice) [Example: Which shortcut key is used for Transform in Blender? i) C, ii) T iii) X, iv) G]. The procedural knowledge test comprised two items that resembled to demonstrated tasks. Each item was provided to students with a committed Blender file (Examples: The top screenshot features two clips from images in the Video Sequence Editor. Add the corresponding transform clips and rearrange them to create the stack featured in the screenshot below). The transfer test comprised one item that involved a more complicated task than demonstrated tasks (Example: The screenshot depicts a composite picture. Use the image clips in the Video Sequence Editor to create this picture effect.). Scoring was no different for all tests. For a correct answer, the items were rated with one point. On the negative answer the items were rated with zero points. For the statistical analysis, the task performance scores were converted to percentages. Cronbach's alpha indicated good results for TPT (α=0.89).

ICT Questionnaire (ICTQ) measured students' degree of familiarity with the use of Computers and Internet and other software applications. This questionnaire comprised twenty-one items (Examples: How familiar are you with image editing software applications?) The students answered these questions by circling a number on a 6-point Likert scale from (1) not at all to (6) very much. Cronbach's alpha value was almost 0.7.

Mental Effort Questionnaire (MEQ) measured the students' perceived cognitive effort during training. This scale is a popular instrument by Paas (1992) that using a 7-point Likert scale. Responses rated from extremely low (1) to extremely high (7). Cronbach's alpha value of 0.67.

Procedure

The experiment lasted approximately two hours. The participants were invited in groups of four. They signed an informed consent form and were seated each in front of a computer with a headset. In the beginning, the study subjects were informed about the intervention. Then, they answered a demographics and ICT questionnaire about the familiarity of software applications. Then, they logged in the LMS course and according to their condition they followed a particular learning path. After each videotutorial, the participants had to answer the MEQ and to work through the TPT of the individual videotutorial. During task execution, the participants could not consult the videotutorials.

Analysis

A mixed factorial repeated measures ANOVA was carried out with the cueing as the between-subjects factor and the time after the video tutorial as a within-subjects factor. An alpha value of 0.05 was used throughout the analysis. The Bonferroni correction was applied whenever multiple tests were conducted, thereby reducing the probability level as needed. Finally, because the assumption of sphericity was violated in some cases (i.e., Mauchly's test of sphericity was statistically significant), the corresponding Greenhouse-Geisser F value and degrees of freedom were used. For significant findings, Cohen's (1988) d-statistic was computed. These tend to be considered as small for d = 0.2, medium for d = 0.5, and large for d = 0.8.

Results

Table 1 shows the mean scores and standard deviations of two dependent variables (i.e., task performance and mental effort). A one-way ANOVA failed to show a significant effect of cueing on task performance, $F(1,114) = 0.574$, $p = .450$. As far as the within-subjects factor is concerned (i.e. time), the repeated measures ANOVA did not indicate any significant time by cueing interaction ($F(2, 228) = 0.137$, $p = .872$). Therefore, performance is not dependent upon cueing. This finding is not in line with our initial hypothesis that cueing would yield higher learning gains compared to the respective reference condition, e.g., no cueing.

Interestingly enough, there was no significant effect of cueing on mental effort, $F(1,114)=0.311$, $p= .578$. The average perceived difficulty was 2.92 for the first video, 3.80 for the second video and 5.12 for the last one. This finding agrees with the general trend of learning scores reported in the previous section, lending support to the idea that the difficulty of the videos (and hence the tasks that followed them) increased. The pairwise comparisons of the means indicated that the mean perceived difficulty of the second video was significantly higher than the first and that the mean perceived difficulty of the last video was significantly higher than that of the second.

Table 1. Descriptive statistics for dependent variables (Study 1)

Cueing strategy	Task performance M (SD)	Mental effort M *(SD)*
Plain (n=60)	72.56 (33.58)	3.99 (0.89)
Cueing (n=58)	76.67 (30.76)	3.91 (1.00)
Total (n=118)	**74.61 (32.17)**	**3.95 (0.95)**

Study 2

The Study 2 was a replication of the Study 1. The main important difference was the demographics population that participated.

Participants

The study participants were 114 undergraduate students (66 females and 48 males) from a Nursing department of University in Central Greece. The students had no prior familiarization with media editing software. They were randomly assigned to one of four treatment conditions and received one course credit point for their participation. The students were randomly assigned to the plain (n = 40), cueing (n = 41) conditions.

Measures

There were no changes in instruments. Good reliability scores were found for MEQ (α=0.88) and for TPT (a=0.74).

