Learning with Background Music: A Field Experiment

Fanjie Li
Faculty of Education
University of Hong Kong
Hong Kong S. A. R.
fanjie@connect.hku.hk

Xiao Hu
University of Hong Kong Shenzhen
Institute of Research and Innovation
P. R. China
xiaoxhu@hku.hk

Ying Que
Faculty of Education
University of Hong Kong
Hong Kong S. A. R.
yingque@connect.hku.hk

ABSTRACT

Empirical evidence of how background music benefits or hinders learning becomes the crux of optimizing music recommendation in educational settings. This study aims to further probe the underlying mechanism through an experiment in naturalistic setting. 30 participants were recruited to join a field experiment which was conducted in their own study places for one week. During the experiment, participants were asked to conduct learning sessions with music in the background and collect music tracks they deemed suitable for learning using a novel mobile-based music discovery application. A set of participant-related, context-related, and music-related data were collected via a pre-experiment questionnaire, surveys popped up in the music app, and the logging system of the music app. Preliminary results reveal correlations between certain music characteristics and learners' task engagement and perceived task performance. This study is expected to provide evidence for understanding cognitive and emotional dimensions of background music during learning, as well as implications for the role of personalization in the selection of background music for facilitating learning.

CCS CONCEPTS

• **Applied Computing ~ Arts and Humanities** ~ Sound and music computing • **Applied Computing** ~ Education • **Human-centered computing ~** Human computer interaction (HCI)

KEYWORDS

background music, learning engagement, learning performance, naturalistic setting, music information retrieval

ACM Reference format:

Fanjie Li, Xiao Hu and Ying Que. 2020. Learning with Background Music: A Field Experiment. In *Proceedings of the 10th International Conference on Learning Analytics & Knowledge (LAK'20). ACM, New York, NY, USA, X pages.* https://doi.org/10.1145/3375462.3375529

LAK'20, March 23–27, 2020, Frankfurt, Germany

ACM ISBN 978-1-4503-7712-6/20/03 $15.00
https://doi.org/10.1145/3375462.3375529

1 INTRODUCTION

Music, often used as a background accompaniment for learning, has been deemed an effective tool for concentration and mood modulation by a considerable number of learners. In fact, the "studying music" has already become one of the most popular tags for music discovery, and thousands of playlists hosted on online music streaming services (e.g., Spotify) are specifically curated for daily learning activities. In spite of the prevalence of studying with music in the background, there is also evidence that the positive effect of music might not be universally true among learners [9,19,27].

How background music plays a role in students' learning process has been studied by educators, cognitive psychologists, and neuropsychologists for over eight decades [23,34]. Although the positive effect of music has been revealed by a number of studies in the research literature [1,8,11], inconsistent and conflicting findings (i.e., detrimental or no effect) have been reported as well [9,16]. With respect to these inconsistent and inconclusive findings, one possible explanation suggested by relevant research is that the effect of music on learning might vary across the types of music in the background [17,20], the complexity of learning tasks [19], and the personal characteristics of learners [6,22]. To this end, empirical evidence for selecting preferable study music in view of the potential moderating effect of music characteristics, task characteristics, and learners' trait is thus worthy of our attention.

Thanks to the recent development of music processing techniques, more fine-grained music features on various music trait dimensions (e.g., dynamics, rhythm, timbre) could be measured in a standardized and objective way through the automatic processing of audio samples. This further provides opportunities for disentangling and anatomizing how each specific music trait dimension plays a role in the interaction between background music and listeners' learning process.

Moreover, disparate hypotheses have also been proposed, which theoretically explains the mixed results. With focuses on different aspects of the learning process, the arousal-mood-hypothesis [14] and the irrelevant sound effect [18] each situated the beneficial or detrimental effect of the background music from the emotional or cognitive perspective respectively.

This study, therefore, aims to further probe the effect of background music with consideration of its potential role in the cognitive and emotional aspects of learning process. Specifically, we are interested in the following research questions:

RQ1: What kind of music would be deemed as enhancing versus distracting learning?

