

# How does Congruence of Scent and Music Affect People's Emotions

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**Abstract:** It is widely believed that there is a relationship between scent and music. For example, there is congruence among certain scent, music, and consumers' buying behaviors according to previous study. However, only limited number of scents and music have been analyzed, which is not sufficient to conclude common characteristics of congruence between scent and music in arousal dimension. Consequently, we investigated the effect of scent on the mood evaluation of music by using four kinds of scents and two music samples. Overall, our results showed the arousal quality of scent would effectively modify the perceived arousal level of music, and scent which was congruent with music on arousal could also increase the affirmation of music. These results therefore underline the potential of scent to enhance listening experience, and those working in the music industry may feel progressively further optimistic in adopting appropriate scent to achieve advanced listening experience.

**Keywords:** *Music, Scent, Congruence*

## 1. INTRODUCTION

### 1.1 Multisensory Correspondences

The notion that people's emotional response is determined based on the whole configuration of stimulus even though they perceive stimuli discretely is commonly accepted [1]. That is, mental images are usually created by combining olfactory, auditory, and visual inputs so that it can be claimed that there is a relationship between different senses such as olfactory and auditory sense. The conception that associations between odors and musical notes or geometrical shapes were grounded in structural perceptual or neurological determinants other than primarily conceptual or linguistic has been declared [2]. It was also mentioned by Piesse that scents appeared to influence the olfactory nerve in certain explicit degrees like sounds [3]. It was reported that the majority of people (or at least a majority of those tested in the research to date;) accurately match certain smells (such as e.g., caramel) with a lower-pitched note than they match other smells (e.g., bergamot) with [4-6]. Another study worth stressing here reviewed the relationship between scent and music examined how the configuration of scent and music affected consumers' buying behaviors and evaluation to the retail environment [7].

Furthermore, the relationship between scent and music was previously demonstrated in the aspect of evoking people's physiological changes, which implies the activity of autonomic nerve system. For instance, unpleasant scent like sweat noticeably influenced people's heartbeat, and

brought out emotional changes [8]. On the other hand, it was shown that when people were listening to music, their breathing cycles tended to become consistent along with the music bars [9]. Thus, people are affected by music and enjoy music. As revealed by Gestalt Principle, human combine and organize different sensory inputs to create a whole mental image, rather than summing up all these parts [10]. There is keen interest, therefore, in extending the notion of Gestalt, to investigate how people's emotional responses towards music will be influenced by scent.

Since just limited numbers of scents and music were applied in prior study, the common characteristics of congruence between scent and music in arousal have not been determined. In addition, little is known about the effect of congruence configuration on people's emotions. Therefore, to further our theoretical understanding of the congruence relationship of scent and music in terms of arousal, we used the Two-Dimensional Mood Scale [11] as mood measurements to examine the effect of scent on participants' emotions towards music. Then, we also investigated the overall hedonic ratings of the configuration of scent and music by 7-level Likert scale. We believe that the results of crossmodal correspondences would be definitely promising in enhancing the listening experience, and realizing further enjoyment of music.

### 1.2 Scent Research

There are around 400,000 kinds of scented compounds out of 2 million kinds of compounds in all existing to our knowledge. Furthermore, 100,000 kinds of them are distinguishable [12]. Thereupon, researchers have

performed study to attain a classification of scent. They classified a couple of kinds of scents based on the affected levels of emotion [13] into five categories (mint, spice, herb, pepper, sweet). On the other hand, scents are generally differentiated along three different, but not necessarily independent dimensions [14]. They include the affective quality of the scent (e.g., how pleasant it is), its arousal quality (e.g., how likely it is to evoke a physiological response), and its intensity (e.g., how strong it is).

In this study, because we mainly focused on arousal quality of scent stimuli, we regulated other dimensions (pleasantness and intensity) of the stimuli in the same level. In addition, to cover a quite wide range of scent, we applied different kinds of scent which were representatively chosen from each category classified above. They were peppermint (mint category), ginger (spice category), rosemary (herb category), fennel sweet (pepper category), and cinnamon leaf (sweet category).

Previous literature has indicated that both peppermint and cinnamon are considered to stimulate central nervous system, and enhance motivation and alertness [15]. Hayder Alkuraishy [16] showed that ginger played a vital role in acceleration of brain function and improved psychomotor performance, leading to significant activation of vigilance, which implied the arousal effect of ginger. Ginger is verified to stimulate in the study from Christoph & Charles [17] as well. Additionally, another research on aromatherapy from Diego MA et al. [18] suggests that rosemary increases alertness shown by decreased frontal alpha through assessing EEG activity. Given these results, it is clear that most of those five kinds of scent chosen prior are high arousal. Therefore, with adequate considerations, other low arousal regarded scent should be included to become a counter-balance to high arousal scent.

