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Reexamination of mood-mediation hypothesis of background-music-dependent effects in free recall

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ABSTRACT

The present study reexamined the mood-mediation hypothesis for explaining background-music-dependent effects in free recall. Experiments 1 and 2 respectively examined tempo- and tonality-dependent effects in free recall, which had been used as evidence for the mood-mediation hypothesis. In Experiments 1 and 2, undergraduates ($n = 75$ per experiment) incidentally learned a list of 20 unrelated words presented one by one at a rate of 5 s per word and then received a 30-s delayed oral free-recall test. Throughout the study and test sessions, a piece of music was played. At the time of test, one third of the participants received the same piece of music with the same tempo or tonality as at study, one third heard a different piece with the same tempo or tonality, and one third heard a different piece with a different tempo or tonality. Note that the condition of the same piece with a different tempo or tonality was excluded. Furthermore, the number of sampled pieces of background music was increased compared with previous studies. The results showed neither tempo- nor tonality-dependent effects, but only a background-music-dependent effect. Experiment 3 ($n = 40$) compared the effects of background music with a verbal association task and focal music (only listening to musical selections) on the participants' moods. The results showed that both the music tempo and tonality influenced the corresponding mood dimensions (arousal and pleasantness). These results are taken as evidence against the mood-mediation hypothesis. Theoretical implications are discussed.

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Environmental context refers to incidental information about the environment in which the focal information is processed. The environmental context is encoded with the focal information into an episodic-memory trace and is used as a retrieval cue at the time of remembering. Therefore, clarifying the functions of the environmental context is essential for understanding episodic-memory processes. Most memory theories and models have incorporated functions of such contexts (see Clark & Gronlund, 1996). These theories and models include SAM (Search of Associate memory) (e.g., Raaijmakers & Shiffrin, 1981; Shiffrin & Raaijmakers, 1992), REM (Retrieving Effectively from Memory) (Shiffrin & Steyvers, 1997), ACT (A simple theory of complex cognition) (Anderson, 2002), TODAM2 (theory of distributed associative memory) (Murdock, 1993), and ICE (item, associated context, and ensemble) (Murnane, Phelps, & Malmberg, 1999).

In early studies, environmental context almost always referred to the place context, namely incidental information about place, room, or location (Godden & Baddeley, 1975; Smith, Glenberg, & Bjork, 1978; see Isarida & Isarida, 2014, for a review). Recent environmental context studies have investigated various types of environmental information, such as a variety of characteristics of visual information on a computer screen (Hockley, 2008; Isarida & Isarida, 2007; Murnane et al., 1999), background music (e.g., Balch, Bowman, &

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Mohler, 1992; Smith, 1985), odour (e.g., Cann & Ross, 1989; Isarida et al., 2014), and video clips, consisting of motion pictures with sound (e.g., Smith & Handy, 2014; Smith & Manzano, 2010). Contexts can be classified in terms of associative generality (Glenberg, 1979). One type of context can associate with all the elements of an event, because it typically remains stable or changes very slowly during the event; this is called global context. Another type of context can associate with a limited number of elements of an event, because it changes relatively quickly; this is called local context. The present study focused on the functioning of background-music context, which is the only acoustic environmental context that has been systematically investigated (e.g., Balch et al., 1992; Smith, 1985). Background-music context is classified as a global context, like place and odour contexts.

Background-music context has distinctive characteristics compared to other global environmental contexts, such as place and odour contexts. Although the physical stimuli of a piece of music change from moment to moment, participants recognize one global image of the musical piece out of the successively presented stimuli. In contrast, the physical stimulus of place or odour is constant throughout an experimental session. Moreover, background music has other interesting characteristics related to the way people, especially young people, process it in contemporary everyday life. People usually listen to music as focal information, similarly to pictures and videos. In everyday life, people often listen to music in the background of various focal activities. Various background-music selections are continuously played in stores, office waiting rooms, restaurants, and so forth. Currently, young people often listen to music over earphones while walking, reading, writing, computing, and so forth. In most of these situations, the music is not processed as focal information but only as subsidiary information of the focal activities. Thus, how background music via earphones influences the focal activities and processing of the focal information may be a new topic in human cognition research.

There have been only four articles in English on background-music-dependent memory (Balch et al., 1992; Balch & Lewis, 1996; Mead & Ball, 2007; Smith, 1985). It should be noted that three of these articles tended to confirm the mood-mediation hypothesis for background-music-dependent effects in free recall. Balch and his colleagues found that a change in music tempo influenced background-music-dependent memory (Balch et al., 1992; Balch & Lewis, 1996). More specifically, neither music genre (jazz vs. classical) nor instrumental timbre (piano vs. brass) but only music tempo (fast vs. slow) produced a background-music-dependent effect in free recall. Balch and Lewis (1996) found that music tempo influenced the arousal dimension of mood. They concluded that the tempo influenced the arousal dimension of mood, and then the mood influenced free recall. Mead and Ball (2007) found that changes in music tonality (major vs. minor key) influenced background-music-dependent effects in free recall. They also analysed rating data of moods and concluded that tonality influenced the pleasantness dimension of mood, and then the mood influenced free recall.

