Multimedia, Multimodal Effects, and Universally Designed Instruction

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Abstract

Cognitive psychology often describes learning as the acquisition and reorganization of cognitive structures [1]. These cognitive structures can be viewed as mental codes, temporary internal representations based on sensory experience [2-6]. In multimedia learning, the representations might involve more than one modality, and therefore have complex influences on the formation of memories [7]. A theoretical basis for the formation and use of multimodal mental codes based on multimedia can be used to better understand how presentation influences learning, especially for people with sensory and cognitive impairments. In turn, testing effects on people with such impairments will shed light on the relative contribution of cognitive versus sensory effects.

1. Introduction

Multimedia provides a complex multi-sensory experience in exploring our world through the presentation of information through text, graphics, images, audio and video, and there is evidence to suggest that a mixture of words and pictures increases the likelihood that people can integrate a large amount of information [7]. Advantages of multimedia design compared to using a single medium might result from the ability to choose among media to present well-structured information [8], using more than one representation to improve memory [3, 6], encouraging active processing [9], and presenting more information at once [7, 10].

In the domain of educational psychology, there is some debate over whether the media used to present information matters. Some contend that differences between treatment groups are due to the instructional method delivered by the media, not the media itself [11]. Others argue that the most powerful attribute of multimedia is its ability to employ combinations of media to enable and constrain how information is presented [12]. I believe that exploring the unique capabilities of a medium and interactions among media with a theoretical basis describing the use of multimodal mental codes can help us understand the particular design mix that will work for a particular task and learner.

2. Review

Learning is the acquisition or reorganization of the cognitive structures humans use to store and process information [1], a process dependent upon working memory [13]. Therefore, instructional design guidelines can be improved through an understanding of working memory [7]. Within working memory, mental codes (i.e., temporary internal representations) are the basis of cognitive processes. Working memory theories characterize cognitive activity as operations combining a processed recoding of sensory input stored in modality-related working memory subsystems. The complex effects of multimodal mental codes, that is, situations in which people are thought to be operating on codes that vary in type and characteristics, have been studied in depth [2-6]. Though the amount of processing involved in the conversion of information from sensory input to internal mental code is a subject of debate, the eventual mental code is commonly thought to depend in part upon the sensory modality of the input from which it is derived.

This assumption is problematic for people with severe sensory impairments, in that presentations can be sensed in only one modality. Research regarding visual materials has been criticized based on the resemblance fallacy: the false assumption that internal representations (resultant mental codes) have the same characteristics as external representations (e.g., graphical representations) [14]. The modal form of information in a representational/processing code format might not be dependent upon its physical form in the world [15]. Therefore, research on modality effects has been – and should be – performed with the caveat that verbal material can evoke the construction of visual representations, and visual material can evoke the construction of verbal representations [6, 7].

Furthermore, there is evidence that regardless of physical presentation modality, there exist circumstances in which a given task may be performed using either a verbal or spatial strategy [16]. Hence, it is possible that the memory codes formed by people with sensory impairments do exist in multiple modalities regardless of the limitations in how the information is sensed. This is consistent with
finding that the benefits of mixing narrations with diagrams [7], are similar to benefits of using pictures and sign language for the deaf [17].

The maintenance and quality of memories depend upon modality of internal representations. Penney [3] characterizes auditory codes as rich and durable compared to visual codes, and Larkin and Simon [8] identify strengths and weaknesses of diagrammatic and verbal information based upon the processing required to interpret kinds of information. In previous studies I have found that the media used to present equivalent information have produced no significant differences in learning [18], contrary to the typical multimedia effect [7, 10]. We believe these results demonstrate an instance when learning depends upon mental codes, not the media. Other conditions under which the external representation of information does not matter are of interest. Future studies manipulating study time, complexity of materials, and learning content are planned. Understanding these boundary conditions may provide further insight into the nature and characteristics of mental modalities, mental codes and cognitive processes.

These boundary conditions are relevant to aiding instruction and have implications for universal access and information presentation. I aim to explore when certain media are beneficial or detrimental to learning in people with sensory impairments. For the same reason that narrations improve learning compared to text [7], closed captioning may reduce learning of people with a hearing impairment. When information is best presented via diagram [8], how can you convey information that same informational content to a blind person? If individual differences in learners change the effects of providing multimedia [7], what predictions can we make about the way cognitive impairments change the effects of multimedia? The overall goal is to find the types of content and media that are appropriate for different disability groups.

Additionally, there can be a reciprocal effect of creating better design for people without disabilities. That is, general design guidelines for multimedia can benefit from an analysis of effects on people with cognitive and sensory impairments. Such guidelines can contribute to the design of universally accessible instruction and inform applications used to customize content [19].

10. References
