EFFECTS OF BACKGROUND MUSIC IN INSTRUCTIONAL VIDEOS ON LEARNERS' RETENTION

Van Thanh Phan, University of Economics Ho Chi Minh City*
thanhptv@ueh.edu.vn
ORCID: 0000-0002-2631-3094

ABSTRACT

Multimedia instructional materials are indispensable in the holistic process of instructional design, particularly for asynchronous online courses. The purpose of the current study was to investigate the impacts of background classical music played in an instructional video on learners' retention. The video started with a pretraining message followed by a narrated instructional content. The results of the study suggest that although classical background music in the pretraining message significantly improved learners' retention, it did not have a remarkable influence when embedded in the narrated content. Practical implications and suggestions for further research are provided.

Keywords: *multimedia learning, instructional videos, background music, pretraining*

INTRODUCTION

Instructional videos are an integral component of learning materials. Prerecorded lectures, screencasts, explainers, scenarios, simulations, and how-to videos are among the most common forms of videos used in educational settings. They act as an excellent enabler for conveying learning content in online courses when students and instructors do not meet in person or interaction occurs intermittently with a time delay (Cooper & Higgins, 2015; Hsin & Cigas, 2013; Laster-Loftus & Cooper, 2019). Given that instructional video production is a complicated, time-consuming, and often costly process that requires significant pedagogical knowledge and technical skills, it would be prudent to take into account first of all whether the instructional videos are truly necessary and subsequently how to design and develop them for assisting students in achieving learning outcomes. The importance of pedagogical values of multimedia learning materials was, indeed, emphasized by Clark (1983, 1994, 2012) in his argument related to the renowned quote "the media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition" (Clark, 1983, p. 445). It may not always be necessary to utilize expensive cutting-edge technologies and exploit invaluable human assets for producing instructional videos; educational budgets should be spent on technologies that yield certain pedagogical implications. The goal is to utilize media effectively and efficiently to deliver instruction (Alammary et al., 2014; Erbas & Demirer, 2019; Kozma, 1991, 2001; Ross & Morrison, 1996; Shuja et al., 2019; Tamim, et al., 2011; Yang et al., 2014). The current paper targets the pedagogical significance of background music in instructional videos.

It is commonly believed that background music is added to multimedia messages to make instructional presentations appealing to audiences (Garner et al., 1989; Garner et al., 1992; Groot, 2006; Shirey & Reynolds, 1988; Schön et al., 2008). The practice of adding background music into a learning environment stems from the ubiquitous occurrence of background music in everyday life. People listen to music when they drive, cook, eat, relax, shop, and drink, to name a few activities. Classical music was found to be the least distracting to learners compared to vocal music and other instrumental music (Iwanaga & Ito, 2002; Ransdell & Gilroy, 2001; Salamé & Baddeley, 1989). Classical music lists conducive to student learning are updated frequently on Spotify, YouTube, and Pandora, and attract a great number of listeners.

Classical music was shown to have a positive impact on cognition and learning because it promotes a relaxing state of the mind and leads to super-learning (Akbiyik & Şimsek, 2009; Küssner, et al., 2016; Lazanov, 1978; Lehmann, et al., 2018; Ostrander et al., 1979). Many other researchers have also found background classical music to have positive effects on human brains by enhancing concentration and learning (Day et al., 2009; Groot, 2006; Hallam et al., 2002; Lazanov, 1978; Mammarella et al., 2007; Schellenberg et al., 2007; Thompson et al., 2001). Hidi (1990), Hidi and Renniger (2006), and Weiner (1990) explained their findings based on the arousal theory and the interest theory. Per the arousal theory and the interest theory, background music is a factor in arousing learners' emotions and holding their attention, thus leading to increased learning. Adding music into instructional materials could also be supported by the multisensory learning approach, which maintains that learning is more effective if it occurs in multimodal forms, i.e., audio, visual, kinesthetic, and tactile (Broadbent, et al., 2018; Shams & Seitz, 2008).

On the other hand, a number of other studies on background music in multimedia messages have found that adding background music into multimedia messages is distracting to learners (Halpern et al., 2007; Harp & Mayer, 1997; Lehmann & Seufert, 2017; Mayer, 2005; Moreno & Mayer, 2000; Musliu, et al., 2017; Ransdell & Gilroy, 2001). These studies support the cognitive theory of multimedia (Mayer, 2021), which indicates that human working memory has limited space and adding background music will overload the working memory. Mayer (2021) indicated that background music is a kind of extraneous and seductive detail that should be excluded from multimedia messages.

Conclusions on the use of background classical music in multimedia learning appear to be equivocal and open to further studies (de la Mora Velasco & Hirumi, 2020; Goltz & Sadakata, 2021; Gonzalez & Aiello, 2019); therefore, the affirmation that music should not be added to instructional videos needs to be carefully scrutinized (Eitel & Kuhl, 2019). Mayer's research findings have been confirmed only in experiments on multimedia messages that were created for university students, about how brakes work and how lightning is produced. His conclusion that background music impedes learning needs to be explored in other instructional content areas and contexts especially when background music interacts with other forms of instructional strategies such as pretraining—a strategy for managing essential processing.