Results

Table 2 shows the mean scores and standard deviations of two dependent variables (i.e., task performance and mental effort). A one-way ANOVA indicated main effects for cueing, $F(1,77) = 8.66$, $p = 0.004$, $\eta^2=0.10$, $d=0.87$. This signals a large effect. Therefore, cueing seems to facilitate performance. This finding is in line with RQ1 that cueing would yield higher learning gains compared to the respective reference conditions, e.g., no cueing.

A one-way ANOVA indicated no main effect for cueing on mental effort $F(1,110) = 0.02$, p = 0.893. A repeated-measures ANOVA indicated a significant main effect of time, $F(1, 110)=25.30$, $p=0.000$, $\eta^2=0.19$. The average perceived difficulty was 3.29 for the first video, 3.39 for the second video and 3.82 for the last one. This pattern is in line with the general trend of learning scores reported above, lending support to the idea that the difficulty of the videos (and hence the tasks that followed them) increased.

Table 2. Descriptive statistics for dependent variables (Study 2)

Cueing strategy	Task performance M (*SD)*	Mental effort M (SD)
Plain (n=40)	56.67 (29.95)	3.51 (0.92)
Cueing (n=41)	69.11 (25.36)	3.49 (1.26)
Total (n=81)	**62.89 (27.66)**	**3.5 (1.09)**

Discussion

In both studies, we examined the effects of a cueing strategy in video-based software training on task performance and mental effort.

In Study 2, a significant effect of cueing on task performance was found, with participants of the cueing condition realizing better performance. In Study 1, these scores were higher for participants of cueing, but there was no significant effect of condition. One plausible explanation, which is supported by multimedia research, is that cueing favours low prior knowledge users in the stages of the selection, organization, and integration of new information with existing knowledge (van Gog, 2014). This finding also resonates in multimedia research meta-analyses (Alpizar et al., 2020; Richter et al., 2016). Compared to low experienced learners, high prior knowledgeable learners have already constructed mental models in long-term memory (Kalyuga, 2014). Hence, it might be concluded that the presence of cueing hindered high experienced users from understanding the most important information. For this reason, future research should consider the amount of cueing for high experienced users when learning a new software application.

A second possible explanation lies in the modality of cueing used. The present study has used only one type of modalities, such as arrows, geometric shapes, and high-brightness frames. The monotonous appearance of these signals may have been attenuated during software training. According to Xie's et al. (2019) meta-analysis, combining two types of modality simultaneously (visual and verbal) can help learners integrate words and images to focus more time on the essential element of learning material. Thus, future studies should investigate a dual modality of cueing in videotutorials to enhance task performance.

Regarding mental effort, both studies indicated that cueing had no influence on mental effort. This finding is in line with many empirical studies (De Koning et al., 2010, 2011; Jarodzka et al., 2013; Lin & Atkinson, 2011) that reported non-significant differences in mental load between control and experimental conditions. Because the videotutorials included technical terms, learners in all groups might have invested high mental effort in studying the videos. This might be supported with the studies' findings that the mental effort scores for all treatment groups were above 3.7 on a 7-point Likert-type scale.

In terms of practical implications, the results of this study highlighted that instructors and multimedia designers should consider learners' prior experience when designing multimedia learning materials including videotutorials. Specifically, visual cues should be provided to low prior knowledge learners while learning from a videotutorial that demonstrates complex procedures. On the contrary, when learners have sufficient prior knowledge to facilitate their learning process, cueing is not necessary or even not beneficial.

Taking all into consideration, the presence of cueing had mixed results in learning from video tutorials. Empirical studies in multimedia learning have revealed positive outcomes of cueing when learning from static materials. In the case of dynamic representations, cueing may not work for video tutorials. Due to the transient nature of the video, the effect of cueing might fade. For this reason, future studies need to investigate the amount of cueing and the modality of cueing during software training. Also, future research will need to replicate the current findings with other complex software applications and different user demographics. To date, most studies have used relatively simple applications rather than complex ones.

As with other studies, this study has one main limitation. We used a specific measure for mental effort. Even though it is a reliable and valid scale, it might not provide an overall accurate portrayal of the students' total cognitive load. Future studies should adopt new cognitive load strategies, i.e. electroencephalography (Antonenko et al., 2010) to provide more sufficient data for more in-depth learning.

Additionally, while former studies have examined cueing, the present study is the first one to experimentally examine it in the case of complex software training with participants who had different levels of ICT skills. Thus, we have attempted to systematically extend former research by investigating the effect of cueing in novel contexts, with complex software applications, and different user expertise levels. While this is, obviously, an essential step in a new direction, more systematic research is required.

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