However, the research on tempo-dependent memory (Balch et al., 1992; Balch & Lewis, 1996) and tonality-dependent memory (Mead & Ball, 2007), which provide the evidence supporting the mood-mediation hypothesis of background-music-dependent memory, may suffer from methodological problems. Thus, the present study reexamined the mood-mediation hypothesis with methodological modifications.

The first potential methodological problem of the previous research involves changing the tempo or tonality of the same musical pieces. Balch and Lewis (1996) and Mead and Ball (2007) compared the original musical pieces with versions transformed in tempo or tonality. This manipulation could evoke a feeling of change and oddness. Consider the case where the piece of music played at test has a different tempo or tonality from that played at study. If participants recognize or are aware that the two pieces were originally identical to each other, then they will be likely to perceive something changed or some oddness of the piece at test. For instance, a change in tonality of the same piece of music, called a parallel key change, has been used by many music composers to make their compositions richer and more colourful by using the feeling of change or oddness, such as the famous "Begin the Beguine" by Cole Porter and "Romance Anonimo" for the classic guitar. More importantly, such a feeling of change and oddness may confound with a mere change in tempo or tonality, so that it overestimates the effect of the change in tempo or tonality. In contrast, any changes in timbre of the same piece of music should not influence the piece's identity; hence there are various versions of

the same piece of music played by different musical instruments.

Otherwise, if participants recognize that the pieces played at study and test are different, comparing the original and transformed pieces will be functionally equal to comparing two different pieces. Note that the effect of tempo or tonality change can be also implemented by changing tempo or tonality between different pieces of music. Such between-pieces manipulation will also change characteristics other than tempo or tonality along with the change in tempo or tonality. However, if many pieces are sampled, the effects of extraneous factors will be balanced. The changing tempo or tonality within the same musical pieces will be necessary only if one piece is used. This is because the effects of extraneous factors cannot be balanced. The problem involving the limited selection of musical pieces is addressed later.

From a mechanical point of view, the original piece and that piece transformed in tempo or tonality may differ only in tempo or tonality, and the other elements of the music remain constant. As described above, however, participants recognize one global image of the musical piece out of the successively presented stimuli. The image of tempo or tonality also constitutes the global image of a musical piece as part of the global image. Thus, a change in only one element of a piece of music can change the total image (Gestalt) of the piece.

To summarize, changing the tempo or tonality within the same musical pieces raises the possibility either that (a) the effects of changes in tempo or tonality are overestimated because of a feeling something changed or oddness; or that (b) the manipulation is functionally equal to the manipulation of changing tempo or tonality between different pieces. Thus, this manipulation has no merit, and, moreover, it is potentially problematic in terms of raising overestimation of the effects of tempo or tonality.

Accordingly, the present study investigated the effect of music tempo or tonality on free recall by comparing the effects between different pieces with the same tempo or tonality and musical pieces with different tempos or tonalities. More specifically, this study used three between-participants conditions: SS (same piece of music with same tempo or tonality), DS (different piece with same tempo or tonality), and DD (different piece with different tempo or tonality) conditions. Note that the SD (same piece with different tempos or tonalities) condition was excluded. If the background-music-dependent memory is reliable, then the amount of recall in the SS condition will be higher than that in the DD condition, and the amount of recall in the DS condition will be between the SS and DD conditions. The following three patterns of results are possible for the amounts of recall for the three conditions.

Pattern A: If tempo and/or tonality exclusively determine the background-music-dependent effect, then recall in the SS condition will be equal to recall in the DS condition, and recall in the DS condition will be higher than that in the DD condition. Therefore, the difference in the amount of recall between the SS and DD conditions would mainly reflect the difference between the DS and DD conditions. This pattern of results would indicate that background-music-dependent memory is mediated by the mood evoked by the music tempo and/or tonality.

Pattern B: If tempo and/or tonality are necessary for producing the background-music-dependent effect, then the amount of recall in the SS condition will be higher than that in the DS condition, and the amount of recall in the DS condition will be higher than that in the DD condition. This result pattern indicates that tempo and/or tonality are one of the determinants of background-music-dependent memory.

Pattern C: If tempo and/or tonality do not influence background-music-dependent memory, then the amount of recall in the SS condition will be higher than that in the DS condition, and the amount of recall in the DS condition will be equal to that in the DD condition. This result pattern indicates that tempo and/or tonality do not influence background-music-dependent memory.

