Effects of Modality, Contiguity, and Redundancy in Multimedia Learning

Mike Schellen

University of North Texas
Abstract

Considerable research has been completed surrounding various elements of cognitive load theory (CLT), instructional design, and learning events. These elements include (but are not limited to) research on the effects of varying modality, contiguity (both spatial and temporal), and redundancy. The research in many cases has produced mixed and sometimes contradictory results. The current paper intends to add to the body of existing research by exploring these elements within the context of video-based learning. Within the existing literature, few studies in this area have been performed with video as a learning modality. The current study is likely to show quiz scores declining when deviating from video with audio. Consistent with dual coding theory, scores should be highest when video is presented with audio narration. Redundancy effect should ensure that video with text and identical narration should produce the lowest scores. No significant difference is expected between participants who view the video with subtitles and no audio and those who view with text in proximity to key visual elements. No significant difference is anticipated due to age or gender, though some significant difference could be attributed to educational background or familiarity with the subject matter.

*Keywords:* modality, contiguity, redundancy, multimedia, dual coding theory, cognitive load theory
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

Effects of Modality, Contiguity, and Redundancy in Multimedia Learning

Considerable research has been completed surrounding various elements of cognitive load theory (CLT), instructional design, and learning events. These elements include (but are not limited to) research on the effects of varying modality, contiguity (both spatial and temporal), and redundancy. The research in many cases has produced mixed and sometimes contradictory results.

Much of the literature supports a dual modality approach to multimedia learning. A commonly cited element regarding dual modality is the modality effect, which indicates that multimedia which incorporate auditory and visual elements improve learning outcomes (Mayer, 2001). Notably, auditory and visual modalities appear to have different capacity demands. A study by Brünken, Plass, and Leutner (2004) provided implications of differing capacity demands based on learning results. Given certain conditions, the modality effect is fairly well-established.

Contiguity involves the proximity of multimedia elements in physical space (spatial) and time (temporal). Mayer and Anderson (1992) indicate that placing words and images closely to one another, either physically or temporally, increases the effectiveness of multimedia. The contiguity principle is less well-established.

An example of redundancy in this context would be the inclusion of audio and identical, concurrent on-screen text within a multimedia event. Though a number of experiments have been done, results have been mixed as to whether such redundancy is beneficial or detrimental. Kirschner (2002) provides an example of redundancy being detrimental within a multimedia context.
Specific questions to be addressed in the current study include:

- Does the use of video with audio provide superior post-test scores relative to video with subtitles, video with text near key visual images, and video with both text and narration in accordance with dual coding assumption?
- Does the contiguity principle promote superior test scores in a video-based format?
- Does redundancy adversely impact post-test scores in accordance with the redundancy effect?
- Will the demographic issues of age, gender, or educational background impact post-test scores within a given video configuration?

The current paper intends to add to the body of existing research by exploring these elements within the context of video-based learning. Much of the existing literature uses animation or still pictures for experiments in this domain. However, in many learning environments (including corporate learning), the use of video for learning has increased dramatically. The author believes video provides a fertile platform for testing and evaluating these elements. The results of this testing and evaluation should provide a foundation for similar research utilizing other multimedia platforms.

**Theory and Research**

One of the prevailing theories with regard to modality is the aforementioned modality effect. A tenet of modality effect is that the auditory and visual channels have limited capacity. Cognitive load experiments have resulted in the validation of finite capacity in both channels. (Brünken, Plass, & Leutner, 2004). Brünken et al (2004) also note that within a given multimedia event, a second concurrent task within the same channel increases cognitive load. This increase in cognitive load decreases performance in both the audio channel and the visual channel. Finally, because of the independence of the visual and auditory channels, an inappropriate load
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

in visual channel can’t be balanced by shifting the load in the auditory channel, nor vice versa (Brünken, Plass, & Leutner, 2003).