RQ2: Would mood enhancement co-occur with learning enhancement?

RQ3: Would learners' personal music preference be related to learning performance and engagement?

Furthermore, instead of following the laboratory experimental approach adopted in previous research, a field experiment was conducted to achieve a higher level of ecological validity. The findings of this study are expected to further our understandings of the interplay between music and learning in naturalistic contexts, provide empirical evidence for selecting preferable studying music, and ultimately provide implications for the role of personalization in the selection of background music for facilitating learning.

2 RELATED WORK

Although how background music plays a role in students' learning process has been studied by educators, cognitive psychologists, and neuropsychologists for over eight decades [23,34], the relationships thereof are still inconclusive. Some studies have found that background music is beneficial to various learning tasks, including verbal learning [8], arithmetic problem solving [11], and spatial processing [1], etc. Other studies, on the other hand, reported detrimental [9,27], or no effects [16,19] of background music on learning.

To explain these heterogeneous findings, two theoretically opposite hypotheses have been thus developed. From the perspective of academic emotion, Husain et al. [14] suggest a possible explanation (i.e., arousal-mood-hypothesis) for the beneficial effect of music on learning. They point out that music is powerful in mood modulation and thus can keep learners in a positive mood and help them reach the optimal level of arousal, which, in turn, exerts a positive influence on their learning performance. Relevant studies on the relationships between music, emotion, and learning are found consistent with this hypothesis. For one thing, the effect of music on emotion (i.e., arousal and valence) has already been proven by the previous studies in musical psychology. Generally, upbeat music often increases listeners' level of arousal, whereas slow music often decreases their arousal level [3]; major-mode music pieces often induce positive mood status (e.g., pleased), while its counterpart (i.e., music in minor mode) is often associated with negative mood status (e.g., depressed) [33]. For another, the effect of academic emotion on learning performance has also been demonstrated by the previous psychological and educational research. As illustrated by the influential Yerkes-Dodson law [35], the influence of arousal on learning performance is in conformity with the pattern of "inverted-U", which means the increasing level of arousal will first lead to improved learning performance but exert detrimental effect afterwards once the turning point has been reached. Moreover, according to Schellenberg [30], the mood valence (i.e., level of happiness) was also found to be correlated with students' performance; i.e., negative and positive emotional status are deemed unfavorable and favorable to cognitive processing respectively.

Despite the theoretical contribution of arousal-mood-hypothesis, it was still criticized for its inadequacy in explaining the negative influence of studying with music in the background, which gives rise to a disparate theoretical assumption. From the perspective of the cognitive functioning in the learning process, the irrelevant-sound-effect (ISE) stresses that the information-load characteristics of the background music will increase the cognitive loads of learners, and thus impairs learning [4,5]. The ISE points out that, because of the auditory reception function is intrinsic to our brain, listening to music while learning inevitably consumes the finite cognitive resources of our brain and thus brings extra cognitive burden to learners [28].

Based on the above hypotheses, several possible moderators in relation to the effect of background music on learning have been subsequently proposed, including information-load characteristics of music (e.g., tempo, loudness) [21], task complexity [19], and learners' working memory capacity [6,24], personality traits [22,23], etc. For instance, the experiment results of Lehmann and Seufert [24]'s research revealed a positive correlation between reading comprehension performance and subjects' working memory capacity. Based on a mini-review, Küssner [22]'s study suggested that, in contrast to extraverts, introverted learners were more likely to suffer from the detrimental effect of music because of their relatively higher cortical arousal. Another experimental study conducted by Etaugh and Ptasnik [7] reported that, compared to participants who were unaccustomed to background music, subjects who habitually listened to music while studying achieved better performance in their verbal learning task.