The pretraining principle maintains that people learn better from multimedia lessons when they know the names and characteristics of the main concepts (Mayer, 2021). Pretraining is believed to reduce the cognitive load when both the audio and visual channels are overloaded with essential processing demands for complex and unfamiliar instructional materials. Once the cognitive load is facilitated and managed properly, learning could occur more easily even when there is a certain source of seductive details such as background music in the videos (Park et al., 2011).

The current paper's primary goal was to examine whether background instrumental music played in instructional videos has an impact on a learner's retention when coupled with the pretraining technique. Findings could contribute to identifying scientific patterns and guidance for whether and how to utilize background music properly in instructional videos. Additionally, they could delineate the boundaries of the attention theory, the arousal theory, the interest theory, and the cognitive theory of multimedia. In particular, the study investigated the retention effects of providing (a) a pretraining message with background music versus without background music and (b) an instructional content with background music versus without background music. The research questions comprised:

1. Are there significant mean differences in retention between students studying a pretraining message with music and those studying a pretraining message without music?
2. Are there significant mean differences in retention between students studying an instructional content presented with music and those studying an instructional content presented without music?
3. Is there a significant interaction on retention between a pretraining message (with

versus without background music) and an instructional content (with versus without background music)?

THEORETICAL FRAMEWORK

This study is grounded in attention theory, arousal theory, interest theory, and the cognitive theory of multimedia learning. Attention theory, arousal theory and interest theory advocate the idea that adding background music into instructional materials will aid learners' attention and improve their learning. On the contrary, the cognitive theory of multimedia learning (Mayer, 2021) generally maintains that adding background music into instructional videos will hurt learning.

Attention Theory

Attention is defined as a filter of information from the environment and a resource allowing the processing of information to occur after being filtered (Wikens, 2021). It could be categorized into two major types, i.e., passive and active (Ratey, 2001). Passive attention means the involuntary process that occurs due to the external and environmental factors such as loud noise, fragrance, or light, whereas active attention refers to the voluntary effort prompted by concentration, needs, and interests. Attention is essentially the first step in the learning process and allow learners to concentrate on the learning content (Ahissar & Hochstein, 2002; Hidi, 1995; Mason, 2010; Schmidt, 1995; Stadler, 1995). It has been found that music improves attention among learners by its rhythm, melody, and harmony (Kasuya-Ueba et al., 2020; Thaut & Gardiner, 2014) and that nonvocal music is better for attention span compared to vocal music (Perham & Currie, 2014; Pryse-Phillips, 2003; Rauscher et al*.,* 1993; Shih et al., 2012). It could, therefore, be hypothesized that music may have a positive impact on attention which in turn would foster learning.

Arousal Theory

Arousal theory explains the relationship between classical music and cognition in that classical music induces differential affects that, in turn, may influence cognition. It had dominated research on motivation in the past (Weiner, 1990). According to arousal theory, students learn better when they are emotionally aroused (Heuer & Reisberg, 1992/2014), especially by music that induces positive and pleasant emotion**s** (Husain et al., 2002). The theory predicts that adding entertaining auditory elements will make learning more interesting, enhancing learners' overall emotional arousal and thereby increasing motivation for learning. Aroused positive emotions have been found to enhance intrinsic motivation (Horan et al., 2012; Moè, 2016; Um et al., 2012), relax the mind to boost effective learning (Norman, 2004), and foster flexibility, thinking, and problem solving (c & Branigan, 2005) as well as cognitive learning (Kelley & Gorham, 1988). It can be presumed that learners will learn more from multimedia messages that include interesting music and pictures than from multimedia messages that do not.

Interest Theory

Interest theory (Hidi, 1990; Hidi & Renniger, 2006) states that interest is a motivational factor that positively impacts learning and predicts that learners with higher levels of interest in the instructional materials have higher levels of attention, recognition, effort, and retention. There are two types of interest: emotional interest and cognitive interest (Kintsch, 1980; Mazer, 2013). The theory predicts that adding interesting music and pictures enhances learners' emotional interests. However, it remains unclear whether seductive details will also enhance cognitive interests that help learners build schemas.

Cognitive Theory of Multimedia Learning

The other side of the study's theoretical framework is the cognitive theory of multimedia. Mayer (2021) proposed the cognitive theory of multimedia learning, which is based on three assumptions: (a) there are two separate channels (auditory and visual) for processing information, (b) there is limited channel capacity, and (c) learning is an active process of filtering, selecting, organizing, and integrating information. The first assumption about dual channels relates to the dual coding theory. The dual coding theory (Paivio, 1971) presents an explanation of how human brains work to process information. Dual coding theory assumes there are two cognitive systems: (a) one specialized for the representation and processing of nonverbal objects/events, and (b) the other specialized for dealing with language. There are three types of processing: (a) representational—the direct activation of verbal on nonverbal representation, (b) referential—the activation of the verbal system by the nonverbal system or vice versa, and (c) associative—the activation of representations within the same verbal or nonverbal system.