The second potential methodological problem of the previous research involves the limited selection of musical pieces. All of the previous studies of background-music-dependent memory have selected only one piece of music per music dimension, such as tempo, genre, timbre, and tonality, although musical selections belong to a large group of random sampling variables. Thus, it is still unclear whether the results reflected the labelled music dimensions or characteristics specific to the selected pieces. More specifically, Balch and Lewis (1996) and Mead and Ball (2007) used only one piece of music (i.e., original and transformed pieces). Balch et al. (1992) assigned only one piece of music to each of the four conditions formed by the factorial

combination of two levels of music tempo (fast vs. slow) and musical genre (classic vs. jazz). In Experiment 2, they separated the effect of tempo from that of genre. In the same-context condition, in which the same piece of background music was presented at both study and test, the effects of the four pieces were combined. On the other hand, in the different-tempo condition, in which different pieces were presented at study and test, the effects of only two combinations (slow classic and fast jazz, fast classic and slow jazz) were combined. Experiment 3 used only slow and fast classical selections, so that the results of the same-context condition came from two musical pieces, and those of the different-context condition came from only one combination. Note that they did not separate the effects of tempo and genre in Experiment 1.

Accordingly, the present study used four musical selections per tempo or tonality and investigated whether the tempo or tonality influenced the production of background-music-dependent memory. Increasing from one to four pieces per dimension markedly increases the number of combinations of pieces played at study and test. More specifically, the number of combinations of musical selections was 8 (= 4 + 4) in the SS condition, 12 [= 4 × (4−1)] in the DS condition, and 16 (= 4 × 4) in the DD condition.

Furthermore, the present study used only an incidental learning paradigm, but not an intentional learning paradigm, for the following reasons. First, all the previous studies proposing the mood-mediation account used an incidental learning paradigm (Balch et al., 1992; Balch & Lewis, 1996; Mead & Ball, 2007). Second, we did not detect music-dependent effects in free recall in an intentional learning paradigm but only in an incidental learning paradigm (Isarida, Isarida, & Hayashibe, 2008).

Moreover, the three previous studies seem to treat the background music as inducing stimuli for moods rather than auditory environmental information. Surely, music can be an effective stimulus for inducing moods. In fact, music usually induces a certain mood when people listen to it as focal information (see Västfjäll, 2002). The previous studies also investigated the mood induction effect of focal music (Balch & Lewis, 1996; Mead & Ball, 2007). However, when people concentrate on processing other focal information, they usually pay little attention to the background music. The processing mechanisms for listening to focal music may be different from those for background music. If so, background music may not be as effective for inducing mood as is focal music. Thus, the present study investigated the mood induction effects of both focal and background music.

Experiment 1

Experiment 1 investigated whether music tempo influences background-music-dependent effects in free recall.

Method

Participants

The participants were 75 undergraduates enrolled in a Developmental Psychology course at Shizuoka Prefectural University in Shizuoka, Japan. They received extra points of course credit for their participation.

Design

Three between-participants conditions were used. The conditions were SS (same piece and same tempo), DS (different pieces and same tempo), and DD (different pieces and different tempos) conditions. The 75 participants were randomly assigned to the SS, DS, or DD conditions, so that each group consisted of 25 participants.

Materials

The to-be-remembered items were 20 unrelated two-kana Japanese words whose association values, referring to the percentage of participants that could write down any associated word(s) within 6 seconds, were no less than 90 (Hayashi, 1976).

For background music, four pieces of classical music in major keys with tempos of 102 to 121 were selected (Appendix A). To make the background-musical selections to be played in Experiment 1, the tempos of the four pieces were altered by computational operations to 180 (fast tempo) and to 80 (slow tempo). The fast- or slow-tempo pieces were randomly assigned to the SS, DS, or DD conditions with the restriction that closely equal number of pieces were assigned. Before the experiment, 15 undergraduates of Shizuoka University, who did not participate in Experiment 1, listened to the pieces and responded that all of them were unfamiliar.

Procedure

Participants individually attended a 20-min experimental session. After instructions, participants were presented 20 items on a 17″ computer screen, one by one at a rate of 5 s per item (the inter-presentation interval was 0.5 s). They were required to report orally as many as possible associates of the currently presented item. The experimenter did not inform participants about the forthcoming free-recall test. The presentation order of the items was randomized across participants. Ten seconds before presentation of the items, a row of two symbols (##) was presented for 10 s as a start signal for item presentation, while the assigned piece of music was played until the end of the item presentation. The pieces of music were presented via a pair of stereo speakers connected to a desktop computer.