Lavender has been proved to increase beta power, suggesting rising drowsiness, and more relaxed [18]. We also found that inhalation of aroma of geranium (rose geranium) essential oil considerably decreased anxiety score as well as diastolic blood pressure [19]. Besides, sweet marjoram is extensively used in cosmeceuticals to treat high blood pressure, stress and palpitations [20], which implies its relaxing effects. The other three low-arousing considered scents are lavender, rose geranium, and marjoram sweet (sweet marjoram).

### 1.3 Music Research

Music is composed of multiple time, pitch- and texture-related variables [21], which makes it very complicated to measure. Accordingly, in this study, we applied minimal

music, because it is perceived as experimental music which only employs limited or minimal musical materials to eliminate the effect of distinct melody. On the other side, unlike the other less-measurable dimensions of music, further evidence reports that physiological arousal dimension is principally indicated by its tempo (bpm, standing for beats per minute) and rhythm [22]. That is, high arousal music is featured with fast tempo, and low arousal music has the trait of slow tempo. To regulate other dimensions except arousal, we used the same piece of music with difference in tempo.

### 1.4 Arousal Congruence

Congruence, as an abstract term, is defined to mean the similarity (fit, agreement, match) between objects. Meanwhile, numerous researchers hold the opinion that pleasure and arousal quality is one of the most important dimensions to assess physiological responses [23]. Arousal dimension shows how energized or flaccid one feels. It contains positive arousal quality such as excited, stimulated, and also negative arousal quality, like stressed out. In this study, arousal congruence refers to the match of the arousal quality between scent and music stimuli. As it has been mentioned before, the research by Mattila & Wirtz [7] clarified that higher evaluation of the retail setting, positive impulse buying behavior was led by the environmental features congruent in terms of arousal (i.e., high arousal scent with high arousal music, and low arousal scent with low arousal music).

## 2. OBJECTIVE

Prior research stating both scent and music can evoke physiological changes implied the likelihood that scent would alter how people perceive music to some extent. In addition, the conclusion that arousal match combinations resulted in more positive assessment of the retail environment and better experience was drawn [7]. On that account, whether this affirmative affective response would guide to improvement of people's mood and music listening experience with arousal matching scent was investigated in this research.

We hypothesized that scent would modify the evaluation of the arousal of music. That is, high arousal scent will make music perceived more arousing, whereas low arousal scent will lower the arousal of music.

Also, as hedonic ratings involving music liking, and listening experience were also investigated in the experiment. That said, we also hypothesized that the scent which was congruent with music on arousal would

bring out enhanced enjoyment of music, compared with incongruent combinations. For example, people would rate high arousal music more affirmative with the presence of high arousal scent, rather than low arousal scent.

### 3. PRELIMINARY STUDY

#### 3.1 Method

Three pilot experiments were conducted in order to determine the proper scent and music stimuli which would be applied in the main experiment. In other words, we were going to choose four kinds of scents, including two high-arousal scents and two low-arousal scents, and two music samples, which contains one high-arousal and one low-arousal.

The measurement of pleasantness and arousal was accomplished by questionnaire developed by excerpting from the PAD (Pleasure, Arousal, and Dominance) Scale [23]. Each dimension contained six pairs of adjective words. That is, for pleasantness: “unhappy – happy”, “annoyed – pleased”, “unsatisfied – satisfied”, “melancholic – contented”, “despair – hopeful”, “unpleasant – pleasant”. For arousal: “calm – excited”, “unaroused – aroused”, “dull – jittery”, “relaxed – stimulated”, “sleepy – wide awake”, “sluggish – frenzied”.

To refrain from the potential interactive effect between scent and music on the same participant as suggested in previous literature, we performed each pretest separately with considerable time interval.

#### 3.2 Experiment of Scent

In the first pretest of scent, eight kinds of scent were examined. They were peppermint, cinnamon leaf, ginger, fennel sweet, rosemary, lavender, rose geranium, and marjoram sweet. We prepared a sample of each scent by putting 3 drops of essential oil on a cotton ball, which was then placed in one of eight plastic sealable cups. This was repeated for the remaining scents. Each cup was labeled from No.1 to 8.

During the pretest, participants opened each cup randomly and smelt it. Then, they answered the questionnaire to evaluate the scent on pleasantness and arousal. Between scents, a cup of coffee powder was accessible to participants to refresh olfactory sense. After refreshing, they moved on to other scent stimuli, repeating the same procedure. In total, there were 12 participants taking part in this pretest.