The second assumption of the cognitive theory on multimedia learning regarding limited capacity in the audio and visual channels is based on the cognitive load theory, which is deeply rooted in the information processing theory. Information processing theory is the idea that humans process information rather than merely responding to stimuli. It explains the cognitive process, which involves perceiving, recognizing, imagining, remembering, thinking, judging, problem-solving, conceptualizing, and planning. Employing aspects of the information processing theory, John Sweller (1988) proposed the cognitive load theory, which emphasizes that working memory is limited. If the complexity of instructional materials is not properly managed, learners will experience a cognitive overload, which has detrimental effects on learning by impairing schema acquisition (Sweller et al., 2011).

The third assumption of the active process of information also relates to the information processing theory. Fundamentally, it states that humans actively engage in the process of "paying attention, organizing incoming information, and integrating incoming information with other knowledge" (Mayer, 2021, p. 50). Mayer (2021) contrasted this assumption with the view of humans as passive processors of information.

Generally, the cognitive theory of multimedia learning maintains that information should be presented in such a way that working memory should not be overloaded. Classical music can be an extraneous cognitive load and should be excluded from instructional multimedia messages. The coherence principle, stemming from the cognitive theory of multimedia learning, claims that seductive details, including background music, could unnecessarily occupy working memory and disrupt learning (Clark & Mayer, 2016; Mayer, 2021). Moreno and Mayer (2000) conducted two experiments for lightning and brakes presentations, when students received both background music and environmental sounds and concluded that students' retention and transfer performance was worse than when they received neither. The study yielded a very high effect size of 1.66. Mayer (2021) asserted that music would likely produce an extraneous cognitive load and inhibit learning.

The pretraining principle, also developed from the cognitive theory of multimedia learning, asserts that learners learn better if they know the key concepts of the instructional material in advance (Mayer, 2021). Mayer et al. (2002) conducted three separate experiments to test the effects of pretraining on learners' transfer performance. The results of this study showed that learners who received pretraining outperformed those who did not, yielding a medium effect size of .9. Pretraining reduces the cognitive load when both the learners' audio and visual channels are occupied with essential demands created by the inherent complexity of the material. The implication of pretraining techniques is to better manage the essential processing demand by reducing the cognitive load of the instructional materials and devoting more of the working memory to processing information.

METHODOLOGY

Participants and Design

We collected data from 92 undergraduate freshman (18–22 years old) business students, attending a large university in South Vietnam (66 females and 26 males). All students' English levels were at least IELTS (International English Language Testing System) 5.0 or an equivalent of IELTS 5.0. It was the program admission requirement that students submit their valid IELTS certification (of 5.0 or higher) or passed an institutional placement English test. All subjects in the program were taught in English. The students' English proficiency levels were overall adequate for them to understand the content of the instructional videos with minimum obstacles caused by linguistic barriers. The participants were enrolled in an undergraduate general English for business communication course. Their participation was completely voluntary and not related to any kind of monetary incentives or class grades.

The study employed a two-by-two factorial design with two pretraining message levels (with music and without music) and two instructional content levels (with music and without music). The dependent variable was retention of an instructional video about American literature. To justify the sample size of the study, a priori power analysis was conducted with G*Power software (Faul et al., 2009). To have a medium-to-large effect ($f = 0.35$) for a two-way analysis of variance (ANOVA) test, the power analysis indicated an estimated sample size of 90. Participants were randomly assigned to one of the four conditions: (1) pretraining with music/instructional content with music (n = 23, 15 females and 8 males), (2) pretraining with music/instructional content without music (n = 23, 8 females and 15 males), (3) pretraining without music/instructional content with music (n = 22, 21 females and 1 male), and (4) pretraining without music/instructional content without music (n = 24, 22 females and 2 males).

Materials

The instructional video contained an initial pretraining message followed by instructional content. The pretraining message included a character list with names and roles of major characters automatically shown one at a time. The pretraining message was presented in two forms—with music and without music. The instructional content of the current study's experiment was a brief video of 7 minutes and 44 seconds summarizing the story *To Kill a Mockingbird*. The video was selected because of its unfamiliarity to participants and its appropriate length not to overload learners. Regarding the instructional content, one condition included illustrating static graphics, narration, and background music, whereas the other only contained illustrating static graphics and narration.