Dual-coding assumption refers to how visual and verbal information are managed in different (but interrelated) systems (Brünken, Plass, & Leutner, 2003). These systems are referred to as the visuospatial and phonological systems, based on Baddeley’s work regarding working memory (1986). This assumption is derived from dual-coding theory (Paivio, 1986).

Spatial contiguity effect posits that cognition is improved when images and text are placed in immediate proximity to one another. Similarly, temporal contiguity effect suggests that visual and auditory information delivered concurrently positively affects learning (Moreno & Mayer, 1999). Moreno and Mayer also advance the idea that on-screen text which is separated from visual elements inhibits learning (1999).

Each of these theories plays a role in the framework of cognitive load theory. Cognitive load is presumed to have three types: intrinsic, extraneous, and germane. According to Brünken, Plass, and Leutner (2003) intrinsic cognitive load is related to the “structure and complexity of the material” (p. 54). Extraneous cognitive load is related to how the information is presented and does not further the learning process. Germane cognitive load refers to load generated from trying to understand the material (Brünken et al, 2003).

The importance of cognitive load to the instructional design process would be difficult to overstate. Brünken, Plass, and Leutner remark that the essence of instructional design is to ensure an appropriate level of cognitive load. Since intrinsic load related to a given learning event is beyond the ability of the designer to control, the designer’s task is to minimize extraneous load while finding the correct level of germane load. Such balancing requires an extensive understanding of working memory. Given that the amount of cognitive load can be calculated through the addition of intrinsic,
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

extraneous, and germane load, a total cognitive load which approaches or exceeds working memory (in either the visual or auditory system) will result in excessive cognitive load (2003). Essentially, learning is adversely impact when cognitive load surpasses working memory (De Jong, 2010).

Method

Participants

An experiment to determine appropriate design methodologies for a given population related to these elements could be done in a setting where a broad demographic variety of people might gather of their own volition, such as a museum research and learning center or similar public venue. Ideally, an ample population of people from varying backgrounds would participate. Participants would be asked basic demographic information, such as age, gender, and level of education. The experiment as described below would be appropriate for ages 13 and older.

Procedure

Prior to the commencement of the experiment, participants would be asked to complete a brief questionnaire to self-assess their expertise on the subject matter of a video they will be shown. The participants’ prior knowledge of the subject matter could be used as an additional variable. Upon completion of the questionnaire, participants would be randomly assigned to watch an instructional video in one of four modes. Each participant would draw a number from one to four, with each number being associated with a video mode. The video modes are video with audio (VWA), video with subtitles and no audio (VWS), video with text in proximity to relevant imagery (VWT), and video with both audio and subtitles (VWAS). Once assigned to a
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

video mode, the existence of the other video modes would not be shared with the participants in an effort to curtail any biases a participant might have toward a particular mode.

Aside from the mode of the video, each video would be identical. The video would be 10 to 15 minutes in length, with a Flesch reading ease value in the range of 60 to 70. The subject matter of the video would be obscure enough to ensure limited expertise within the general population.

Upon completion of the video, participants will be asked to spell three words in reverse to help mitigate the immediacy effects of having just seen the video. Participants will then be given a multiple-choice quiz related to the content of the video. Finally, participants will be interviewed briefly for open-ended reflections regarding the experience.

The quizzes would be scored and the interviews would be collected and analyzed for qualitative data. Correlations would be sought between quiz scores and interview responses as related to variables within the study. Such variables include the demographics of age, gender, and level of education, along with familiarity of the subject matter and video modality.

Discussion

The current study is likely to show quiz scores declining when deviating from video with audio. One possible reason for this is comfort and familiarity with the video with audio mode. Additionally, and consistent with dual coding theory, scores should be highest when video is presented with audio narration. In a study of design principles in animation, Hasler, Kersten, and Sweller (2007) found that visual images with concurrent narration do not create information redundancy, and therefore do not impose excess load on working memory. Rather, Hasler et al
indicate that the combination of audio and imagery were essential for enhanced comprehension (2007).