We performed Friedman's ANOVA on semantic words individually. In pleasantness dimension, the result of Friedman's ANOVA of “unhappy – happy” ( $p=.000$ ) showed significant difference was found among these

scent stimuli. Following up the Friedman's ANOVA, we conducted Post-hoc analysis using Wilcoxon signed-rank test, and found out rose geranium, rosemary, peppermint, and lavender were perceived significantly happier than other scent. For example, the ratings of peppermint was significant higher than ginger ( $\Delta=2.92$ ,  $p=.002$ ). Similar results also appeared between lavender and marjoram sweet ( $\Delta=1.58$ ,  $p=.008$ ), and rosemary and marjoram sweet ( $\Delta=1.08$ ,  $p=.016$ ), and so on. The same analysis procedure was repeated in other semantic word pairs in pleasantness dimension. Therefore, significant difference was attained on “annoyed – pleased” ( $p=.001$ ), “unsatisfied – satisfied” ( $p=.003$ ), “melancholic – contented” ( $p=.003$ ), “despair – hopeful” ( $p=.000$ ), and “unpleasant – pleasant” ( $p=.003$ ). Accordingly, rosemary, rose geranium, peppermint, and lavender were evaluated as significantly pleasant scent.

As to the evaluation on arousal, a significant difference between peppermint and rose geranium ( $\Delta=1.75$ ,  $p=.017$ ) as well as between rosemary and rose geranium ( $\Delta=1.83$ ,  $p=.018$ ) on “sleepy – wide awake” was shown. The dissimilarity between peppermint and rose geranium ( $\Delta=1.75$ ,  $p=.007$ ) and rosemary and rose geranium ( $\Delta=1.67$ ,  $p=.012$ ) was also ensured on the scale of “sluggish – frenzied”. While, no significant difference was found between lavender and any other high arousal scent, though it was supposed to be low arousal scent according to previous literature.

Since it is plain to see that all the scent samples were over-highly rated on arousal dimension, we adjusted the amount of essential oil to one drop to modify the arousal evaluation. We also altered the scent container to another type with a narrow mouth, so that participants can smell the scent only through the upper cap, and the larger capacity of this container could also accommodate more scented air. We realized that no concrete evidence had shown the refreshing effect of the smell of coffee. Oppositely, it could be extra load of olfactory sense. Thus, taking a deep breath or smelling one's own finger and hand would be a superior way to refresh rather than coffee powder.

In this way, we re-examined the eight kinds of scent to confirm the arousal level of them, especially lavender. However, hardly changes did we obtain in the pretest, though with three participants. Consequently, we turned to apply the scent of hinoki and green apple to instead lavender, because they were reported to have relaxation effect previously [24, 25]. At the same time, to regulate the number of scent stimuli, we removed the scent of ginger, because it was often rated significantly low on pleasantness, and improper to be chosen.

With these scent stimuli, we performed the preset again with ten participants. As a result, green apple, rose geranium, rosemary, and peppermint were repeatedly evaluated as pleasant stimuli. However, as green apple was seen too affirmative to be in the same valence level with the other relatively pleasant scent, therefore, rose geranium, rosemary, peppermint, and hinoki were provisionally selected. As for the results in arousal dimension, rose geranium differed significantly from peppermint ( $\Delta=2.10$ ,  $p=.05$ ) and rosemary ( $\Delta=2.70$ ,  $p=.028$ ) on “relaxed – stimulated”. Hinoki was also noticeably perceived as low arousal scent, when compared to rosemary ( $\Delta=2.10$ ,  $p=.014$ ). We could found similar results from the evaluation of other words, such as “sleepy – wide awake”, where rosemary was considerably high arousing than rose geranium ( $\Delta=2.20$ ,  $p=.011$ ) and hinoki ( $\Delta=1.60$ ,  $p=.043$ ), and peppermint also scored remarkably high than rose geranium ( $\Delta=2.10$ ,  $p=.011$ ).

Therefore, based on the results interpreted above, we decided to choose hinoki, rose geranium as low arousal scent, whereas peppermint and rosemary to be the high arousal stimuli.

### 3.3 Experiment of Scent

As for the pretest on music, at first, we examined the four music samples made from two pieces of musical works: *Phasing*, and *Pendulum* by Steve Reich, in that they were both composed of repeated musical phrases, and only changed gradually on tempo. The tempo of *Pendulum* changes from fast to slow, whereas *Phasing* varies from slow tempo to fast tempo. The four music samples last 40 seconds, and contain both slow and fast part of each musical work. These music stimuli were played by speakers of MacBook in the same volume ( $75\text{dB}\pm 3\text{dB}$ ). Participants were required to rate each of them on pleasantness and arousal using the same questionnaire as before, after listening to it for 40 seconds. Then, they repeated this procedure and finished rating all the music stimuli in random order. 8 participants were involved in this pretest.