The Mozart Sonata K. 448, 2nd Movement—Andante was selected as the background music piece for the video with background music because of its possible positive effects on learning (Hetland, 2000; Jackson & Tlauka, 2004; Jausovec & Habe, 2005; Lazanov, 1978; Padulo et al., 2020; Pryse-Phillips, 2003; Rauscher et al., 1993, 1997). The 2nd Movement—Andante did not vary dramatically in tempo or volume, which reduced the likelihood of startling participants. Additionally, the Mozart Sonata K. 448, 2nd Movement—Andante was not a very popular classical music piece among most people who did not have a strong interest or extensive experience with classical music. This helped minimize the episodic and semantic memory corresponding with the music piece, which could lead to preferential/biased processing of the verbal stimuli (Jäncke & Sandmann, 2010). The music volume was kept at its original loudness level in the pretraining message and dimmed down to −10 dB in the instructional content with audio narration still at the normal rate of 0 dB to make the narration audible to participants.

Criterion Measures

The criterion measures of the study consisted of a participant questionnaire and a retention test. All measures were completed by the participants via mobile phone. The participant questionnaire solicited demographic information and their recall of the story *To Kill a Mockingbird*. The prior knowledge question was "How much do you know about the story *To Kill a Mockingbird*?" Participants rated their knowledge of the story on a 5-point scale (*Not at All—Very Well*). The retention test comprised six multiple-choice questions about the key points of the instructional content. For each question answered correctly, participants scored 1 point. The test was validated using Cronbach's alpha, which yielded a value of .915, suggesting that the test items had relatively high internal consistency. The questions and corresponding response options were:

1. What was Tom Robinson suspected of?
   - A. Robbing.
   - B. Raping.
   - C. Stealing.
   - D. Smuggling.
2. Scout and Jem got teased because....
   - A. they did not have a mother.
   - B. their father defended a black man.
   - C. they did not perform well at school.
   - D. their father was a bad lawyer.
3. On which occasion were Scout and her brother attacked?
   - A. Easter.
   - B. Halloween.
   - C. Thanksgiving.
   - D. Christmas.
4. When discussing how to solve the problem of Bob's death, Atticus wanted to say that....
   - A. Jem killed Bob in self-defense.
   - B. Scout and Jem killed Bob in self-defense.
   - C. Boo Radley killed Bob to protect the children.
   - D. Bob tripped off a roof and fell on his own knife.
5. What did the sheriff decide to say?
   - A. Jem killed Bob in self-defense.
   - B. Scout and Jem killed Bob in self-defense.

Table 1. Means and Standard Deviations for Retention

	Pretraining with music		Pretraining without music	
	Instructional content with music (*n*=23)	Instructional content without music (*n*=23)	Instructional content with music (*n*=22)	Instructional content without music (*n*=24)
Retention score	3.74 (.86)	3.87(1.35)	3.32(1.04)	2.88(1.42)

Note: Standard deviations are presented in parenthesis.

C. Boo Radley killed Bob to protect the children.
D. Bob tripped off a roof and fell on his own knife.

6. Why did Boo Radley ask Scout to walk him home?
   A. Because he did not know the way home.
   B. Because he was afraid.
   C. Because he did not want others to see him go alone.
   D. Because he felt lonely.

Procedures

The study was conducted in classrooms with 20–25 students evenly divided into treatment groups in each experimental session. The main investigator came into the room and began by explaining the general goals of the study. The participants were also informed that they would be asked to complete several questions related to the experiment; however, they were not informed of the specific purpose of those questions. Next, each participant randomly received a slip of paper that included the link to the survey pertaining to the treatment condition. Participants typed in the survey link on their cellphones and followed the instructions to participate in the study. They each answered demographic questions, watched the assigned instructional video, and answered the six retention test questions. The assigned instructional videos were different for each group: (1) pretraining with music and instructional content with music, (2) pretraining with music and instructional content without music, (3) pretraining without music and instructional content with music, and (4) pretraining without music and instructional content without music. Participants' separate cell phones/earphones allowed them to watch the videos individually without being interrupted by the videos and audios from other treatment conditions. Demographic questions and retention test items were the same for all groups.

RESULTS

Data were screened to ensure that the assumptions of factorial ANOVA were met. To eliminate outliers, cases with retention scores of 0 or no answers to very few answers to demographic questions were removed. The outliers were altered with a maximum (retention score of 5)/minimum (retention score of 2) values. A univariate ANOVA was conducted. Table 1 shows the means and standard deviations by pretraining types (pretraining with music versus pretraining without music) and instructional content presentation (instructional content with music and instructional content without music).

The results revealed that there was a significant effect of music in the pretraining message on retention at the $p < .05$ level ($F[1,88] = 8.01$, $p = .006$, partial $\eta^2 = .083$). On the other hand, the effect of the music played in the background of the instructional content presentation on retention scores was not significant ($F[1,88] = .39$, $p = .53$, partial $\eta^2 = .004$). No interaction effects were found between the pretraining message (with music versus without music) and instructional content (with music versus without music) ($F[1,92] = 1.32$, $p = .26$, partial $\eta^2 = .015$).