After the item presentation, the experimenter required participants to turn around and gave them a 30-s instruction for an unexpected 2-min oral free-recall test. Synchronously with the start of the instructions, the experimenter began playing the assigned piece of music until the end of the free-recall test. The reason for requiring the participants to turn around was to prevent them from using visual environmental information as retrieval cues. At the end of the experiment, participants were debriefed.

Results and discussion

Figure 1 shows the proportions of items recalled for the SS, DS, and DD conditions. A one-way analysis of variance (ANOVA) for the three conditions yielded a significant effect of the conditions, $F(2, 74) = 4.86$, $MSE = 4.62$, $p = .011$, $\eta_p^2 = .119$. To test the pairwise comparisons between the three conditions, Ryan's procedure was performed using an alpha level of .05. This procedure revealed that the recall probability in the SS condition was significantly higher than that in the DS and DD conditions, but the difference between the DS and DD conditions was not significant.

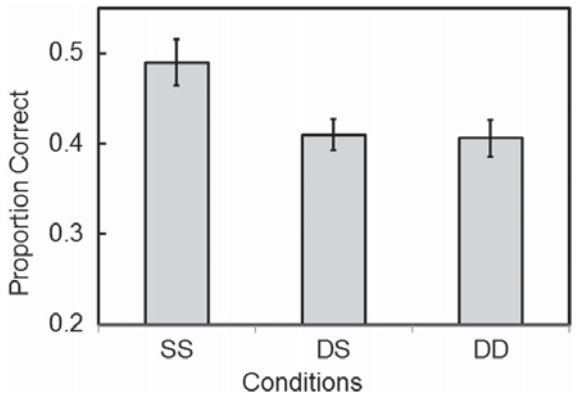

Figure 1. Proportion of items recalled for SS (same piece and same tempo), DS (different piece and same tempo), and DD (different piece and different tempo) conditions in Experiment 1. Error bars represent standard errors of the mean.

The results of Experiment 1 clearly correspond to Pattern C, indicating that music tempo does not influence background-music-dependent effects in free recall.

Experiment 2

Experiment 2 investigated whether music tonality influences background-music-dependent effects in free recall.

Method

Participants

The participants were 75 undergraduates enrolled in a Developmental Psychology course at Shizuoka Prefectural University in Shizuoka, Japan. They received extra points of course credit for their participation. None had participated in Experiment 1.

Design

Experiment 2 used music tonality (same or different) between study and test as a between-participants factor, instead of the music tempo used in Experiment 1. Otherwise, the design of Experiment 2 was identical to that of Experiment 1.

Materials

The to-be-remembered items were identical to those used in Experiment 1.

For background music, eight pieces of music were selected. Four of them were in major keys, and the other four were in minor keys. The tempos of all pieces were allegro or allegretto. The musical selections are shown in Appendix B.

Procedure

The procedure was identical to that used in Experiment 1.

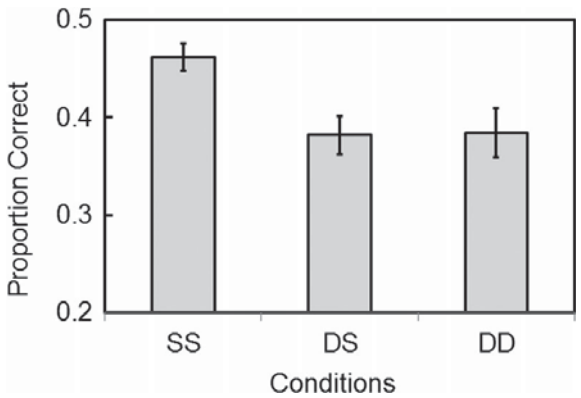

Figure 2. Proportion of items recalled for SS (same piece and same tonality), DS (different piece and same tonality), and DD (different piece and different tonality) conditions in Experiment 2. Error bars represent standard errors of the mean.

Results

Figure 2 shows the proportions of items recalled for the SS, DS, and DD conditions. A one-way ANOVA for the three conditions yielded a significant effect of the conditions, $F(2, 74) = 4.93$, $MSE = 4.22$, $p = .010$, $\eta_p^2 = .121$. To test the pairwise comparisons between the three conditions, Ryan's procedure was performed using an alpha level of .05. This procedure revealed that the recall probability for the SS condition was significantly higher than that for the DS and DD conditions. However, the difference between the DS and DD conditions was not significant.

The results of Experiment 2 clearly correspond to Pattern C, as was also found for Experiment 1, indicating that music tonality does not influence background-music-dependent effects in free recall.