Analyzing in a similar way with scent stimuli, we found that *Phasing*-fast tempo (high arousal) was perceived remarkably happier than *Phasing*-slow tempo (low arousal) ( $\Delta=.50$ ,  $p=.016$ ), and no significant difference between *Phasing*-fast tempo (high arousal) and *Pendulum*-slow tempo (low arousal). While on the scale of “unsatisfied – satisfied”, a significant difference was revealed between *Phasing*-fast tempo (high arousal) and *Pendulum*-slow tempo (low arousal) ( $\Delta=1.50$ ,  $p=.026$ ), which conveyed that choosing either low arousal music could not eliminate

the difference on pleasure between them. Additionally, the result of “melancholic – contented”, “despair – hopeful”, and “unpleasant – pleasant” also supported this point of view.

However, the most obvious finding of this pretest was the perceived arousal level of two pieces of music was noticeably different. That is, two music samples from *Phasing* were both higher rated than those from *Pendulum*.

Therefore, we carried out another test on music by using four music stimuli in different tempos manipulated from a same piece of music, *Phasing*. They were, 100% of the original tempo, 80% of the original tempo, 60% of the original tempo, and 40% of the original tempo. Each of them was still 40 seconds.

The results of the Friedman’s ANOVA analysis on pleasure revealed that all the music samples were evaluated affirmative, without difference in pleasure dimension. Nevertheless, there was significant difference on “sleepy – wide awake” between samples in 40% and 100% of the original tempo ( $\Delta=2.67$ ,  $p=.027$ ), as well as on the scale of “sluggish – frenzied” ( $\Delta=2.67$ ,  $p=.026$ ). As a result, the music sample in 40% of the original tempo was determined as low arousal stimulus, the music sample in 80% of the original tempo was selected as high arousal music stimulus.

## 4. MAIN EXPERIMENT

### 4.1 Method

In the first part of the questionnaire in the main experiment, the participants were instructed to assess their present mood state by means of the Two-Dimensional Mood Scale (TDMS) composed of eight adjective words (including energetic, lively, lethargic, listless, relaxed, calm, irritated, and nervous) [11] based on pleasure and arousal. The reason why we altered to the TDMS other than the PAD scale which was used in preliminary study, was significant difference did not appear in all the Semantic words in the prior pretest, so that we turned to apply a more compact one with less words. Participants evaluated each word on a 7-level Likert scale, with -3 being “not at all”, and 3 “very much”.

As for the second part of the participants’ evaluation, they also had to rate on three questions based on a 7-level scale, being -3 “totally disagree” and 3 “totally agree”. They rated how much they enjoyed the music, and how much it matched to the scent. Finally, the participants were asked whether listening experience was enhanced by the scent.



## 4.2 Stimuli & Procedure

With the results of preliminary study, we used four kinds of scent which could be divided into two groups: high arousal group (peppermint, rosemary) and low arousal group (rose geranium, hinoki). In the aspect of music stimuli, we chose the samples made from Phasing, which were 40% of the original tempo as the low arousal music, and 80% of the original tempo as the high arousal music. 20 participants were involved in this experiment, consisting of 12 males, and 8 females, aged from 21 to 32 years old (mean age of 24.75 years, SD of 2.47). All of them were students in University of Tsukuba.

In this experiment, including the control group without scent, all the participants perceived 10 combinations of scent and music stimuli, and then answered a questionnaire after each combination, to assess their mood state and the overall evaluation of combined stimuli. These containers of scent samples were labelled from No.1-No.5, while the two music samples were marked as A (low arousal) and B (high arousal).

By drawing lots, we were able to examine the stimuli in a random order. As consistent with the number of stimulus combinations, there were also 10 lots to distinguish them. For example, the lots written in "1A" means the No.1 scent sample, and the A music sample.

First of all, participants signed on the consent document, and agreed to be involved in this experiment, after being well informed the conditions and instructions about the experiment. Then, they started to perceive each configuration by drawing lots. After they wrote down the number of stimuli combination, we started to play the music stimulus, and participants opened the cap of the scent container. They kept holding the scent container to smell the scent while listening to music. During the same period, they were also replying the questionnaire. Note that there was a 10-minute interval in the middle of the experiment. We opened the window to ventilated the scented air, and also asked the participant to get refreshed. In total, the experiment lasted for around 15 minutes.