DISCUSSION

The present study compared the differential effects of background classical music on learners' retention. The results show that background music played in the pretraining section of an instructional video had a significant effect on learners' retention. Learners studying with the pretraining message that had background music recalled more details of the instructional content than those who studied without background music in the pretraining step. The finding supports and extends previous research regarding attention theory, arousal theory and interest theory, which overall predicted that adding background music would enhance learners' overall emotional interests and motivation and thereby increase learners' performance (Hidi, 1990; Hidi & Renniger, 2006; Kasuya-Ueba et al., 2020; Mason, 2010; Thaut & Gardiner, 2014; Weiner, 1990). It did not uphold the coherence principle (Mayer, 2021)— adding music in the pretraining message with key character names and roles did not appear to significantly hinder information processing but actually boosted retention of the instructional content. It could be argued that because the audio and visual channels were properly operated with only music in the audio channel and on-screen text in the visual channel, the coherence principle did not apply. In other words, in the pretraining section the only stimulus processed in the audio channel was the background music; there was no audio narration accompanying it.

At the same time, it should be noted that the retention scores of the groups studying with music in the instructional content with narration and those studying without music showed that background music did not have a significantly different impact. Consequently, the assumption that adding background music will overload learners' cognition was overall not validated in the current study. Neither the cognitive theory of multimedia learning nor the theories advocating the use of music in facilitating learning—attention theory, arousal theory, and interest theory—were confirmed. One plausible explanation for the fact that background music did not inhibit retention when played simultaneously with audio narration is that the pretraining message presenting the key characters' names and roles had successfully reduced the cognitive load of the instructional content, leading to retention occurring regardless of the background music (Park et al., 2011). It should also be noted that the background music in the instructional content was dimmed down to −10 dB to enable audibility for the narration. It could be reasoned that the music was not loud enough to startle or distract the participants, thus did not intrude on their comprehension of the story. If this was the case, further research should investigate the level of background music volume and its ratio to audio narration volume at which learning could start to degrade.

Several limitations of the study require cautious interpretation of the findings. First, the study did not measure the motivation or interest level of learners, nor was the correlation of motivation to learning performance explored. Although it came to our awareness that background music confirmed the attention, arousal, and interest theories, more meticulous and accurate measures of how background music correlates with attention, arousal, and interests in affecting retention should be carefully researched. Second, a study undertaken with a reasonably small sample may not warrant the generalizations regarding how background music affects retention. While findings allowed confidence in arguing that background music in the pretraining proved the benefits of adding music to enhance retention, a larger sample size could have provided better external validity.

In summary, the findings of the study partly supported attention theory, arousal theory and interest theory. Background music added to the pretraining section improved learners' retention of the content presented in the instructional content. Nevertheless, background music that had to compete with narration in the audio channel did not prove to either significantly improve or hinder learners' retention. Working memory is limited and should be used economically; yet, adding background music into an instructional video should not be avoided at all cost for fear of violating the coherence principle. An important implication of the study is that music should be added to the display of content when there is not another source of audio narration played simultaneously. A combination of background music and narration is optional given the music volume is properly controlled. In the current study, the music volume was instinctively dimmed so that it is not too loud, startling, and distracting. A ratio of music volume to narration volume, therefore, is worth investigating in further research projects to provide more reliable methods for mixing the volume of background music and audio narration. In addition, further research should contribute to the knowledge of appropriate pairing options for music types and instructional content areas. Very little is known about the appropriate approaches to pair up musical genres and instructional content. Mozart's music was used in this study and shown to have effects on retention, where the instructional content was literature. Had the music been other instrumental types or the instructional content been math, business, or technology, the effects of music could have been different. Constructing similar research on different kinds of music and content may yield more insights into the effective patterns of embedding background music in instructional videos.

DISCLOSURE

This research is funded by University of Economics Ho Chi Minh City, Vietnam.

References

Ahissar, M., & Hochstein, S. (2002). The role of attention in learning simple visual tasks. In M. Fahle & T. Poggio (Eds.), Perceptual learning (pp. 253–272). MIT Press.

Akbıyık, C., & Şimsek, N. (2009). Accelerated learning in classroom and computer environments. Eurasian Journal of Educational Research, 37, 32–52.

Alammary, A., Sheard, J., & Carbone, A. (2014). Blended learning in higher education: Three different design approaches. Australasian Journal of Educational Technology, 30(4), 440–454. https://doi.org/10.14742/ajet.693

Broadbent, H. J., White, H., Mareschal, D., & Kirkham, N. Z. (2018). Incidental learning in a multisensory environment across childhood. Developmental Science, 21(2), e12554. https://doi.org/10.1111/desc.12554

Clark, R. C., & Mayer, R. E. (2016). eLearning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning (4th ed.). John Wiley & Sons, Inc.

Clark, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445–459. https://doi.org/10.3102/00346543053004445

Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42(2), 21–29. https://doi.org/10.1007/BF02299088

Clark, R. E. (2012). Media are "mere vehicles": The opening arguments. In R. E. Clark (Ed.), Learning from media (2nd ed.; pp. 1–12). Information Age Publishing, Inc.