Experiment 3

Experiments 1 and 2 did not show that either the tempo or the tonality of the background music influenced background-music-dependent effects in free recall. Experiment 3 investigated whether the tempo and/or tonality of background music would influence the corresponding dimension of mood. An incidental verbal association task, which may make participants less sensitive to the mood, was used, as in Experiments 1 and 2. The previous studies demonstrating the mood-mediation hypothesis used a pleasantness rating task (Balch et al., 1992; Balch & Lewis, 1996; Mead & Ball, 2007), which may make participants more sensitive to the mood of the background music. Additionally, in two of those studies, participants listened to focal music but not to background music when the participants rated their moods.

Experiment 3 compared the effects of background music in a verbal association task with focal music on the induction of participants' moods. In the focal-music condition, participants only listened to musical selections before rating their current mood. In the background-music condition, participants were required to conduct the same task as that used in Experiments 1 and 2 before rating their current mood. Furthermore, Experiment 3 investigated whether, and if so how, the musical dimensions (tempo and tonality) would influence the corresponding mood dimensions (arousal and pleasantness). Participants individually listened to four pieces of music consisting of fast, slow, major-key, and minor-key pieces one by one. The four pieces were randomly selected from the pieces used in Experiments 1 and 2, except that the two pieces from the same selection with different tempos or tonality were not included in the four pieces.

The previous studies had found that focal-music tempo influenced the arousal dimension of mood (Balch & Lewis, 1996) and focal-music tonality influenced the pleasantness dimension of mood (Mead & Ball, 2007). If tempo- and/or tonality-dependent effects on mood were found with the background music used in the present study, then the mood-mediation hypothesis would be disconfirmed for the corresponding mood dimension. If so, then the clearly found tempo- and/or tonality-dependent mood would have done nothing to produce the background-context-dependent effect in free recall.

Otherwise, if any of the music dimensions did not influence mood, then this would imply either that the present manipulation could not induce a mood, or that background music, in general, cannot induce a mood. The former case implies that the present study cannot specify the validity of the mood-mediation hypothesis. The latter case is unfavourable for the mood-mediation hypothesis. Unfortunately, Experiment 3 cannot specify which case is more plausible, so further research will be needed.

Method

Participants

Participants were 42 undergraduates enrolled in an Introductory Psychology course at Shizuoka University, Hamamats, Japan. They received extra points of

course credit for their participation. None had participated in Experiments 1 or 2.

Design

Two between-participants conditions, focal- and background-music conditions, were designed. The 42 participants were randomly assigned to either of the conditions.

Materials

The items for the free-association task were 80 unrelated two-kana Japanese words, whose association values were no less than 90 (Hayashi, 1976), as had been used in Experiments 1 and 2. The 80 words were randomly assigned to four 20-word lists. Sixteen pieces of music were used. They consisted of the four fast and four slow pieces of music used in Experiment 1, and the four major-key and four minor-key pieces used in Experiment 2.

Procedure

Participants individually attended a 15-min experimental session. All the participants were presented with four pieces of music, consisting of fast, slow, major-key, and minor-key selections randomly selected from the four fast and four slow pieces of music used in Experiment 1, and the four major-key and four minor-key pieces used in Experiment 2. The presentation order was randomly selected from the following four sequences: "fast, minor, slow, and major", "slow, major, fast, and minor", "minor, fast, major, and slow", and "major, slow, minor, and fast". These sequences were designed to counterbalance the presentation order, and fast and slow pieces and major-key and minor-key pieces were not temporally adjacent.

In the focal-music condition, participants only listened to each musical selection for 110 s as focal information, before rating their current mood. In the background-music condition, participants were presented a row of two symbols (##) for 10 s, and then the 20 items one by one, as in Experiments 1 and 2. Participants were required to report orally as many as possible associates of the currently presented item while one of the background music selections was played, before the mood rating. During the respective mood ratings, no musical selection was played. Participants were required to rate their current mood on a 9 × 9 "mood grid", used by Mead and Ball (2007), which depicted the mood dimensions of arousal and pleasantness (see Appendix C; also see Russell, Weiss, & Mendelsohn, 1989). At the end of the experiment, participants were debriefed.

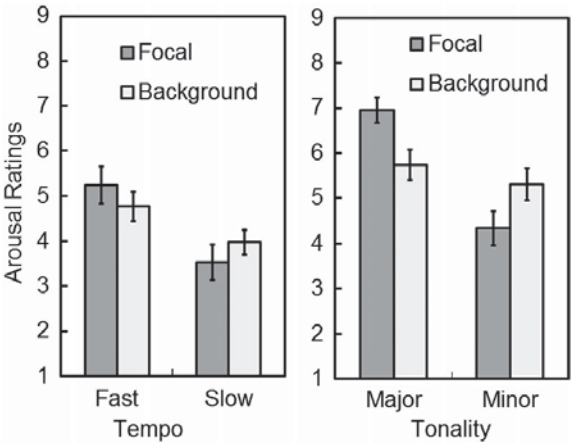

Figure 3. Mean ratings of arousal dimension of mood for focal and background music as a function of music tempo (left panel) and of music tonality (right panel). Error bars represent standard errors of the mean.

