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Research report

Mozart effect, cognitive dissonance, and the pleasure of music

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HIGHLIGHTS

- ► Music helps overcoming cognitive dissonance and hold contradictory knowledge.
- ► This might be fundamental for human evolution and ability to think.
- ► The 'Mozart effect' might be caused by overcoming cognitive dissonance.
- ► Students reduce thinking time during stressful tests, but music reverses this.
- ► A 'mystery of music' might be due to overcoming cognitive dissonance.

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ABSTRACT

We explore a possibility that the 'Mozart effect' points to a fundamental cognitive function of music. Would such an effect of music be due to the hedonicity, a fundamental dimension of mental experience? The present paper explores a recent hypothesis that music helps to tolerate cognitive dissonances and thus enabled accumulation of knowledge and human cultural evolution. We studied whether the influence of music is related to its hedonicity and whether pleasant or unpleasant music would influence scholarly test performance and cognitive dissonance. Specific hypotheses evaluated in this study are that during a test students experience contradictory cognitions that cause cognitive dissonances. If some music helps to tolerate cognitive dissonances, then first, this music should increase the duration during which participants can tolerate stressful conditions while evaluating test choices. Second, this should result in improved performance. These hypotheses are tentatively confirmed in the reported experiments as the agreeable music was correlated with longer duration of tests under stressful conditions and better performance above that under indifferent or unpleasant music. It follows that music likely performs a fundamental cognitive function explaining the origin and evolution of musical ability that have been considered a mystery.

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1. Introduction – 'Mozart effect', cognitive dissonance, and music

Music, its strong power over humans, its origin and cognitive function have been a mystery for long time. Aristotle [1] listed the power of music among the unsolved problems. Kant [2], explaining the epistemology of the beautiful and the sublime, could not explain music: "(As for) the expansion of the faculties. . . in the judgment for cognition, music will have the lowest place among (the beautiful arts). . . because it merely plays with senses." According to Darwin [3], the human musical faculty "must be ranked amongst the most mysterious with which (man) is endowed" because music is a human cultural universal that appears to serve no obvious adaptive purpose. Among current evolutionary psychologists and musicologists some argue that music plays no adaptive role in human evolution. So following Kant, Pinker [4] has suggested that music is an "auditory cheesecake," a byproduct of natural selection that just happened to "tickle the sensitive spots." Other contemporary scientists suggest that music clearly has an evolutionary role, and point to music's universality [5]. In 2008, Nature published a series of essays on music [6]. A detailed review of arguments on both sides was given in [7–9]. The authors of these essays agreed that music is a cross-cultural universal, still "none. . . has yet been able to answer

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the fundamental question: why does music have such power over us?" [10].

The paper explores a hypothesis that music has a fundamental cognitive function: to help overcoming cognitive dissonances, CD. Below we define CD and discuss in details their relation to the entire human evolution [7–9]. It follows that overcoming CD could be a fundamental cognitive function of music. In this paper we experimentally demonstrate a tentative validity of this hypothesis.

We explore relations between music and CD using the 'Mozart effect.' This is a short-term improvement on "spatial-temporal reasoning" [11,12]. The idea that 'listening to Mozart makes you smarter' has been so much hyped by the media that many scientists conducted experiments to verify its validity. A short-term effect of any improvement was illustrated, and specificity to Mozart and music was questioned [13–15]. Here we do not attempt to prove again the 'Mozart effect,' we use this scientifically well-known effect [11–15] as a probe into the possible fundamental cognitive function of music.

Cognitive dissonance (CD) is a discomfort caused by holding conflicting cognitions [16–18]. This is among the most influential and extensively studied theories in psychology [e.g., 19]. It is known that this discomfort is usually resolved by devaluing–discarding a conflicting cognition. Any two elements of knowledge contradict each other to some extent, leading to CD and to de-motivation of knowledge accumulation [7–9]. In particular, emergence of language and the following accumulation of knowledge would be devalued. Therefore the current theory of CD questions motivations essential for the entire human evolution, unless a powerful cognitive mechanism would emerge in parallel with language, which would enable holding contradictory cognitions.

