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The efficacy of musical emotions provoked by Mozart's music for the reconciliation of cognitive dissonance

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Debates on the origin and function of music have a long history. While some scientists argue that music itself plays no adaptive role in human evolution, others suggest that music clearly has an evolutionary role, and point to music's universality. A recent hypothesis suggested that a fundamental function of music has been to help mitigating cognitive dissonance, which is a discomfort caused by holding conflicting cognitions simultaneously. It usually leads to devaluation of conflicting knowledge. Here we provide experimental confirmation of this hypothesis using a classical paradigm known to create cognitive dissonance. Results of our experiment reveal that the exposure to Mozart's music exerted a strongly positive influence upon the performance of young children and served as basis by which they were enabled to reconcile the cognitive dissonance.

The effect of listening to Mozart's music on spatial reasoning has been investigated extensively since 1993[1,2]. Moreover, in 2008, Nature[3] published a series of essays on music. The authors agreed that music is a cross-cultural universal, still "no one... has yet been able to answer the fundamental question: why does music have such power over us?"[4]. Here we provide experimental demonstration that music helps tolerating cognitive dissonance. Cognitive dissonance is "a discomfort caused by holding conflicting cognitions" simultaneously[5,6]. People prefer to avoid this discomfort and usually they do it by devaluation of conflicting knowledge[7]. A recent hypothesis[8], experimentally validated here, suggested that music can help mitigating cognitive dissonance and keeping conflicting knowledge in mind.

Ancient Greeks knew that people did not like the dissonance and tend to resolve it by devaluing a conflicting cognition. In the Aesop's fable, when a fox sees high-hanging grapes, his desire to eat grapes and inability to reach them are in conflict. The fox overcomes this cognitive dissonance by deciding that the grapes are sour and not worth eating. Since the 1950s cognitive dissonance became a widely and well intensively studied area of psychology. It is known that tolerating cognitive dissonance is difficult, and people often make irrational decisions to avoid it[9]. In the present study, cognitive dissonance was experimentally created in 4-year-old children using a well-established method (the induced-compliance paradigm). According to the previous research, similar cognitive dissonance as adults can be confirmed in children as young as 4-year-olds, using this method[6]. The experiment was conducted twice to validate the findings (referred to as "the first experiment" and as "the second experiment" below). The general procedure adopted in both experiments was essentially identical with that of previous research[9]. With each child, in the first session, an experimenter, who had not been notified of the purpose of the present experiment, played an "evaluation game" to elicit a toy ranking. In the next session, while the child was playing with toys, the experimenter said "I have to leave now for a few minutes to do an errand. But why don't you stay here and play with these toys while I am gone? I will be right back. You can play with this one [pointing], this one, and this one. But I don't want you to play with [mentioning the name of the second-ranked toy]." According to the previous research this was expected to create cognitive dissonance, and eventually to result in devaluing the second-ranked toy. Exactly this result was observed, when the experimenter returned and played "ranking game" again: the toy previously ranked as the second was devalued to near bottom rank.

On the other hand, according to the previous research, no need to reconcile cognitive dissonance could be experimentally demonstrated as the increase of rating of the forbidden toy by the participants[9]. Based upon these findings, we performed here experimentation with another group of children that was different only in one respect. Namely, the participants were exposed to music while playing alone (one of Mozart sonatas in the first experiment, and one of Mozart piano concertos in the second experiment). We have decided to use these music pieces as stimulus excerpts because psychophysiological effects of this sonata or concerto upon its listeners have been extensively investigated as "the Mozart effect[2]": it enhances cognitive performance of the listeners and increases the listeners' brain activation. Ten minutes of listening to the sonata was found to enhance the performance of spatial reasoning skills in both adults and young children. Concerning this sonata, electroencephalographic measurements in young children during exposure to the music revealed enhanced synchrony of the firing pattern of the right frontal and the left temporoparietal regions, as well as increased power of the beta spectrum in extremely extensive brain regions. Such accumulating evidence might lead to a hypothesis that the children exposed to music might have been more aroused than usual, rather than having been calmed down. The activity of the limbic system could have been calmed down, which nevertheless could predispose the children to pleasure as noted before.

If such music would indeed help mitigating cognitive dissonance, we would expect that devaluing of the second-ranked toy would be not as strong as without music, or possibly the increase of the rating of that toy would occur[9]. The results should be explained as indicating that the music exerted a strongly positive influence upon the performance of the children not only at relatively lower levels of their cognition (such as spatial reasoning), but also at much higher levels, so that it could have served as a basis by which the children were enabled to reconcile the cognitive dissonance, as hypothesized in the theory of the cognitive function of music[8]. In fact, this is exactly what was observed. The group of children exposed to music did not devalue the "forbidden" toy. We concluded that indeed music helped mitigating the cognitive dissonance and no devaluation was needed.