Cooper, D., & Higgins, S. (2015). The effectiveness of online instructional videos in the acquisition and demonstration of cognitive, affective and psychomotor rehabilitation skills. British Journal of Educational Technology, 46(4), 768–779. https://doi.org/10.1111/bjet.12166

Day, R., Lin, C., Huang, W., & Chuang, S. (2009). Effects of music tempo and task difficulty on multi-attribute decision-making: An eye-tracking approach. Computers in Human Behavior, 25(1), 130–143. https://doi.org/10.1016/j.chb.2008.08.001

de la Mora Velasco, E. M., & Hirumi, A. (2020). The effects of background music on learning: A systematic review of literature to guide future research and practice. Educational Technology Research and Development, 68, 2817–2837. https://doi.org/10.1007/s11423-020-09783-4

Eitel, A., & Kuhl, T. (2019). Editorial: Harmful or helpful to learning? The impact of seductive details on learning instruction. Applied Cognitive Psychology, 33(1), 3–8. https://doi.org/10.1002/acp.3513

Erbas, C., & Demirer, V. (2019). The effects of augmented reality on students' academic achievement and motivation in a biology course. Journal of Computer Assisted Learning, 35(3), 450–458. https://doi.org/10.1111/jcal.12350

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41, 1149–1160. http://doi.org/10.3758/BRM.41.4.1149

Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. Cognition and Emotion, 19(3), 313–332. http://doi.org/10.1080/02699930441000238

Garner, R., Brown, R., Sanders, S., & Menke, D. (1992). "Seductive details" and learning from text. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), The role of interest in learning and development (pp. 239–254). Erlbaum

Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of "seductive details" on macroprocessing and microprocessing in adults and children. Cognition and Instruction, 6(1), 41–57. https://doi.org/10.1207/s1532690xci0601_2

Goltz, F., & Sadakata, M. (2021). Do you listen to music while studying? A portrait of how people use music to optimize their cognitive performance. Acta Psychologica, 220, 103417. https://doi.org/10.1016/j.actpsy.2021.103417

Gonzalez, M. F., & Aiello, J. R. (2019). More than meets the ear: Investigating how music affects cognitive task performance. Journal of Experimental Psychology: Applied, 25(3), 431–444. https://doi.org/10.1037/xap0000202

Groot, A. M. B. (2006). Effects of stimulus characteristics and background music in foreign language vocabulary learning and forgetting. Language and Learning, 56(3), 463–506. https://doi.org/10.1111/j.1467-9922.2006.00374.x

Hallam, S., Price, J., & Katsarou, G. (2002). The effects of background music on primary school pupils' task performance. Educational Studies, 28(2), 111–122. https://doi.org/10.1080/03055690220124551

Halpern, D. F., Graesser, A., & Hakel, M. (2007). 25 learning principles to guide pedagogy and the design of learning environments. American Psychological Society Taskforce on Life Long Learning at Work and at Home. https://louisville.edu/ideastoaction/-/files/featured/halpern/25-principles.pdf

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. Journal of Educational Psychology, 89(1), 92–102. http://doi.org/10.1037/0022-0663.89.1.92

Hetland, L. (2000). Listening to music enhances spatial-temporal reasoning: Evidence for the Mozart effect. Journal of Aesthetic Education, 34(3/4), 105–148. https://doi.org/10.2307/3333640

Heuer, F., & Reisberg, D. (2014). Emotion, arousal and memory for detail. In S.-A. Christianson (Ed.), The handbook of emotion and memory: Research and theory. Psychology Press. https://doi.org/10.4324/9781315807454 (Original work published 1992)

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. Review of Educational Research, 60(4), 549–571. http://doi.org/10.3102/00346543060004549

Hidi, S. E. (1995) A reexamination of the role of attention in learning from text. Educational Psychology Review, 7, 323–350. https://doi.org/10.1007/BF02212306

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. Educational Psychologist, 41(2), 111–127. http://doi.org/10.1207/s15326985ep4102_4

Horan, S. M., Martin, M. M., & Weber, K. (2012). Understanding emotional response theory: The role of instructor power and justice messages. Communication Quarterly, 60(2), 210–233. https://doi.org/10.1080/01463373.2012.669323

Hsin, W. J., & Cigas, J. (2013). Short videos improve student learning in online education. Journal of Computing Sciences in Colleges, 28(5), 253–259.