A recent hypothesis suggests that music originated in human evolution to help overcoming negative consequences of CD [7–9]. Music was argued to be this powerful mechanism overcoming negative effects of CD. Because all decisions are made in the hedonic dimension of consciousness [20] and result from the maximization of pleasure [21], one may suspect that such an influence of music also takes place in that dimension, *i.e.* that pleasure/displeasure operates also in the case of the 'Mozart effect' [14].

As pleasure [22] was shown to be the 'common currency' postulated by McFarland and Sibly [23] to allow motivations to 'talk' to one another and establish behavioral priorities, it was natural to explore whether pleasure would also fulfill the same function with CD where two cognitions are in conflict with one another in our mind. A music ability to help holding contradictory cognitions has been demonstrated experimentally in [24,25]: music has helped young children (4 y.o.a.) to avoid devaluing an attractive toy, while not playing with it. The fundamental and broad claims about musical role in cognition and human evolution require multifaceted evaluation. Here we approach relations between music and CD in a different setting of student performance on academic tests. School tests are well known to lead to anxiety and cognitive dissonance [26–28]. We evaluate two hypotheses: first, that the hedonicity (*i.e.* pleasure or displeasure experienced) from music could modulate the ability to tolerate stress caused by CD, and second, whether the result would lead to an applied use of music during academic examination tests.

2. Methods

Two groups of 5th year high school (14–15 y.o.a.) of both sexes served as participants. They answered a multiple choice type training test with 12 questions of their scientific course for 15 min. After they had completed the test each received a form with 3 additional questions on face A and, after answering those, two final questions on face B (reverse).

2.1. Environmental music

What was aimed at was to play music to both groups: one calm and quiet to one group and, to the second group, a music widely different, vivid, and drawing attention. The nature and hedonicity of the environmental music played during the test had been selected by probing on other teenagers (one female and three males) who did not participate in the experiment. No explanation was given to that group beside the task of saying whether they liked or disliked different types of music they heard. The two melodies that received 4 votes were selected, either pro and against it. Care has been put to provide music without words. Calm music was Mozart sonata in D for two pianos K.448 (used in [24,25]), especially the Andante; it was determined to be 'Pleasant', and the other music was a koto solo with some disharmonious sequences, by Kuro Kami and Sakura Miyotote, determined to be 'UnPleasant'. The loudspeaker had been placed near the ceiling in the center of the class-room. In both sessions the music intensities were: 55 dB homogenous in the room, as checked from a sonometer.

2.2. Participants

Sixty four participants took place in two groups and subjected to Mozart ($n = 32$) and Koto ($n = 32$) music. The two groups had identical grades performance.

It happened that some of the participants in the Mozart group, found that music UnPleasant, and some from the koto group found it Pleasant. Therefore the results were sorted, not on the account of the music heard, but on the pleasure or the displeasure experienced: 30 rated their music as Pleasant, and 21 as UnPleasant. Also, in both groups (13 participants altogether), rated on Questionnaire Page B (see below) the music they heard as indifferent (zero hedonicity). These 13 participants served as a control and were labeled the 'UnHedonic' group.

2.3. Questionnaires

Participants answered a multiple choice type training test with 12 questions of their scientific course for 15 min. All questions concerned theoretical knowledge of the muscular and skeletal systems. At the end of their academic tests the participants answered two short questionnaires on separate pages, the first one, Page A, probed their behavioral performance and the second one, Page B, probed their experience. This protocol was arranged that way in order to avoid drawing the participants' attention on the environmental music and on their awareness aroused by the previous questions on face A. The music had been stopped at the end of the test, i.e. before these final questionnaires were opened.