Results

The results of changes of the participant's ranking of the attractiveness of a "forbidden" toy are summarized in Table 1. In the first experiment with exposure to Mozart's sonata, 15 of the 25 participants increased their rating of the toy, 7 did not alter their rating, and 3 decreased it, whereas without exposure to music 5 participants increased their rating, 14 did not alter and 6 decreased it. The rating of the toy was more likely to increase with exposure the sonata than without exposure to the music and less likely to decrease with such exposure than without such exposure ($\chi^2(1) = 4.58$, $P = 0.032$). When the difference between the rank in the first rating and the rank in the second rating was computed for each participant, the average scores were statistically significant between the two participant groups ($t(48) = 3.48$, $P < 0.001$). In the second experiment with exposure to Mozart's concerto results were similar: 15 of the 25 participants increased their rating of the toy, 6 did not alter their rating, and 5 decreased it. In contrast, without exposure to music, 6 participants increased their rating, 14 did not alter it and 5 decreased it. The difference between the two conditions again was statistically significant ($\chi^2(1) = 7.06$, $P = 0.029$). When the average difference between the rank in the first rating and the rank in the second rating for each participant was compared between the two participant groups, the difference was statistically significant ($t(48) = 3.63$, $P < 0.001$). There were no statistically significant differences between the two experiments: without exposure to music ($\chi^2(1) = 0.08$, $P = 0.962$) or with exposure to either sonata or concerto ($\chi^2(1) = 0.09$, $P = 0.956$).

Table 1 | Change in attractiveness of the second-ranked toy when it was forbidden to play with it in the first and the second testing

The first testing

Experimental condition	Rating		
	Increase	Same	Decrease
Mild suggestion with music	15	7	3
Mild suggestion without music	5	14	6
Severe suggestion without music	16	8	1

The second testing

Experimental condition	Rating		
	Increase	Same	Decrease
Mild suggestion with music	15	6	4
Mild suggestion without music	6	14	5
Severe suggestion without music	14	8	3

In each experiment a group of 25 participants experienced a third experimental condition, a strongly worded suggestion not to play with the toy ("I don't want you to play with [mentioning the name of the second-ranked toy]. If you played with it, I would be disappointed. I would have to take all of my toys and go home and never come back again. You can play with all the others while I am gone, but if you played with [mentioning the name of the second-ranked toy], I would think you were just a baby."). This third experimental condition, according to previous research, was expected to produce no cognitive dissonance, and accordingly it was conducted without exposure to music, since no devaluation was expected. Results for this third experimental condition are also summarized in Table 1.

In the first experiment 16 participants increased their rating, only one participant decreased it, and 8 did not alter it. This was significantly different from the change of ranking (devaluation due to cognitive dissonance) reported previously for participants who experienced a mild suggestion without exposure to music ($\chi^2(1) = 9.33$, $P = 0.009$). When the difference between the rank in the first rating and the rank in the second rating was computed for each participant, the average scores were statistically significant between the two participant groups ($t(48) = 3.21$, $P < 0.001$). However, this change of ranking recorded under the third experimental condition was not significantly different from the change of ranking recorded for participants reported previously with exposure to music ($\chi^2(1) = 1.03$, $P = 0.597$). When the average difference between the rank in the first rating and the rank in the second rating for each participant was compared between the two participant groups, the difference was not statistically significant ($t(48) = 0.59$, $P = 0.674$). These results confirmed expectation based on the previous research[10] that a strongly worded suggestion would produce no cognitive dissonance and no devaluation. Similar results were obtained in the second experiment: 14 participants increased their rating, 3 participants decreased it, and 8 did not alter it. This was significantly different from the change of ranking (devaluation due to cognitive dissonance) recorded for participants who experienced a mild suggestion without exposure to music ($\chi^2(1) = 8.44$, $P = 0.004$). When the difference between the rank in the first rating and the rank in the second rating was computed for each participant, the average scores were statistically significant between the two participant groups ($t(48) = 3.30$, $P < 0.001$). However, this change of ranking recorded under the third condition was not significantly different from the change of ranking previously recorded for participants with exposure to music ($\chi^2(1) = 0.32$, $P = 0.852$). When the average difference between the rank in the first rating and the rank in the second rating for each participant was compared between the two participant groups, the difference was not statistically significant ($t(48) = 0.53$, $P = 0.713$). Again there were no statistically significant differences between experiments ($\chi^2(1) = 0.13$, $P = 0.936$).