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of musical tempo and mode on arousal, mood, and spatial abilities. Music Perception 20(2), 151–171. https://doi.org/10.1525/mp.2002.20.2.151

Iwanaga, M., & Ito, T. (2002). Disturbance effect of music on processing of verbal and spatial memories. Perceptual and Motor Skills, 94, 1251–1258. http://doi.org/10.2466/pms.2002.94.3c.1251

Jackson, C. S., & Tlauka, M. (2004). Route-learning and the Mozart effect. Psychology of Music, 32, 213–220. https://doi.org/10.1177/0305735604039285

Jäncke, L., & Sandmann, P. (2010). Music listening while you learn: No influence of background music on verbal learning. Behavioral and Brain Functions, 6, 3. http://doi.org/10.1186/1744-9081-6-3

Jausovec, N., & Habe. K. (2005). The influence of Mozart's sonata K. 448 on brain activity during the performance of spatial rotation and numerical tasks. Brain Topography, 17, 207–218. doi: https://doi.org/10.1007/s10548-005-6030-4

Kasuya-Ueba, Y., Zhao, S., & Toichi, M. (2020). The effect of music intervention on attention in children: Experimental evidence. Frontiers in Neuroscience, 14, 757. https://doi.org/10.3389/fnins.2020.00757

Kelley, D. H., & Gorham, J. (1988). Effects of immediacy on recall of information. Communication Education, 37(3), 198–207. https://doi.org/10.1080/03634528809378719

Kintsch, W. (1980). Learning from text, levels of comprehension, or: Why anyone would read a story anyway? Poetics, 9, 87–98. http://doi.org/10.1016/0304-422X(80)90013-3

Kozma, R. (1991). Learning with media. Review of Educational Research, 61(2), 179–211. http://doi.org/10.3102/00346543061002179

Kozma, R. B. (2001). Robert Kozma's counterpoint theory of "learning with media." In R. E. Clark (Ed.), Learning from media (pp. 137–178). Information Age Publishing.

Küssner, M. B., Groot, A. M. B, Hofman, W. F., & Hillen, M. A. (2016). EEG beta power but not background music predicts the recall scores in a foreign-vocabulary learning task. PLOS ONE, 11(9), e0163759. https://doi.org/10.1371/journal.pone.0161387

Laster-Loftus, A., & Cooper, L. (2019). The role of instructional videos in psychology students' course success. Journal of Educators Online, 16(2). https://www.doi.org/10.9743/JEO.2019.16.2.5

Lazanov, G. (1978). Suggestology and Suggestopedia: Theory and practice. United Nations Educational, Scientific, and Cultural Organization.

Lehmann, J. A. M., Hamm, V., & Seufert, T. (2018). The influence of background music on learners with varying extraversion: Seductive detail or beneficial effect? Applied Cognitive Psychology, 33(1), 85–94. https://doi.org/10.1002/acp.3509

Lehmann, J. A. M., & Seufert, T. (2017). The influence of background music on learning in the light of different theoretical perspectives and the role of working memory capacity. Frontiers in Psychology, 8, 1902. http://doi.org/10.3389/fpsyg.2017.01902

Mammarella, N., Fairfield, B., & Cornoldi, C. (2007). Does music enhance cognitive performance in healthy older adults? The Vivaldi effect. Aging Clinical and Experimental Research, 19, 394–399. https://doi.org/10.1007/BF03324720

Mason, J. (2010). Attention and intention in learning about teaching through teaching. In R. Leikin & R. Zazkis (Eds.), Learning through teaching mathematics. Mathematics teacher education (Vol 5). Springer. https://doi.org/10.1007/978-90-481-3990-3_2

Mayer, R. E. (Ed.). (2005). The Cambridge handbook of multimedia learning. Cambridge University Press.

Mayer, R. E. (2021). Multimedia learning (3rd ed.). Cambridge University Press.

Mayer, R. E., Mathias, A., & Wetzell, K. (2002). Fostering understanding of multimedia messages through pretraining: Evidence for a two-stage theory of mental model construction. Journal of Experimental Psychology: Applied, 8(3), 147–154. https://doi.org/10.1037/1076-898X.8.3.147

Mazer, J. P. (2013). Student emotional and cognitive interest as mediators of teacher communication behaviors and student engagement: An examination of direct and interaction effects. Communication Education, 62(3), 253–277. https://doi.org/10.1080/03634523.2013.777752

Moè, A. (2016). Does displayed enthusiasm favour recall, intrinsic motivation and time estimation? Cognition and Emotion, 30(7), 1361–1369. https://doi.org/10.1080/02699931.2015.1061480

Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. Journal of Educational Psychology, 92(1), 117–125. http://doi.org/10.1037/0022-0663.92.1.117

Musliu, A., Berisha, B., Musaj, A., Latifi, D., & Peci, D. (2017). The impact of music on memory. European Journal of Social Sciences, 4(4), 222–227. https://doi.org/10.26417/ejser.v10i2.p222-227

Norman, D. (2004). Emotional design: Why we love (or hate) everything. Basic Books.

Ostrander, S., Schroeder, L., & Ostrander, N. (1979). Superlearning. Delacorte Confucian.

Padulo, C., Mammarella, N., Brancucci, A., Altamura, M., & Fairfield, B. (2020). The effects of music on spatial reasoning. Psychological Research, 84, 1723–1728. https://doi.org/10.1007/s00426-019-01182-6

Paivio, A. (1971). Imagery and verbal processes. Holt, Rinehart, and Winston.