Notwithstanding the impact of the aforementioned research, to uncover the underlying mechanism, efforts are still needed for the development of a theoretical framework which sensibly integrate the disparate theoretical perspectives mentioned above and the potential moderators scatteredly identified in relevant research. Besides, it is noteworthy that the limited ecological validity of previous laboratory-based studies has also been deemed to be responsible for the inconclusive findings in the research literature [19]. With tight schedules of the laboratory experiments, constrained music stimulus, and artificial learning tasks, it could be hard for laboratory experiments to simulate real-life learning scenarios.

Based on the above discussion, this study aims to investigate how background music could possibly play a role in the cognitive and emotional aspects of learning process. We also adopted a naturalistic experiment design to achieve a higher level of ecological validity.

3 EXPERIMENT DESIGN

To simulate the real-life music discovery experience of learners, a field experiment was conducted in participants' own study places for one week. During the experiment, participants were asked to conduct learning sessions with music in the background and add the music they deem suitable for learning to their personal playlists. To facilitate longitudinal data collection in naturalistic settings, a novel mobile music app (i.e., Moody App) was developed and provided to participants for music searching and listening. Participants' searching behavior as well as self-reported learning performance and learning engagement were collected by the Moody App via system log files and pop-up surveys.

3.1 The Music App

The Moody App (Figure 1) is a novel mobile-based music discovery application, which supports mood-based music discovery (i.e., music selection based on its happiness and energy), automatic and customizable playlist generation (e.g., genre-based music filtering), user activity monitoring and logging, and interactive online survey.

A total of 10K music pieces in the Moody database are freely accessible to the system users, where all tracks are originally obtained from the Jamendo music database under Creative Common licenses.

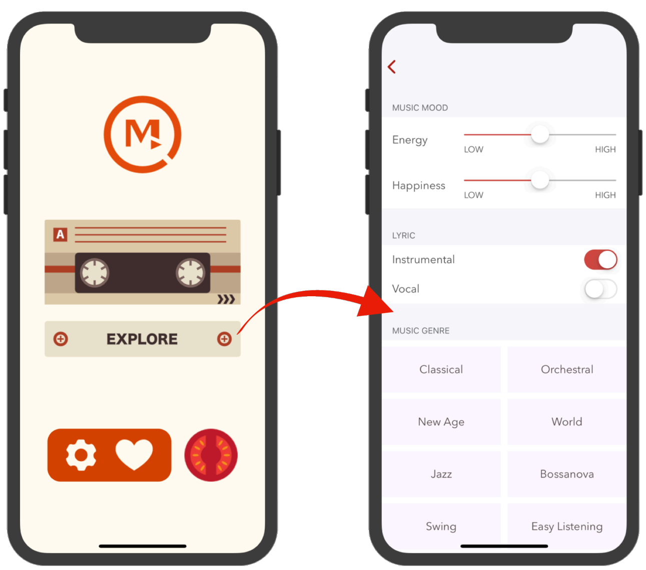

Figure 1: Interface of the Moody App

3.2 Procedure

The whole experiment can be divided into three major phases.

Phase 1: pre-experiment survey and instructions. During registration, participants needed to complete a pre-experiment questionnaire for demographical information collection and personality trait assessment (Ten Item Personality Inventory, TIPI [10]). Subsequently, a face-to-face instruction session was held where a consent form was presented to and signed by the participant. During the session, a detailed introduction to the experimental task and the Moody App was presented to the participants. Additionally, a set of computer-based cognitive tests were arranged in the session for assessing participants' cognitive capacity including working memory and multitasking. Due to space limit, this short paper presents preliminary results of this study, while data of personal traits including those obtained from the cognitive tests will be analyzed in a separate paper.

Phase 2: one-week field experiment. During phase 2, participants were encouraged to perform their learning tasks with music playing in the background. To minimize interruption, the Moody App would, by default, automatically select the next music piece to play based on participants pre-specified music filtering criteria. Participants could build their personal music library effortlessly by simply skipping the disliked tracks and collecting the preferable ones. Meanwhile, the interactive online survey would also periodically pop up on the Moody App so as to track and record a set of context-related data as well as participants' self-reported learning performance and learning engagement.

