The Impact of Colors on Learning

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Abstract: The purpose of this review paper is to find out how colors can impact leaners' learning by manipulating their cognition and emotions.

Keywords: Colors, memory, cognition, emotion

Introduction

The use of colors in instructional materials has proven to play an important role in creating different emotional reactions and capturing learners' attentions. The purpose of this review paper is to find out how colors can impact leaners' learning by manipulating their cognition and emotions. In this paper, we will specifically review scholars' studies on how memory functions, how colors influence learners' memory performances and their cognitive loads, and how colors stimulate learners' emotions and further motivate learners to learn.

A visual design has two functions: One is to support learners to process materials cognitively, and the other is to influence leaners' attitude and motivation effectively (Moreno, 2007; Plass, Heidig, Hayward, Homer, & Um, 2014). In other words, the first function is to influence learners' cognition, and the second function is to influence learners' emotions.

Learners' cognitive abilities refer to the way learners "perceive, pay attention, remember, think, and understand the lessons" (Dzulkifli, & Mustafar, 2013, p. 3). Based on some scholars' works on cognitive loads (such as Gerjets &Scheiter, 2003; Pollock, Chandler, & Sweller, 2002; Renkl & Atkinson, 2003), Brunken, Plass, and Leutner (2003) stated that a learner's cognitive load includes the sum of intrinsic, extraneous, and germane loads. Intrinsic load refers to the load caused by "the structure and complexity of the materials" (p.54), which cannot be manipulated by instructional designers. Extraneous load refers to the load caused by how information is presented. Germane load refers the load caused by "learners' efforts to process and comprehend the material" (p.54). The latter two loads can be manipulated through instructional design. Sweller, van Merriënboer, and Paas (1998) stated that working memory load "may be affected either by the intrinsic nature of the material (intrinsic cognitive load), or alternatively, by the manner in which the material is presented, or the activities required of students (extraneous cognitive load)" (p.259). Extraneous cognitive load can be changed by

instructional interventions, but not intrinsic cognitive load since it has something to do with the material.

Color and Memory

The structure of memory includes sensory memory, short-term memory, and long-term memory (Atkinson & Shiffrin, 1968). When information first reaches the sensory memory, it will give a short amount of attention to the incoming information, analyze its physical and sensory characteristic, and then move the information to the short-term memory for recognition and labelling. The information which is further analyzed will move to the long-term memory for permanent storage (Dzulkifli & Mustafar, 2013).

Attention is required when learners scan the information and select those parts "that require further processing" (MacKeracher, 2004, p.105). "When we pay attention to certain information, we are actually selecting and focusing certain amount of information to be processed in our cognitive system" (Dzulkifli & Mustafar, 2013, p. 4). Colors help learners increase their attention levels on certain information, which help such information to be transferred to short-term and long-term memories, thus increasing their chance of memorizing such information (Dzulkifli & Mustafar, 2013). For example, warm colors such as red, orange, and yellow have been recognized as the ideal colors to increase learners' attentions and stimulate their active participations in activities (Wilson, 1966). Dzulkifli and Mustafar (2013) stated that arousal, "the state of being alert physically and internally" (p.5), can enhance short-term and long-term memories.

The brain structures include spatial and visual processing of working memory; the *spatial system* is modality independent and processes only spatial cues, while visual system is modality dependent and processes only visual cues (Keller & Grimm, 2005). Color can help learners improve their earning efficiency (Vetter, Ward, & Shapiro, 1995), since learners can process color automatically without requiring conscious process (Keller & Grimm, 2005). Based on previous studies, Keller and Grimm (2005) reported that color as a graphical device can reduce visual search time and might support learners to quickly access information. Kumi, Conway, Limayem, and Goyal (2013) stated that color "can enhance the organization and presentation of information, decrease search times, and enable the identification and organization of information" (p.5). Color is a clue which helps learners retrieve information (Hanna & Remmington, 1996; Keller & Grimm, 2005). Compared with the monochromatic information, color-coded information visualizations can better support knowledge acquisition (Keller & Grimm, 2005).

Changing the hue can affect recall (Isen, Daubman, & Nowicki, 1987). For example, "using a blue background increases the likelihood that the information delivered will be remembered" (Kumi, Conway, Limayem, & Goyal, 2013, p.12). The respondents "exposed to a blue background had some reason other than their affective reaction to the color blue for having a higher recall of the presentation than respondents exposed to a yellow background" (Kumi, Conway, Limayem, & Goyal, 2013, p.12).

Mehta and Zhu's (2009) study indicates that different colors can affect "performances on different types of cognitive tasks" (p. 1045). Specifically, red, associated to danger and failures, can activate a prevention focus to remind people to prevent such negative outcomes, thus enhancing performance on detail-oriented cognitive tasks such as a memory task, proofreading and accuracy related task, and task requiring attention to detail. Red enhances persuasion. Blue, associated to openness and freedom, can activate a promotion focus to promote people to achieve positive outcomes, thus enhancing creative tasks.