## 4.3 Analysis

Friedman's ANOVA was performed for the main experiment, with scent condition and music stimuli as factors and participant ratings (mood assessment and hedonic ratings) as measurement. Furthermore, we calculated Wilcoxon signed-rank test in order to compare the effect of these scents. All of the post hoc pairwise comparisons were Bonferroni corrected.

## 4.4 Result

### 1) Emotional Responses:

To observe participants' corresponding mood state, we ran Friedman's ANOVA on each adjective for two music stimuli separately, with scent stimuli as factor and participants' ratings as measures. Significant difference is shown by asterisk in each figure ( $p < .05$ ).

#### A. Energetic (Figure 1):

We detected that the evaluation on both music stimuli was notably modified by scent. In particular, peppermint significantly raised the energetic level compared with control group ( $\Delta = 1.30$ ,  $p = .018$  for low arousal music and  $\Delta = 1.25$ ,  $p = .003$  for high arousal music). Some other interesting findings also appeared, that hinoki considerably increased energetic rating ( $\Delta = 1.15$ ,  $p = .005$ ) of low arousal music as well though hinoki was regarded as low arousal scent, and significant difference for high arousal music between peppermint and rosemary occurred ( $\Delta = 1.40$ ,  $p = .006$ ) despite that they were both high arousal scent being supposed to rise up arousal level.

#### B. Lively (Figure 2):

On lively rating, significant difference was hardly found for low arousal music. However, peppermint seemed to make high arousal music to be perceived remarkably livelier than rosemary ( $\Delta = 1.25$ ,  $p = .026$ ) although both of them were considered as high arousal scents.

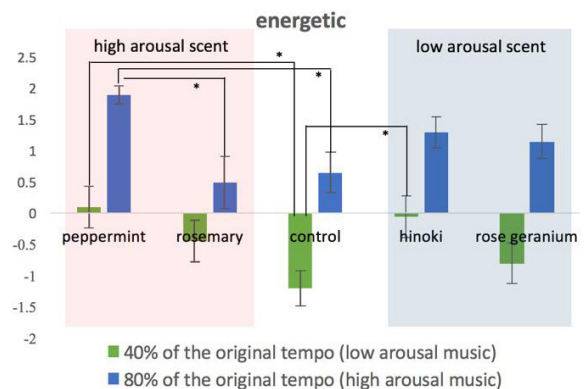


Figure 1: Ratings of Energetic

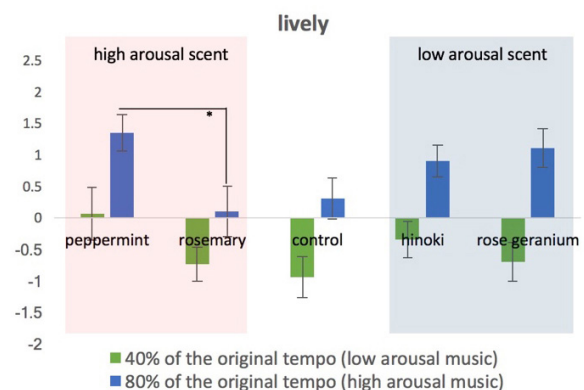


Figure 2: Ratings of Lively

### C. Relaxed (Figure 3):

No markedly difference between scent stimuli and control group for high arousal music, but the significant difference between hinoki and rose geranium was seen ( $\Delta=.85$ ,  $p=.022$ ) which means they had thoroughly contrasting effect on the music on relaxing scale, even though they were both considered as low arousal scent. On the other hand, for low arousal music, we found rosemary noticeably lowered the relaxing level of the music, compared with control group ( $\Delta=1.45$ ,  $p=.005$ ) and other scent stimuli (peppermint  $\Delta=1.40$ ,  $p=.004$ , hinoki  $\Delta=1.05$ ,  $p=.017$ , and rose geranium  $\Delta=1.35$ ,  $p=.015$ ).

### D. Calm (Figure 4):

We found that rose geranium obviously affect high arousal music to be perceived as further calmer, compared with hinoki ( $\Delta=.95$ ,  $p=.018$ ). Even compared to control group, hinoki also demonstrated the intensifying quality, in spite of the fact that it was low arousal scent.

### E. Irritated (Figure 5):

We observed for low arousal music, the result of rosemary was considerably different from control group ( $\Delta=1.20$ ,  $p=.021$ ), which indicated music was influenced to sound more irritating by rosemary. Besides, the evalua-

tion of rosemary also noticeably differed from rose geranium ( $\Delta=1.05$ ,  $p=.007$ ). While, for high arousal music, rose geranium made music perceive incredibly less irritating than control group ( $\Delta=1.25$ ,  $p=.006$ ), and also hinoki ( $\Delta=1.20$ ,  $p=.007$ ).