Results and discussion

Figures 3 and 4 show the effects of tempo (fast or slow) and tonality (major or minor) on the mean mood scores for the arousal (Figure 3) and pleasantness (Figure 4) dimensions of mood in the focal-music and background-music conditions.

Two separate 2 (music type: focal or background music) × 2 (music tempo: slow or fast) mixed-factor ANOVAs were computed for the arousal and

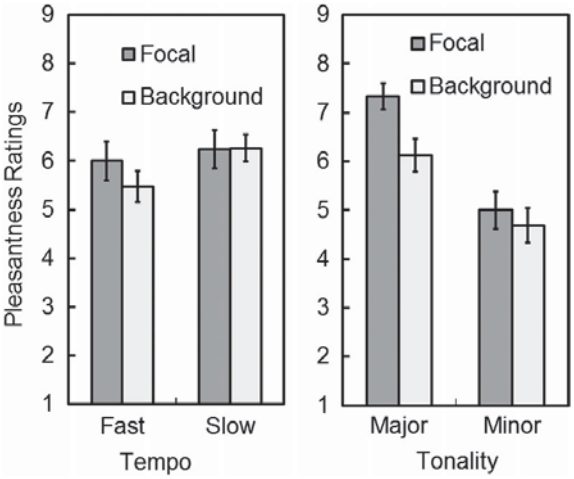

Figure 4. Mean ratings of pleasantness dimension of mood for focal and background music as a function of music tempo (left panel) and of music tonality (right panel). Error bars represent standard errors of the mean.

pleasantness dimensions of mood. For the arousal dimension, the main effect of music type was not significant, $F < 1$, but that of tempo was significant, $F(1, 40) = 14.86$, $MSE = 2.21$, $p < .001$, $\eta_p^2 = .271$. The interaction was not significant, $F(1, 40) = 2.05$, $MSE = 2.21$, $p = .160$, $\eta_p^2 = .049$. For the pleasantness dimension, the main effect of music type was not significant, $F < 1$, and the main effect of tempo did not reach significance, $F(1, 40) = 3.16$, $MSE = 1.74$, $p = .083$, $\eta_p^2 = .073$. The interaction was not significant, $F < 1$.

Furthermore, two separate 2 (music type: focal or background music) × 2 (music tonality: major or minor key) mixed-factor ANOVAs were computed for the arousal and pleasantness dimensions of mood. For the arousal dimension, the main effect of music type was not significant, $F < 1$, but that of tempo was significant, $F(1, 40) = 23.48$, $MSE = 2.08$, $p < .001$, $\eta_p^2 = .369$. The interaction was also significant, $F(1, 40) = 12.13$, $MSE = 2.08$, $p = .002$, $\eta_p^2 = .232$. Because the interaction was significant, further analyses were conducted. For the focal-music condition, the simple effect of tonality was significant, $F(1, 40) = 34.69$, $MSE = 2.08$, $p < .001$, $\eta_p^2 = .464$, but was not significant for the background-music condition, $F < 1$. Additionally, for the major-key selections, the simple effect of music type was significant, $F(1, 40) = 6.11$, $MSE = 2.08$, $p = .016$, $\eta_p^2 = .070$, but did not reach significance for the minor-key selections, $F(1, 40) = 3.94$, $MSE = 2.08$, $p = .051$, $\eta_p^2 = .047$. For the pleasantness dimension, both the main effect of music type, $F(1, 40) = 6.09$, $MSE = 2.15$, $p = .018$, $\eta_p^2 = .232$, and the main effect of tonality, $F(1, 40) = 34.59$, $MSE = 2.15$, $p < .001$, $\eta_p^2 = .463$, were significant. The interaction was not significant, $F(1, 40) = 2.00$, $MSE = 2.15$, $p = .165$, $\eta_p^2 = .047$.

The results showed that the present background music and the present focal music could each influence mood, with one exception. The effect of tonality on the arousal dimension of mood was not found in the background-music condition but was found in the focal-music condition. Although the inducing effects of the background music seemed to be somewhat attenuated in comparison to the focal music, both the focal and background music showed that music tempo influenced the arousal dimension of mood, and music tonality influenced the pleasantness dimension, as was also shown in previous studies (Balch & Lewis, 1996; Mead & Ball, 2007).

Experiment 3 used a pair of speakers to play the background music, as in preceding studies, and a verbal association task. It should be noted that it is not clear whether the same background-music-dependent mood as in the present study will be found if the background music was played via headphones or earbuds, and if the focal processing task was more salient or attractive. This is another interesting topic to be addressed in future studies.