Phase 3: post-experiment interview. Upon the completion of the field experiment, a face-to-face interview was arranged for each participant, where participants' feedback on their music listening behavior, music preference during learning, and general experience of experimental tasks and the Moody App was collected. Each participant was paid a nominal renumeration at the end of the experiment.

3.3 Pop-up Surveys

To track and record participants' learning context, the proposed music app implemented a popup survey to periodically collect participants' emotional status, task load, as well as their self-reported learning performance and learning engagement.

Both discrete and dimensional measures were used to indicate participants' emotional status. Specifically, Scherer [31]'s semantic space for emotions was adapted to select the discrete emotion adjectives (e.g., excited, happy, pleased, sleepy, bored, depressed, frustrated, annoyed). Moreover, based on Russell et al. [29]'s circumplex model of emotion, two affective dimensions, i.e., valence (unpleasant vs. pleasant) and arousal (calm vs. energetic) were measured using a set of continuums as well.

Besides, participants' task load (i.e., the mental demand and temporal demand of learning task) was measured using the instrument adapted from the NASA task load index [12]. Specifically, the mental demand refers to the amount of mental activity required such as calculating, remembering, etc. (i.e., easy and simple versus demanding and complex), while the temporal demand refers to the time pressure felt due to the task (i.e., slow and leisurely versus rapid and hurried). Additionally, the textual description of learning tasks was obtained from participants for further analysis as well.

Finally, given our primary interest in how music benefits learning, two constructs, i.e., total concentration on the task at hand and altered sense of time, have been borrowed from the flow theory to indicate participants' learning engagement and were measured using the adapted flow state scale [15]. Specifically, both constructs depict a special absorbing experience from two different perspectives. "Total concentration on the task at hand" ([15] p.81) was measured as participants' average rating of three statements (i.e., "My attention was focused entirely on what I was doing", "I had total concentration", "I was completely focused on the task at hand") on 7-point Likert Scales (1=Strongly disagree, 7=Strongly agree), while the "altered sense of time" ([15] p.81) was measured as participants' average rating of "Time seemed to alter (either slowed down or speeded up)", "It felt like time went by quickly", and "I lost my normal awareness of time" also on 7-point Likert scales (1=Strongly disagree, 7=Strongly agree). Additionally, given the limited feasibility of measuring learning performance in naturalistic experiment design, this study only measured participants' perceived learning performance using the question (i.e., "To what extent did the music affect your performance on this task?") adapted from Mayfield [25]'s research design. Participants responded to this question on a 7-point Likert scale (1=Very much distracted me, 4=Had no effect, 7=Very much enhanced my work).

During the field experiment, the music app was designed to periodically pop-up pre-survey and post-survey so that the data could be analyzed per session (i.e., a music listening period between pre-survey and post-survey). Particularly, the pre-survey contains questions on participants' emotional status and task load, while the post-survey includes questions on participants' task engagement, task performance, current emotional status, and ratings for music listened during the course of each session.

4 PRELIMINARY RESULTS

4.1 Participants and Learning Sessions

30 postgraduate students (13 males, 17 females) in a comprehensive university in Hong Kong were recruited as the participants of this field experiment, whose majors ranged from information science, education, computer science, engineering, architecture, and linguistics. Specifically, 12 of them had received formal music training. Concerning their music listening habits, they responded with "almost always" (2), "usually" (5), "sometimes" (11), "rarely" (8), and "never" (4) when asked how frequently they listened to music while learning.

Over the one-week period, a total of 195 valid learning sessions were recorded by the Moody App (approximately 6.5 sessions per participant), after the exclusion of sessions with duration less than five minutes and sessions containing missing data caused by technological failures (e.g., App crashes). Among the 195 sessions, 2618 music listening records could be traced from participants' session listening histories (approximately 13 songs listened per session).