Color, Emotions and Cognition

Color affects behavior as well as cognitive abilities, performance, and intentions (Kumi, Conway, Limayem, & Goyal, 2013). Some scholars regarded that colors help learners increase their arousal. Greene, Bell, and Boyer's (1983) study indicates that among 10 different hues, yellow hue shows higher arousal and evaluation results than other colors, even though there is no much difference in terms of which colors influence people's boredom. A study conducted by Plass, Heidig, Hayward, Homer, and Um (2014) indicates that warm colors such as yellow and orange rather than cold colors such as gray used in materials can enhance students' learning.

Positive emotions/moods help learners recall more possible functions for an object from long-term memory (Isen, Shalker, Clark, & Karp, 1987). Learners recognize incoming information by comparing such information to the information stored in memory (MacKeracher, 2004). Positive emotions help learners retrieve the other positive information saved on their memory. Isen, Shalker, Clark, and Karp (1978) stated that "a positive event may cue other positive material in memory, and this may establish both the cognitive loop that we have proposed as the mediator and the phcnomonologically experienced emotional state of feeling good" (p. 11). For example, instructors use different colors to highlight students' texts to differentiate the various levels of the knowledge produced by learners. Such highlights may increase learners' attentions since they cue instructors' views of their work, thus emotionally motivate learners' learning. Plass, Heidig, Hayward, Homer, and Um (2014) found that:

> learners using the positive emotional design variant perceived these materials as less difficult, invested more mental effort in processing of the content, and reported higher levels of motivation, satisfaction, and perception toward the learning materials than learners receiving the neutral design variant. (P. 10)

Color "can produce an emotional arousing effect. But the degree or range of arousal varies depending on the emotional element that is attached with specific type of colour" (Dzulkifli, & Mustafar, 2013, p. 6). Learners may have different interpretations of colors due to their prior experiences of colors or their assumptions of colors associated with cultural norms and events in their lives. For example, Green is associated with calmness, and black is associated with sadness (Dzulkifli, & Mustafar, 2013). Red and violet, falling "on the fringes of the visible spectrum, often occur in association with the potentially dangerous wave-lengths just outside" (Wilson, 1966, p. 949). Wilson (1966) stated that "the red was variously described as more stimulating, exciting, awakening, attention-drawing, overpowering, and lively" (p. 948). He predicted that "arousal values of various hues are related thus: R>O>Y>G>B>I>V" (p. 949).

Colors have different meanings in different cultures. Affective reactions to colors varies with culture (Adams & Osgood, 1973). Kumi, Conway, Limayem, and Goyal (2013) stated that it is possible that "reactions of Americans to blue and yellow may differ from the reactions of people in other cultures" (p.13). US residents may favor blue, while the citizens in other cultures may favor other hues.

Implications

Information processing systems of working memory have their own limitation in cognitive capacity. The goal of the instructional design is to decrease the cognitive overload in the information-processing systems (Keller & Grimm, 2005).

Information processing systems were differentiated into different systems, including verbal, visual, and spatial information processing systems, among which the visual information processing system is modality dependent and processes only visual cues (Keller & Grimm, 2005; Logie, 1995). According to Mayer (2014), two information-processing systems, auditory/verbal vs. visual/pictorial, all have limited capacity. To decrease the cognitive load, it is necessary for information to be presented as both verbal (e.g. text) and pictorial. Cognitive processing can be overloaded with too much information. Instructional designs should help to reduce cognitive overload and use multiple presentation codes (verbal, pictorial, spatial) to split up the cognitive load on different information processing systems for better processing and memory.

Brunken, Plass, and Leutner (2003) stated that "the same learning material can induce different amounts of memory load when different instructional strategies and designs are used for its presentation" (p. 54). Using colors in teaching and learning can help instructors manipulate adults' learning. The findings of this review can inform practitioners about better color choices they can use in highlighting learning materials. It can inform the design of future instructional materials, particularly when it comes to the use of specific highlighting colors. This review can also provide practitioners the color choices that can be used to help learners increase their attentions to materials and help practitioners see the connections between colors, emotions, and cognitive learning.

Positive emotions can improve cognitive and affective outcomes (Um, Plass, Hayward, & Homer, 2012). Knowing how colors affect behaviors is informative for designers and environmental psychologists in terms of how to use arousing hues (warm colors such as red, orange, and yellow) to prevent learners from getting bored, and passive hues (cold colors such as green and blue) to keep learners calm (Wilson, 1966).

Information representations should be designed to deter cognitive overload to find out if information visualizations can be used to acquire knowledge through memorizing and understanding abstract data structures and how or in what way information visualizations need to be designed to support acquiring knowledge.

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