### F. Nervous (Figure 6):

This comparison only achieved statistical significant between rosemary and control group for low arousal music ( $\Delta=1.30$ ,  $p=.008$ ), indicating that rosemary greatly raised the nervous level of music.

Furthermore, no significant results were observed on the evaluation of lethargic and listless among each group, so that we can clarify these scent stimuli did not have much effect on music samples in the dimension of lethargic and listless.

To summarize, these results definitely revealed that scent would alter people's perception of music stimuli. Specifically, high arousal scent including peppermint and rosemary tended to modify music to be recognized more stimulated, regardless of it was positive (e.g., energetic) or negative (e.g., irritated, nervous). From the same perspective, rose geranium, as one of the low arousal scent, also appeared to lessen evoking level (e.g., irritated) significantly, and helped to calm down (e.g., relax, calm)

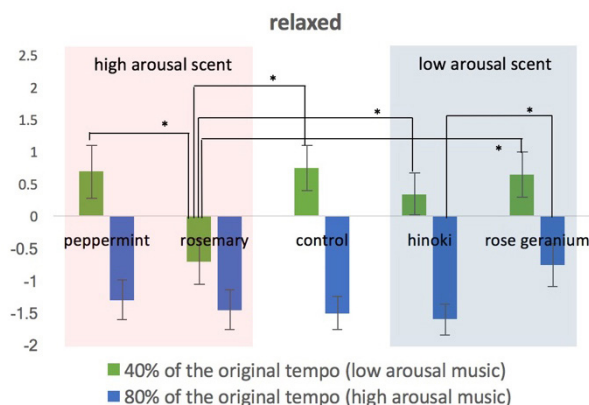


Figure 3: Ratings of Relaxed

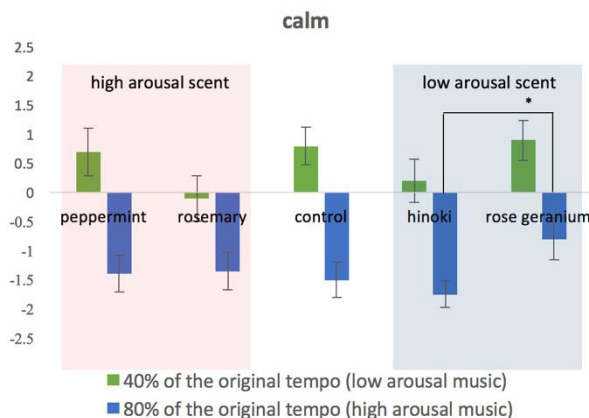


Figure 4: Ratings of Calm

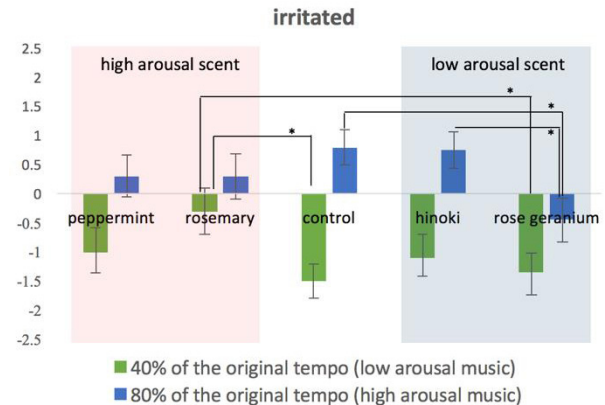


Figure 5: Ratings of Irritated

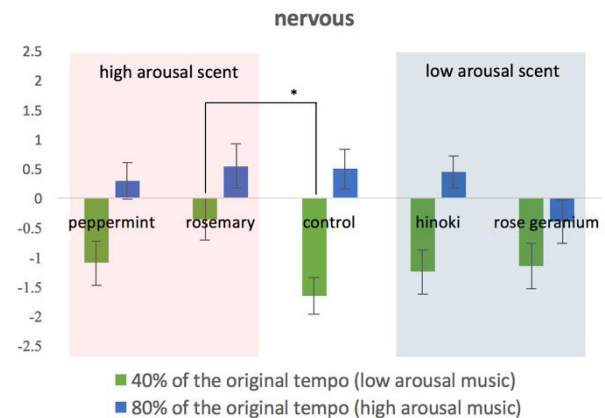


Figure 6: Ratings of Nervous

to some extent. Accordingly, we can, now believe the results are consistent with the hypothesis that scent will modify the evaluation of the corresponding emotional responses towards music, in arousal dimension.