General discussion

Experiments 1 and 2 both showed clear background-music-dependent effects in free recall. Additionally, Experiment 3 showed that specific dimensions of background music influence the corresponding mood dimensions. Namely, music tempo influenced the arousal dimension of mood, and music tonality influenced the pleasantness dimension, as was also shown in previous studies (Balch & Lewis, 1996; Mead & Ball, 2007). Nonetheless, neither music tempo nor music tonality influenced the production of background-music-dependent effects in free recall. These results indicate that background-music-dependent memory is not specific to any music dimensions influencing mood. Thus, the present results are taken as evidence against the mood-mediation hypothesis for explaining background-music-dependent effects in free recall (Balch et al., 1992; Balch & Lewis, 1996; Mead & Ball, 2007).

The present results, along with the previous results, imply that background-music-dependent memory is not specific to any music dimensions influencing mood. Otherwise, there is another possibility that tempo- and tonality-dependent effects will appear only if the music pieces presented at study and test are identical or highly similar. On one hand, the change in tempo or tonality between identical or highly similar pieces would evoke a certain feeling of change and oddness, which may decrease recall. On the other hand, a different piece of music may make the contexts highly dissimilar so that adding another different dimension, such as tempo or tonality, does not add to the dissimilarity. In any case, the present results are taken as evidence against the mood-mediation hypothesis for explaining background-music-dependent effects in free recall. The change in tempo or tonality between even highly dissimilar pieces of music did induce a corresponding change in mood but did not change recall.

The tempo- and tonality-dependent free recall found in the previous studies may have reflected the feeling of something changed or odd about the music (Balch & Lewis, 1996; Mead & Ball, 2007) caused by changing tempo or tonality within the

same piece of music and/or specific characteristics of the stimulus music in the small samples of music pieces (Balch et al., 1992; Balch & Lewis, 1996; Mead & Ball, 2007). In comparison with these previous studies, the present study (a) excluded the condition presenting the same musical piece with different tempos or tonalities at study and test, and (b) increased the number of sampled pieces of background music. If tempo- and/or tonality-dependent effects on memory were reliable and robust, the present three (SS, DS, and DD) conditions in Experiments 1 and 2 would have revealed systematic differences supporting either or both of these phenomena —that is, Pattern A, or at least Pattern B. However, neither Experiment 1 nor Experiment 2 showed Pattern A or B, but both unanimously showed Pattern C.

In general, there are several findings unfavourable for the mood-mediation hypothesis. A mood-dependent effect does not seem to be robust enough to mediate background-music-dependent memory. Eich and Metcalfe (1989) found mood-dependent effects in free recall for self-generated words but not for presented words. Almost all the subsequent studies on mood-dependent memory have used free recall of self-generated words (e.g., Balch, Myers, & Papotto, 1999; Eich, 1995). In contrast, various environmental context-dependent effects in memory have been found for both self-generated and presented words. These findings suggest that explaining background-music-dependent memory for presented words by mood-dependent memory would be implausible. Moreover, Balch and Lewis (1996) reported that music tempo influenced the arousal dimension of mood, which further influenced free recall. In contrast, Balch et al. (1999) concluded that the pleasantness dimension, but not the arousal dimension, influenced memory. These conflicting results indicate unreliability of mood-dependent effects in memory.

From an alternative point of view, Mulligan (2011) provided empirical evidence against the mood-mediation account of place-dependent memory (e.g., Eich, 1995). He claimed that environmental manipulations in context-dependent memory studies, such as varying indoor versus outdoor locations (e.g., McKone & French, 2001; Parker, Gellatly, & Waterman, 1999) or varying music and odour along with place (e.g., Parker, Dagnall, & Coyle, 2007), often would inadvertently influence mood. He manipulated place context without such manipulations so as not to change corresponding mood. Additionally, he measured mood during both encoding and retrieval. Despite no changes in mood related to place changes, a place-dependent effect in recall was clearly found. He concluded that the place-context-dependent effect was not mediated by mood, because the effects occurred without place-related changes in mood. In contrast, the present study found that tempo and tonality of background music did change mood, but neither tempo nor tonality changed free recall. Thus, Mulligan (2011) and the present study unanimously demonstrated no relationship between mood and memory.

Background-music-dependent memory may reflect associations between items and a global image of each piece of music rather than associations between each item and the physical stimulus of the piece contiguous with the item. As described in the introduction, participants recognize one global image of the musical piece out of the successively presented stimuli. Furthermore, the present study found that free recall is not influenced by any specific dimension of mood. Rather, background-music-dependent memory may be determined by a more general factor, such as mental context. Smith (1995) theoretically proposed that environmental context-dependent memory is actually caused by associations between the mental context and focal information rather than by associations between representations of the environment and focal information. He proposed that the mental context consists of not only representations of ambient environments and mood but also the participant's mental set, physiological states, active memories, and other incidental factors. The global image of a musical selection may constitute the mental context of a study episode possibly including a mood. For instance, Sahakyan and her colleagues accounted for competition between lists or items by mental context (Sahakyan & Hendricks, 2012; Sahakyan & Kelley, 2002).