4.2 The Role of Music Characteristics

As the music listened during each session were normally selected by the Moody App based on certain pre-specified music filtering criteria, the music pieces in each session generally possess relatively consistent characteristics. This allows us to compare participants' task engagement and task performance based on the general characteristics of music in different sessions.

Particularly, the dominant genre (i.e., the genre that appeared most in a session), percentage of vocal music (i.e., music with lyrics), average tempo, average rhythm strength, as well as the average happiness level and energy level of music were computed to represent the general music characteristics of each session.

Music Genre. Each music piece involved in this study had a set of metadata provided by Jamendo, including genres. To represent the general music style associated with each session, we further defined the dominant genre as the genre tag that appeared most in each session and computed it from the session listening history. According to a Pearson's Chi-Square test, a statistically significant association between dominant genre in a session and participants' perceived learning performance was observed ($\chi(5) = 24.86$, $p < .001$). Table 1 briefly summarizes how participants' perceived learning performance distributed for 5 major genres.

As shown in Table 1, sessions with easy listening music mostly received positive report on perceived learning performance (71.43%), while sessions with pop music and classical music received more negative responses (54.05% and 70.59% respectively). This observation is consistent with the common impression that easy listening music is generally preferable for listening while studying and pop music might be deemed undesirable by some learners who believe vocal singing in pop music can distract them from their major tasks. Interestingly, despite of the so-called Mozart Effect reported in the research literature [30], among sessions with classical music as primary genre, the negative effect of music on learning performance was reported at a higher percentage. Some possible explanations of this phenomenon might be: 1) classical music normally possesses more complexity in its musical structure which might increase the cognitive load of learners; 2) as per discussions in the forthcoming section (section 4.4), learners' personal music taste also plays an important role in the interaction between background music and learning. Just as a participant stated in his post-interview: *"I did try some classical music. But I have to admit that it does not fit my taste, and I don't know why ... I just can't immerse myself in it."* (Participant #25)

Table 1: Perceived Performance across 5 Major Genres

Genres	Perceived learning performance		
	Distract (1-3)	No effect (4)	Enhance (5-7)
Easy listening	14.29%	14.29%	71.43%
Jazz	44.44%	16.67%	38.89%
Rock	47.06%	11.76%	41.18%
Pop	54.05%	16.22%	29.73%
Classical	70.59%	17.65%	11.76%

Fine-grained Music Features. Apart from music genre, this study also analyzed fine-grained music features in terms of instrumentation (i.e., instrumental or vocal), rhythm-related acoustic features (i.e., tempo and rhythm strength), and the music emotion (i.e., level of happiness and energy). Specifically, a range of acoustic features were extracted using a specialized python library for music and audio signal processing (i.e., LibROSA) [26], including tempo (i.e., beats per minute) and rhythm strength (i.e., the average of the onset strength envelope [13]). Moreover, the emotion of each music piece was obtained via the predictive modeling of acoustic features using support vector machines (SVM) and training data obtained from Hu [13]'s previous study.

The percentage of vocal music and the average of the numerical indicators were then calculated to represent the central tendency of music characteristics of each session.

Since the measures were repeatedly collected for multiple times during the one-week session, repeated measures correlation [2] was applied to investigate the relationship of the aforementioned music features and participants' task engagement and task performance. To control Type I errors that might happen in multiple comparisons, Benjamini-Hochberg procedure [32] was applied and the results are shown in Table 2.

Table 2: The Effect of Music Characteristics on Learning

Music Features	Repeated Measures Correlation Coefficient		
	Concentration	Sense of Time	Performance
pct_vocal	-.015	.026	-.008
rhythm_str	-.043	-.062	-.095
tempo	-.018	-.116	-.140
happiness	.152*	.159*	.185
energy	.183*	.196*	.105

N=30, L=195 (number of sessions/repeated measures). *: $p<0.05$; pct_vocal = percentage of vocal music, rhythm_str = rhythm strength.