## 2) Hedonic Ratings

In order to identify how much people enjoyed the music with the presence of scent, firstly, Friedman's ANOVA as well as post hoc pairwise comparisons were performed on each individual music sample, with scent conditions as factors and evaluation as measures. As indicated by Figure 7, scent stimuli definitely exerted a significant influence over the preference level of music. Rosemary noticeably decreased the valence of low arousal music, compared with hinoki ( $\Delta=1.15$ ,  $p=.008$ ). This observation implies that the scent which is congruent with music on arousal would progress people's enjoyment of music than the scent which is incongruent. Moreover, we found that the result of rosemary was also significantly different from that of peppermint ( $\Delta=1.20$ ,  $p=.019$ ) and control group ( $\Delta=.90$ ,  $p=.032$ ), which pointed to the fact that rosemary was considered to not match with low arousal music sample. As to the analysis on high arousal music, hardly no remarkable result was seen besides peppermint greatly enhanced music liking ( $\Delta=1.05$ ,  $p=.012$ ), contrast with control group. Another absorbing finding was under the control condition, the valence dimension of low arousal music sample was rated further higher than high arousal music sample ( $\Delta=1.00$ ,  $p=.033$ ), whereas difference between other combinations was barely found.

To determine the better match to high arousal music sample, peppermint scored significantly higher than hinoki ( $\Delta=1.15$ ,  $p=.008$ ), which revealed that peppermint, a kind of high arousal scent, was regarded to be congruent with high arousal music. Compared with high arousal music without scent, peppermint also have a

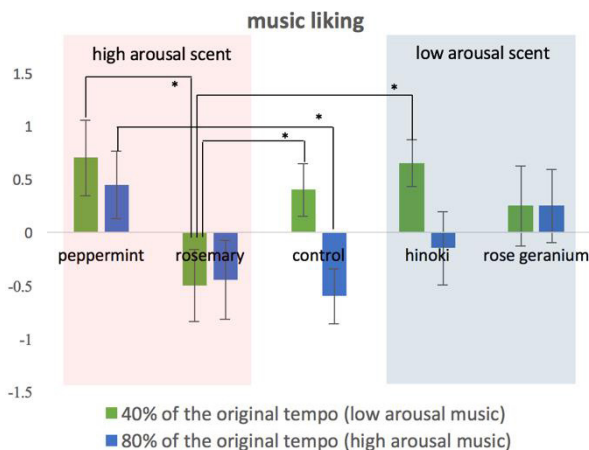


Figure 7: The Result of How Much They Enjoyed Music

superior performance on matching ( $\Delta=1.20$ ,  $p=.023$ ). Oppositely, no significantly difference was found when comparing ratings on low arousal music. Figure 8 shows the stimuli-match results from both music samples.

For high arousal music, peppermint appreciably brought out a positive effect on listening experience than hinoki ( $\Delta=1.20$ ,  $p=.007$ ), suggesting that enhanced listening experience could be obtained with the help of the scent, which was congruent with music on arousal, rather than incongruent configurations. Furthermore, when comparing with control condition, the combination with peppermint was noticeably affirmative as well ( $\Delta=1.50$ ,  $p=.009$ ). However, we also noticed that the performance of rose geranium significantly was superior than rosemary ( $\Delta=1.30$ ,  $p=.021$ ), hinoki ( $\Delta=1.50$ ,  $p=.002$ ), and control group ( $\Delta=1.80$ ,  $p=.007$ ), even though the low arousal scent was supposed not to match to high arousal music. Unexpectedly, there was no significant difference among the effect of scent on low arousal music samples (Figure 9).