Empirically, Isarida and Isarida (1999) separated changes in internal or mental factors (tension, concentration, mood, and so forth) from changes in place (classroom, corridor, campus grounds, library, and so forth) between a class and a lunch break in college. They found that recall was influenced not by the changes in the places but by changes in the internal or mental factors. Similarly, Isarida et al. (2014) found that the size of odour-dependent effects in free recall did not decrease with decreasing intensity of olfactory sensation because of adaptation. The results imply that the odour-dependent memory

does not reflect any association between each item and the olfactory information contiguous to the item, but rather reflects the associations between items and certain global contextual information, such as the mental context of the experimental environment with a specific odour. As such, the global environmental context-dependent memory may reflect associations between items and the mental context of a study episode.

There have been only four studies of background-music-dependent memory, and three of them focused only on demonstration of the mood-mediation hypothesis. Therefore, there are still many other characteristics and functions to be elucidated for background-music contexts. For instance, it is still unclear whether background-music-dependent memory is exclusively found in incidental-learning paradigms. Three of the four previous studies used only an incidental-learning paradigm (Balch et al., 1992; Balch & Lewis, 1996; Mead & Ball, 2007). Isarida et al. (2008) reported that background-music-dependent effects in free recall were not found in an intentional-learning but only in an incidental-learning paradigm. Smith (1985) found no background-music-dependent effect in immediate free recall of intentionally learned words, but found it in a two-day delayed unexpected final free-recall test. It is unclear whether the final test in Smith's study was the second test for the intentionally learned words or the first test for the incidentally experienced episode of the initial recall test. Furthermore, Smith found background-music-dependent memory in the two-day delayed test but not in the immediate test, whereas Balch et al. (1992) found the effects not in a two-day delayed test but in the immediate test. Accordingly, there are many important topics still to be addressed in future research.

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Appendix A

Musical selections used in Experiments 1 and 3

Schubert, Franz: Piano Sonata #17, in D Major, the first movement, in D Major, D850, Allegro vivace, mean tempo = 114.2.

Haydn, Franz J.: Piano Sonata #9, in D Major, the first movement, in D Major, Moderato, mean tempo = 120.1.

Beethoven, Ludwig van: Piano Sonata #31, in A flat Major, the first movement, Moderato cantabile molto espressivo, mean tempo = 102.4.

Schubert, Franz: Piano Sonata #21, in B flat Major, the first movement, Molto Moderato, mean tempo = 111.4.

Note: The mean tempos were computationally analysed by the MixMeister BPM Analyzer.

Appendix B

Musical selections used in Experiments 2 and 3

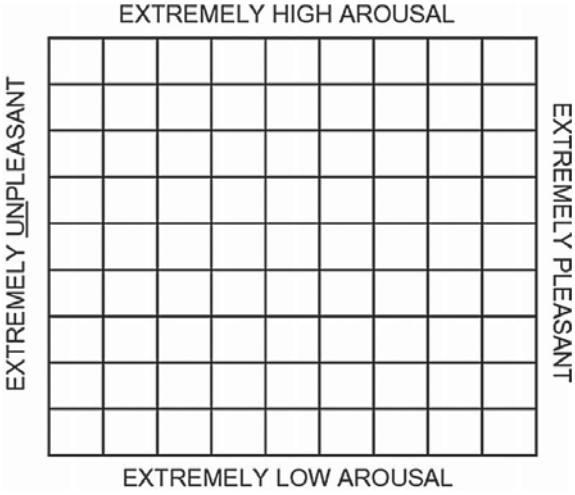
Major key

Mozart, Wolfgang, A: Piano Concerto #25, the third movement, in C Major, Allegretto.

Beethoven, Ludwig van: Symphony #7, the first movement, in A Major, Allegro.

Bach, Johan S.: Works for Lute, BWV998, in E flat Major, Allegro.

Chopin, Fryderyk F.: Etude Op.10–8, in F Major.



Minor key

Mozart Wolfgang, A: Piano Concerto # 20, the third movement, in D minor, Allegro.

Beethoven, Ludwig van: Piano Sonata #23, the third movement, in F minor. Allegro ma non troppo–Presto

Bach, Johan S.: Works for Lute, BWV996, Gigue, in E minor.

Chopin, Fryderyk F: Etude Op.25–12, in C minor.

Appendix C

Mood grids used in Experiment 3

Participants were required to place a cross in this grid to register their response.

Figure C1