Park, B., Moreno, R, Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. Computers in Human Behavior, 27(1), 5–10. https://doi.org/10.1016/j.chb.2010.05.006

Perham, N., & Currie, H. (2014). Does listening to preferred music improve reading comprehension performance? Applied Cognitive Psychology, 28(2), 279–284. https://doi.org/10.1002/acp.2994

Pryse-Phillips, W. (2003). Companion to clinical neurology (2nd ed.). Oxford University Press.

Ransdell, S. E., & Gilroy, L. (2001). The effects of background music on word processing writing. Computers in Human Behavior, 17(2), 141–148. doi:10.1016/S0747-5632(00)00043-1

Ratey, J. J. (2001). A user's guide to the brain. Pantheon Books.

Rauscher, F. H., Shaw, G. L., & Ky, C. N. (1993). Music and spatial task performance. Nature, 365, 611. http://doi.org/10.1038/365611a0

Rauscher, F. H., Shaw, G. L., Levine, L. J., Wright, E. L., Dennis, W. R., & Newcomb, R. L. (1997). Music training causes long-term enhancement of preschool children's spatial-temporal reasoning. Neurological Research, 19(1), 2–8. https://doi.org/10.1080/01616412.1997.11740765

Ross, S. M., & Morrison, G. R. (1996). Experimental research methods. In D. H. Jonassen (Ed.), Handbook of research for educational communications and technology (pp. 1148–1170). Macmillan.

Salamé, P., & Baddeley, A. (1989). Effects of background music on phonological short-term memory. The Quarterly Journal of Experimental Psychology, 41(1), 107–122. https://doi.org/10.1080/14640748908402355

Schellenberg, E. G., Nakata, T., Hunter, P. G., & Tamoto, S. (2007). Exposure to music and cognitive performance: Tests of children and adults. Psychology of Music, 35(1), 5–19. https://doi.org/10.1177/0305735607068885

Schmidt, R. (1995). Consciousness and foreign language learning: A tutorial on the role of attention and awareness in learning. In R. Schmidt (Ed.), Attention and awareness in foreign language learning (Technical Report #9) (pp. 1–63). University of Hawaii, Second Language Teaching & Curriculum Center.

Schön, D., Boyer, M., Moreno, S., Besson, M., Peretz, I., & Kolinsky, R. (2008). Songs as an aid for language acquisition. Cognition, 106(2), 975–983. https://doi.org/10.1016/j.cognition.2007.03.005

Shams, L., & Seitz, A. R. (2008). Benefits of multisensory learning. Trends in Cognitive Sciences,12(11), 411–417. https://doi.org/10.1016/j.tics.2008.07.006

Shih, Y. N., Huang, R. H., & Chiang, H. Y. (2012). Background music: Effects on attention performance. WORK: A Journal of Prevention, Assessment & Rehabilitation, 42(4), 573–578. https://doi.org/10.3233/WOR-2012-1410

Shirey, L., & Reynolds, R. (1988). Effect of interest on attention and learning. Journal of Educational Psychology, 80(2), 159–166. http://doi.org/10.1037/0022-0663.80.2.159

Shuja, A., Qureshi, I. A., Schaeffer, D. M., & Zareen, M. (2019). Effect of m-learning on students' academic performance mediated by facilitation discourse and flexibility. Knowledge Management & E-Learning, 11(2), 158–200. https://doi.org/10.34105/j.kmel.2019.11.009

Stadler, M. A. (1995). Role of attention in implicit learning. Journal of Experimental Psychology: Learning, Memory, and Cognition, 21(3), 674–685. https://doi.org/10.1037/0278-7393.21.3.674

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285. http://doi.org/10.1207/s15516709cog1202_4

Sweller, J., Ayres, P., & Kalyuga, S. (2011). Cognitive load theory. Springer.

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P.

C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. Review of Educational Research, 81(1), 4–28. https://doi.org/10.3102/0034654310393361

Thaut M. H., & Gardiner J. C. (2014). Musical attention control training. In M. H. Thaut & V. Hoemberg (Eds.), Handbook of neurologic music therapy (pp. 257–269). Oxford University Press.

Thompson, W. F., Schellenberg, E. G., & Husain, G. (2001). Arousal, mood, and the Mozart effect. Psychological Science, 12(3), 248–251. http://doi.org/10.1111/1467-9280.00345

Um, E., Plass, J., Hayward, E., & Homer, B. (2012). Emotional design in multimedia learning. Journal of Educational Psychology, 104(2), 485–498. https://doi.org/10.1037/a0026609

Weiner, B. (1990). History of motivational research in education. Journal of Educational Psychology, 82(4), 616–622. http://doi.org/10.1037/0022-0663.82.4.616

Yang, K., Wang, T., & Chiu, M. (2014). How technology fosters learning: Inspiration from the "Media Debate." Creative Education, 5(12), 1086–1090. https://doi.org/10.4236/ce.2014.512123