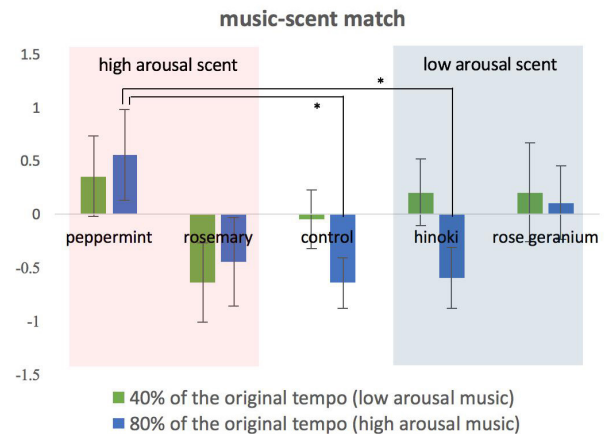


Figure 8: The Result of How the Combination Was

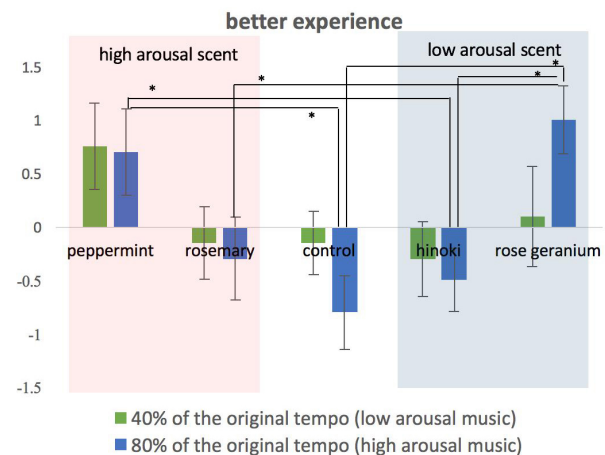


Figure 9: The Result of Whether Better Experience Was Obtained by Scent

## 5. DISCUSSION

Our findings emphasized the effect of scent on people's emotional responses towards music. It was revealed that the arousal quality of scent could alter the perceived arousal level of music. In particular, high arousal scent can influence music to be rated more arousing, whereas low arousal scent also has the potential impact on lowering the arousal of music (see the result of "energetic" and "irritated" in Section 4.4). Aside from this, in this study, we also observed that high arousal music was evaluated more preferable and enjoyable, with the presence of high arousal scent, such as peppermint, rather than low arousal scent (see the result of "music liking" Section 4.4). Since it was reported that scent could bring out physiological changes, shown by rate variability and neuronal activity [9], high arousal scent was supposed to activate the activity of sympathetic nerve system. When combined with high arousal music, the strengthened sympathetic activity will certainly lead to higher tension, and higher level of excitement, which could be demonstrated by the ratings of high arousal music on energetic (Figure 1).

However, rosemary, the same as peppermint, which is high arousal scent, was found significantly varied on the evaluation of energetic. Here, we presume another dimension of scent, valence, played an essential role. No prior study has approached the fact that arousal and valence, the two dimensions are independent from each other. Thus, it is plausible to say affirmative nature affects arousal quality to some extent. Similar example was exhibited by hinoki on the ratings of relaxed for high arousal music (Figure 3), which was significantly different from rose geranium.

Oppositely, the scent which people is considerably familiar with is usually considered as much preferable and positive [26], like peppermint, and rose geranium. As a result, they were greatly high-rated regardless that the combination of scent and music in incongruent on arousal, such as the evaluation of irritated (Figure 5), as well as rose geranium significantly improved the listening experience for high arousal music, contrast with rosemary and hinoki

In this research, we have shown the high arousal scent is congruent with high arousal music, but congruent relationship has not been brought to light for low arousal music. This is in contrast to the study which previous reported that congruency between scent and music existed in both high arousal and low arousal [7]. The possible reason might be the two music samples used in

our study did not share the same valence, so that the difference of valence led to the deviation of the impact of scent on music.

Some limitations that we encountered while deciding the proper music stimuli are worth mentioning here. In particular, music contains such excessive elements that makes it unbelievably hard to eliminate the irrelevant components except for arousal quality. We applied minimal music to get rid of the other disturbing elements though, the preference of this type of music did not seem to be optimistic, shown by the results of preliminary study. We suppose one of the possible reasons could be minimal music is extraordinary different the music we usually listen to. People who are acquainted with minimal tend to be really fond of it, whereas people who are unfamiliar with it think it is disgusting. Such extreme dissimilarity of music might be an attentional bias.

Although in the pilot experiment, we focused on manipulating music samples by using the much-preferred works, *Phasing*, rather than *Pendulum*, and selected the two samples which were relatively rated pleasant, the slight distinction of preference was amplified when only comparing those two in the main experiment. So, this could interpret the appearance of significant difference on music liking.

## 6. CONCLUSION

Summarizing, our works demonstrated the effect of scent on people's emotional responses towards music. It seemed that people tended to associate the arousal quality of scent with that of music. Additionally, for unfavorable high arousal music, high arousal scent definitely increased the affirmation of music, and people were more likely to obtain a better experience with the presence of scent which was congruent with music in arousal dimension than incongruent condition. Here, we demonstrated that it would be possible to analyze how the emotional aspects involved in scent-music experience can affect such multisensory correspondences. Since music is widely used in various aspects, such as background music in movies, affirmative scent would effectively dispel the horrified or irritated atmosphere of a thriller, if the audience are not encouraged enough to watch such movies. Thus, congruent scent is positively expected to create an enhanced experience of music in other areas.

Due to the fact that low arousal music examined in our study was barely influenced by scent, therefore, more cases analyzing these potential modulatory effects, and



others with special focus on how our emotional relation with scent can have a significant impact on the perceived affirmation of music, are still in demand.

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