In addition, all of the participants were tested to evaluate the changes in attractiveness of a toy when it was simply withdrawn. The purpose of this testing (referred to as "the control test") was to establish a proper baseline for the experiment as conducted in the previous research by examining whether the participants did change their ranking of the crucial toy in a systematic direction or not simply when the toy was withdrawn. The results are summarized in Table 2. Among the 25 children who had previously in the first experiment experienced a mild suggestion with exposure to music, 16 increased their rating of the toy, 3 decreased it, and the remaining 6 did not alter it. Similarly, 16 increased their rating, 4 decreased it, and 5 did not alter it in the group that had previously experienced the mild suggestion without exposure to music. The difference was not statistically significant ($\chi^2(1) = 0.09$, $P = 0.956$). Similar results had been observed among the 25 participants who had previously experienced a strongly worded suggestion without exposure to music, 15 increased their rating of the toy, 2 decreased it, and the remaining 8 did not alter it. This change of ranking for a withdrawn toy was not significantly different from that of the participants who previously had experienced the mild suggestion with exposure to music ($\chi^2(1) = 0.72$, $P = 0.696$) or without exposure to music ($\chi^2(1) = 0.32$, $P = 0.853$). The data presented in Table 2 reveal that the attractiveness of a toy for the children tended to be enhanced if it was merely withdrawn temporarily from them. This tendency was observed in all tested groups, and is consistent with previously reported findings[9]. To summarize, all these additional experiments undertaken for comparison with expectations based on the past research went as expected.

Discussion

When forbidden to play with the toy (with no exposure to music) the 25 children in the group that had experienced a mild suggestion were more likely to devalue that toy than the 25 children in the group that had experienced a strong suggestion. These findings are in accordance with the following notion proposed by the classical theory of cognitive dissonance: when a child experienced a strong suggestion, his cognition that he did not play with an attractive toy was consonant with his cognition that he was strongly suggested not to play with the toy. In contrast, when a child refrained from playing with a toy in the absence of a strong suggestion, he experienced cognitive dissonance; his cognition that he did not play with the toy can be interpreted to have been dissonant with his cognition that it was attractive. To reduce this dissonance, he devalued the toy. These results, obtained using methodology that reproduced the cognitive dissonance effects observed in previous research[9], indicate that these children experienced cognitive dissonance. Under the same circumstances, however, the 25 children in the group who were exposed to Mozart's sonata were less likely to devalue the toy; the same was true for the 25 children in the group who were exposed to Mozart's concerto. This indicates that music has enabled the children to reconcile the cognitive dissonance, as hypothesized by the theory of the cognitive function of music[8].

Whereas these experiments do not directly witness on the effect of music on human evolution, they testify to several fundamental problems. First, every cognition or a piece of knowledge contradicts to inborn instinctual drives to some extent (otherwise instinctual drives would be sufficient for making decisions involving this cognition; this cognition would not be useful and it would not appear; the same applies to any pair of cognitions: if there is no even a minor contradiction among them, one of these cognitions is useless). In other words, useful cognitions always involve contradictions. The very process of thinking involves evaluating contradictory options. According to the current understanding of cognitive dissonance, contradictory cognitions are devalued[9]. Therefore accumulation of knowledge and ability to think requires a mechanism for tolerating (overcoming) cognitive dissonance. In view of importance of this conclusion, even a first step in this paper toward identifying a mechanism for tolerating cognitive dissonance is fundamentally important.

A second fundamental question addressed by our experiments concerns existence of cognitive function of music. As discussed, contemporary cognitive and evolutionary musicology faces great controversies in attempting to identify such a function for music[10,11]. This question has been addressed by great minds for about 2,500 years, and the conclusion has been that it remains a mystery[12]. Tolerating cognitive dissonance and making thinking possible could be such a fundamental cognitive function of music.

In the present study, the experimental condition of "strongly worded condition" was presented without music, as it is assumed that this condition would not create any cognitive dissonance. However, an inclusion of the with-music treatment within this condition relative to the without-music treatment could strengthen the present findings; if there is indeed no dissonance, there should be no difference in changes of ranking with or without music for the strongly worded condition. Also, the evaluation of the arousal status of the participants after different treatments should be of importance as a complementary measure in helping resolve whether they did experience cognitive dissonance. Apparently, these are issues that are to be investigated in the near future.

Table 2 | Change in attractiveness of the second-ranked toy when it was merely withdrawn

Previous experience	Rating		
	Increase	Same	Decrease
Mild suggestion with music	16	6	3
Mild suggestion without music	16	5	4
Severe suggestion without music	14	7	4

Methods

This investigation was conducted according to the principles expressed in the Declaration of Helsinki. All experimental protocols are consistent with the Guide for the Experimentation with Humans and were approved by the Institutional Ethical Committee of Primate Research Institute, Kyoto University.