Beyond that, one deviation from the literature is expected. In accordance with the spatial contiguity effect, it would be expected that performance would be greater for the VWT group than it would for the VWS group. A potential weakness of the VWS mode is that the absence of spatial contiguity creates the need for excessive scanning. Moreno and Mayer (1999) assert that the lack of proximity between text and an animation adversely impacted performance. As such, it is far more important to maintain proximity between visual and textual components than it is to place text elsewhere for aesthetic purposes. In essence, text and visuals should be placed in a manner in which they can be processed concurrently. However, since video with subtitles is familiar because of closed captioning, and because video is an unfamiliar medium for visuals and text in proximity, one could argue that the difference will either favor the VWS group, or that no significant difference will occur. It is anticipated that the VWAS group will have the lowest scores, due to the redundancy principle. A study done by Kirschner (2002) using animation found that using animation with narration was superior to animation with narration and text.

No significant difference is anticipated due to age or gender. However, some significant difference could be attributed to educational background or familiarity with the subject matter. Renkl and Atkinson noted that learner levels affected intrinsic cognitive load. For participants less familiar with the subject matter, intrinsic cognitive load is increased due to less support from established schemas. As more schemas are formed, working memory availability increases (2003). Paas, Renkl, and Sweller (2004) highlight the importance in designing with schemas in mind, stating that schemas can become automatic through practice which in turn frees working
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

memory. Therefore, the creation of instruction should include means for developing and automating schemas.

One significant limitation of the study is that no participant is subjected to more than one video format. This decision was made as a matter of practicality, as it may be unreasonable for a participant to view the same video four different times in four different video formats. Additionally, four viewings of the same video, regardless of format, would have necessarily skewed the test results.

The implications for this study will be the affirmation or challenge of the previously-mentioned multimedia theories. This potentially could shape theories and practices related to instructional design, specifically as they relate to the growing trend of video-based learning. Such practices may impact closely-related media, such as asynchronous, self-paced eLearning.

Conclusion

The purpose of this study is to support existing literature regarding instructional design practices for multimedia-based learning. A focal point of this investigation centers on the ever-growing occurrence of video-based learning. While much of the existing literature supports the theories cited in this paper, few if any of the studies behind those theories are specific to video-based learning.

This experiment supports the importance of considering cognitive load in the design of instruction. While most of the literature discusses excessive cognitive load, Brünken, Plass, and Leutner (2004) offer that extraneous load is irrelevant if the total cognitive load doesn’t exceed the capacity of working memory. Implications for future experiments include the need to ensure
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

that cognitive load exceeds working memory when attempting to quantify adverse impacts to learning.

Designers could be lulled into the trap of believing that the sole design principle is the reduction of extraneous cognitive load. According to Brünken, Plass, and Leutner, this is often achieved through the removal of all extraneous design components. Such minimalism in design may create learning materials with low extraneous cognitive load, but may lack effectiveness due to a lack of interesting design elements. Thus, other design considerations must be balanced against imposed cognitive load (2004).

Few dispute the relationship between cognitive load theory and instructional design. De Jong discusses how instructional systems relate directly to both cognitive load theory and working memory. De Jong further explains that working memory capacity is tied to learning abilities and academic success (2010).

The results of this experiment should further additional study in related areas. One potential area for further examination is asynchronous, self-based eLearning, which often mirrors and even incorporates video elements. The proliferation of eLearning and video, especially in corporate environments, provides a fertile environment for additional research. Other forms of interactive media may benefit from the results of this experiment as well. One example of a growing interactive medium where such study may be useful is in desktop publishing, including eBooks and digital publications. Study could be ever further extended to web sites on various mobile learning platforms. A final area of additional research would be the allowance of participants to control the starting, stopping, and rewinding of the video. In working with animation, Hasler, Kersten, and Sweller concluded that this type of element activity could
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

improve test outcomes (2007). More research should be done to determine if such results are
generalizable to video-based learning.
EFFECTS OF MODALITY, CONTIGUITY, AND REDUNDANCY

References