As shown in Table 2, the happiness and energy of music were both found to be positively correlated with the engagement-related constructs (i.e., total concentration on the task at hand, altered sense of time), while neither showed significant relationship with participants' perceived task performance. The above observations suggest that the effect of music emotion might be primarily engagement-related rather than a direct effect on the learning performance per se. Just as a participant's comment on the reason for studying with background music: "*Honestly, I believe that music would more or less distract me and decrease my efficiency anyway. Actually, the reason I prefer studying with background music is it can help me enter the state of learning and sustainably engage in learning.*" (Participant #29)

On the other hand, our results also suggest that, even though some characteristics of music (i.e., tempo, rhythm strength, vocal element) have been reported as important music selection criteria by some participants in their post-interviews, the relationship between these music characteristics and learning might not be universally applicable to all learners. Further analysis might as well investigate if interesting relationship exists when participants' personal factors (e.g., working memory capacity) and their task load at the moment (e.g., mental demand of learning task) are considered.

4.3 The Relationship between Mood Enhancement and Learning

As mentioned in section 3.3, participants' valence and arousal were measured before and after each session. With respect to the previous discussions on arousal-mood-hypothesis, a series of repeated measures correlation analyses [2] were conducted to testify if enhancement of learners' emotional status is associated with enhancement of learning engagement and learning performance (Table 3). Benjamini–Hochberg procedure [32] was applied to control the potential Type I error introduced by multiple comparisons.

Table 3: Emotional Change and Learning

Emotion	Repeated Measures Correlation Coefficient		
	Concentration	Sense of Time	Performance
chg_v	.124	.072	.248**
chg_a	.080	.169*	.067

N=30, L=195. *: $p<0.05$, **: $p<0.01$; chg_v=change of valence, chg_a=change of arousal.

As shown in Table 3, the change of valence shows significant positive correlation with participants' perceived learning performance (p = .001), while the change of arousal is also found to be positively correlated with altered sense of time (p = .028). These results and our previous discussions on the association between music emotion and learning (see section 4.2) both further evidence that one of the most important ways in which music benefits learning is closely related to mood modulation and mood enhancement. It is thus not surprising that, participants' self-reported reason for studying with background music were mostly affection-related, such as *"enhanc(ing) my mood and mak(ing) the learning process more enjoyable"* (Participant #2), *"energiz(ing) myself when tired or sleepy"* (Participant #27), and *"sooth(ing) my mood when I am facing some annoying problems or when I am feeling anxious"* (Participant #13).

4.4 The Role of Personal Music Preference

The final part of our preliminary analysis investigates the role of learners' personal music preference. Specifically, we compute the average rating of music listened during each session as the indicator of to what extent the background music per session suits participants' personal music taste. Repeated measures correlation analyses [2] revealed that the average music rating shows significant positive relationship between total concentration on the task at hand (r = .316, p < .001), altered sense of time (r = .300, p < .001), and perceived learning performance (r = .450, p < .001). This finding further implies the importance of customized playlist generation for learners.

5 SUMMARY, LIMITATIONS AND FUTURE WORK

This study aims to explore how background music befits learning through an experiment in naturalistic setting. A one-week field experiment was conducted in participants' own study places where participants were asked to search for and listen to music while studying using a novel mobile-based music retrieval application, Moody App. A set of participant-related, context-related, and music-related data were collected via the pre-experiment questionnaire, surveys popped up in the music app, and the logging system of the music app. Preliminary results reveal significant correlations between certain music characteristics (e.g., genre, music emotion) and learners' task engagement and perceived task performance. Our findings provide empirical evidence for the effect of background music on learning in naturalistic settings, which helps further our understanding on this question. Moreover, the findings also provide a series of implications for designing personalized music recommendation system in educational setting. In particular, how music emotion correlates with learning engagement and the importance of leveraging music's power in mood modulation and mood enhancement.