Participants. As participants, we recruited 75 typically developing 4-year-old boys from several kindergartens in Kyoto and Aichi prefectures, Japan. We obtained written informed consent from the parents of all participants involved in our study. They were randomly assigned to either of three groups, each of which was made up of 25 children, for subsequent experimentation. The experimental room was a sound-attenuated playroom (3.5 m X 5.5 m) familiar to all of the participants. It contained a one-way observation mirror and a low table on which the experimenter was able to display five toys. A ceiling speaker was installed in the ceiling of the room, just above the table. For the toys displayed, a total of 10 different miniature cartoon monster figures (known as "Pockemon" figures) were randomly chosen. They were randomly assigned to either of two sets, each of which comprised of five figures. All 10 figures were produced on the basis of images of monster characters that appeared in a TV cartoon, "Pocket Monster". All of the toys were extremely popular with children in Japan, particularly with young boys, and an opportunity to play with them was expected to be met with enthusiasm. Prior to the commencement of the experimental session, the experimenter spent several weeks at the kindergartens playing with the children, so that all of them could have known her well when the session started.

Procedure. In all, each participant was subjected to the experiments twice (the first and the second experiments) and to the control test once during the present study, i.e., each experiment was designated to evaluate the changes of the attractiveness of a toy to the participants when it was forbidden to play with it, and the control test was designated to evaluate the change of the attractiveness of the toy to the participants when it was simply withdrawn. Both experiments were conducted for each child, with an interval of 14 to 15 weeks. The experiments were separated by the control test, which was undertaken after the first testing experiment with an interval of 7 to 8 weeks. One of the prepared two sets of toys was used for the first experiment and the subsequent control test whereas the other set was used for the subsequent second experiment.

In each of the first and the second experiments, the experimenter led each participant into the experimental room, closed the door, and showed the participant the toys. She explained what each monster toy was, and allowed the participant to play with it briefly before moving on to the next one. After the participant became familiar with all the toys, the experimenter suggested a "question game" following which the participant was provided with an opportunity to play with the toys. The experimenter placed all the toys on the floor and was seated on the opposite side of the low table from the participant. Having put two of the toys on the table (for example, *Jorohda* and *Yonoire* shown) she asked "Suppose you could play with either *Jorohda* [picking it up], or *Yonoire* [picking it up]. Which one would you rather play with?"

After the participant responded, the experimenter replaced the two toys on the floor, put two other monster toys on the table, and continued until the participant made choices between all 10 possible pairs. By this procedure, a ranking was elicited, from the most preferred toy (rank 1) to the least preferred (rank 5) toy. As far as following this procedure, some inconsistencies in choices of the participant could have been expected (e.g., the participant preferred toy A over toy B, toy B over toy C, but also toy C over toy A). However, actually, these did not occur in the present experiment. After the participant ranked the toys, the experimenter picked up the second-ranked toy, placed it on the table in the center of the room, arranged the remaining toys on the floor, and said: "I have to leave now for a few minutes to do an errand. But why don't you stay here and play with these toys while I am gone? I will be right back. You can play with this one [pointing], this one, and this one. But I don't want you to play with [mentioning the name of the second-ranked toy]."

At this point, the experimental conditions were introduced. To each of the 25 children in one of the three groups that would experience a strongly worded suggestion, the experimenter continued: "I don't want you to play with [mentioning the name of the second-ranked toy]. If you played with it, I would be disappointed. I would have to take all of my toys and go home and never come back again. You can play with all the others while I am gone, but if you played with [mentioning the name of the second-ranked toy], I would think you were just a baby. I will be right back."

To each of the children in the other two groups, who would experience a mildly worded suggestion, the experimenter instead continued: "I don't want you to play with [mentioning the name of the second-ranked toy]. If you played with it, I would be annoyed. But you can play with all the others while I am gone, and I will be right back."

The experimenter then left the room. As she was leaving the room, she switched on an audio player connected to a ceiling speaker in the room, if the child in the room was in one of the two groups of the participants who experienced a mildly worded suggestion, so that Mozart's sonata for two pianos in D major, K448 and Mozart's piano concerto No.23 in A major K488 was played, in the first experiment and in the second experiment, respectively (the sound pressure level: 65 dB in either experiment). The music continued to be played until the experimenter came back and switched off the player, whereas the children in the other two groups remained without such exposure to music during that period. To summarize, the overall design of the first experiment and that of the second experiment differed in only one respect: music was played in one of the three participant groups. In addition, the group of participants who had experienced a mild suggestion with music in the first experiment, subsequently experienced a strongly worded suggestion without music in the second experiment, while the group of participants who had experienced a mild suggestion without music in the first experiment, subsequently experienced a mild suggestion with music in the second experiment, and the remaining group, consisting of those participants who had experienced a strongly worded suggestion without music in the first experiment, experienced a mild suggestion with music in the second experiment.

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Author contributions

NM and LP conceived of the study, and participated in its design and coordination and drafted the manuscript. NM conducted the experiments and participated in the data analysis and interpretation. Both authors read and approved the final manuscript.

Additional information

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