Nonetheless, this study still has some limitations to be noted. First, the sample size (N = 30) of this study is still relatively small. There is also a lack of diversity in terms of participants' cultural background. For more accurate and generalizable results, future work could recruit larger and more culturally diversified samples to further testify the reported findings. Besides, it's also noteworthy that the measurement of learning performance, learning engagement, and the emotional status were based on participants self-reported measures, while caution is needed for its subjectivity and reliability.

In addition to addressing the limitations discussed above, future work can further probe how learners' personal factors and mental workload play a role in respect of the effect of background music on learning. More complex interactions among the whole set of variables can also be examined via predictive modeling and association rule mining. Finally, clustering analysis of music selected by participant might also depict the big picture of preferable music for studying. Last but not least, potential correlations between learners' personal factors and music preference during learning might also reveal interesting results.

ACKNOWLEDGMENTS

This study is supported by National Natural Science Foundation of China (No. 61703357), a General Research Fund (No. HKU 176070) and a Theme Based Research Scheme (No. T44-707/16/N) from the Research Grants Council of the Hong Kong S. A. R., China.

REFERENCES

[1] L. Angel, D. Polzella, and G. Elvers. 2010. Background Music and Cognitive Performance. Perceptual and Motor Skills, 110, 3 (2010), 1059.

[2] J. Z. Bakdash, and L. R. Marusich. 2017. Repeated Measures Correlation. Frontiers in psychology, 8 (2017), 456-456.

[3] W. R. Balch, and B. S. Lewis. 1996. Music-Dependent Memory: The Roles of Tempo Change and Mood Mediation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 22, 6 (1996), 1354-1363.

[4] C. P. Beaman. 2005. Auditory distraction from low-intensity noise: a review of the consequences for learning and workplace environments. Applied Cognitive Psychology, 19, 8 (2005), 1041-1064.

[5] R. Boyle, and V. Coltheart. 1996. Effects of irrelevant sounds on phonological coding in reading comprehension and short-term memory. Quarterly Journal of Experimental Psychology Section a-Human Experimental Psychology, 49, 2 (May 1996), 398-416.

[6] E. A. Christopher, and J. T. Shelton. 2017. Individual Differences in Working Memory Predict the Effect of Music on Student Performance. Journal of Applied Research in Memory and Cognition, 6, 2 (2017), 167-173

[7] C. Etaugh, and P. Ptasnik. 1982. Effects of studying to music and post-study relaxation on reading comprehension. Perceptual and Motor Skills, 55, 1 (1982), 141-142.

[8] L. Ferreri, and L. Verga. 2016. Benefits of Music on Verbal Learning and Memory: How and When Does It Work? Music Perception: An Interdisciplinary Journal, 34, 2 (2016), 167-182.

[9] A. Furnham, and L. Strbac. 2002. Music is as distracting as noise: the differential distraction of background music and noise on the cognitive test performance of introverts and extraverts. Ergonomics, 45, 3 (2002), 203-217.

[10] S. D. Gosling, P. J. Rentfrow, and W. B. Swann Jr. 2003. A very brief measure of the Big-Five personality domains. Journal of Research in personality, 37, 6 (2003), 504-528.

[11] S. Hallam, J. Price, and G. Katsarou. 2002. The Effects of Background Music on Primary School Pupils' Task Performance. Educational Studies, 28, 2 (2002), 111-122.

[12] S. G. Hart, and L. E. Staveland. 1988. Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research, Advances in Psychology. North-Holland, Amsterdam, Netherlands.

[13] X. Hu, and Y. H. Yang. 2017. Cross-Dataset and Cross-Cultural Music Mood Prediction: A Case on Western and Chinese Pop Songs. IEEE Transactions on Affective Computing, 8, 2 (2017), 228-240.

[14] G. Husain, W. F. Thompson, and E. G. Schellenberg. 2002. Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial Abilities. Music Perception: An Interdisciplinary Journal, 20, 2 (2002), 151-171.

[15] S. Jackson, and R. C. Eklund. 2004. The Flow Scales Manual. Fitness Information Technology

[16] L. Jäncke, E. Brügger, M. Brummer, S. Scherrer, and N. Alahmad. 2014. Verbal learning in the context of background music: no influence of vocals and instrumentals on verbal learning. Behavioral and brain functions: BBF, 10, 1 (2014), 10-10.

[17] L. Jäncke, and P. Sandmann. 2010. Music listening while you learn: No influence of background music on verbal learning. Behavioral and Brain Functions, 6, 1 (2010), 3.

[18] D. Jones. 1999. The cognitive psychology of auditory distraction: The 1997 BPS Broadbent Lecture. British Journal of Psychology, 90, 2 (1999), 167-187.

[19] J. Kämpfe, P. Sedlmeier, and F. Renkewitz. 2010. The impact of background music on adult listeners: A meta-analysis. Psychology of Music, 39, 4 (2010), 424-448.

[20] J. Kantner. 2009. Studying with music: Is the irrelevant speech effect relevant. Applied Memory. Nova Science Publishers, NY, US. 19-40

[21] D. M. Kiger. 1989. Effects of Music Information Load on a Reading Comprehension Task. Perceptual and Motor Skills, 69, 2 (1989), 531-534.

[22] M. B. Küssner. 2017. Eysenck's Theory of Personality and the Role of Background Music in Cognitive Task Performance: A Mini-Review of Conflicting Findings and a New Perspective. Frontiers in Psychology, 8.

[23] J. A. M. Lehmann, V. Hamm, and T. Seufert. 2019. The influence of background music on learners with varying extraversion: Seductive detail or beneficial effect? Applied Cognitive Psychology, 33, 1 (2019), 85-94.

[24] J. A. M. Lehmann, and T. Seufert. 2017. The Influence of Background Music on Learning in the Light of Different Theoretical Perspectives and the Role of Working Memory Capacity, 8, 1902

[25] C. Mayfield, and S. Moss. 1989. Effect of Music Tempo on Task Performance. Psychological Reports, 65, 3_suppl2 (1989/12/01 1989), 1283-1290.

[26] B. McFee, C. Raffel, D. Liang, D. P. Ellis, M. McVicar, E. Battenberg, and O. Nieto. 2015. librosa: Audio and music signal analysis in python. Proceedings of the 14th python in science conference, 8

[27] N. Perham, and H. Currie. 2014. Does listening to preferred music improve reading comprehension performance? Applied Cognitive Psychology, 28, 2 (2014), 279-284.

[28] G. D. Rey. 2012. A review of research and a meta-analysis of the seductive detail effect. Educational Research Review, 7, 3 (2012), 216-237.

[29] J. A. Russell, A. Weiss, and G. A. Mendelsohn. 1989. Affect grid: a single-item scale of pleasure and arousal. Journal of personality and social psychology, 57, 3 (1989), 493.

[30] E. G. Schellenberg. 2012. Cognitive performance after listening to music: A review of the Mozart effect. Music, health, and wellbeing (2012), 324-338.

[31] K. R. Scherer. 2005. What are emotions? And how can they be measured? Social Science Information, 44, 4 (2005), 695-729.

[32] D. Thissen, L. Steinberg, and D. Kuang. 2002. Quick and Easy Implementation of the Benjamini-Hochberg Procedure for Controlling the False Positive Rate in Multiple Comparisons. Journal of Educational and Behavioral Statistics, 27, 1 (2002), 77-83.

[33] G. Webster, and C. Weir. 2005. Emotional Responses to Music: Interactive Effects of Mode, Texture, and Tempo. Motivation and Emotion, 29, 1 (2005), 19-39.

[34] P. L. Whitely. 1934. The Influence of Music on Memory. The Journal of General Psychology, 10, 1 (1934), 137-151.

[35] R. M. Yerkes, and J. D. Dodson. 1908. The relation of strength of stimulus to rapidity of habit-formation. Journal of Comparative Neurology and Psychology, 18, 5 (1908), 459-482.