On Page A the participants were requested to:

- write the exact time of their completion of the academic test; thus providing their individual duration
- rate from 0 to 10 how difficult they had found the test
- write from 0 to 100 the grade they expected to have earned
- rate from 0 to 10, the intensity of their stress

On Page B the participants answered the following two questions:

- Have you been aware that music was played during the test? Answer Y/N.
- Did you like it? Rate your pleasure/displeasure experience, as a number between -5 and +5, with the following landmarks: -5 very unpleasant, -3 unpleasant, 0 indifferent, +3 agreeable, +5 very agreeable.

3. Results

3.1. Grade performance and hedonicity of music

Grades earned by students in Pleasant music condition were higher than for UnPleasant or UnHedonic. The differences are statistically significant. (This is similar to the 'Mozart effect'); Relationships for UnPleasant vs. UnHedonic are not statistically significant, Table 1. Here and below MW and T denote Mann–Whitney and Student *T*-tests; arrows ←···→ indicate the compared pair of conditions; reported numbers for each pair of conditions show the probability of accepting null hypothesis, p ($p = 1$ corresponds to no difference, $p < 0.05$ is usually interpreted as statistically significant difference between the pair of conditions).

3.2. Other variables

See Tables 2–5.

Table 1
Grades earned (from 0 to 16). Grades by students in Pleasant music condition were above the two other groups. Higher grades under pleasant music than under unpleasant or indifferent music, were statistically significant.

	Pleasant	UnPleasant	UnHedonic
Median	14.00	12.00	12.50
Mean	13.60	12.17	12.12
St. dev.	1.84	2.39	2.58
Pleasant > UnPleasant	←– $p_{MW}=0.02$; $p_T=0.01$ –→		
Pleasant > UnHedonic		←– $p_{MW}=0.03$; $p_T=0.04$ –→	
UnPleasant vs. UnHedonic			←– $p_{MW}=0.96$; $p_T=0.48$ –→

Table 2
Duration was shorter under Pleasant music than under UnHedonic music and UnPleasant condition. The difference did not reach statistical significance for Pleasant vs. UnPleasant, but significant for Pleasant vs. UnHedonic.

	Pleasant	UnPleasant	UnHedonic
Median	11.00	11.00	13.00
Mean	11.13	11.76	12.69
St. dev.	2.43	2.23	2.10
Pleasant < UnPleasant	←– $p_{MW}=0.44$; $p_T=0.17$ –→		
Pleasant < UnHedonic		←– $p_{MW}=0.05$; $p_T=0.02$ –→	
UnPleasant vs. UnHedonic			←– $p_{MW}=0.22$; $p_T=0.12$ –→

Table 3
Rating for Difficulty. Ratings were lower for Pleasant condition than for the other two. These differences do not reach the threshold for statistical significance ($p<0.05$).

	Pleasant	UnPleasant	UnHedonic
Median	4.00	5.00	5.00
Mean	4.35	4.50	4.92
St. dev.	2.00	2.22	2.43
Pleasant > UnPleasant	←– $p_{MW}=0.80$; $p_T=0.40$ –→		
Pleasant > UnHedonic		←– $p_{MW}=0.43$; $p_T=0.23$ –→	
UnPleasant vs. UnHedonic			←– $p_{MW}=0.60$; $p_T=0.28$ –→

Table 4
Median Expected_Grade was higher for Pleasant condition than for the other two. These differences are statistically significant.

	Pleasant	UnPleasant	UnHedonic
Median	80.00	75.00	75.00
Mean	80.70	74.62	70.85
St. dev.	9.90	9.67	15.49
Pleasant > UnPleasant	←– $p_{MW}=0.04$; $p_T=0.02$ –→		
Pleasant > UnHedonic		←– $p_{MW}=0.04$; $p_T=0.03$ –→	
UnPleasant vs. UnHedonic			←– $p_{MW}=0.73$; $p_T=0.22$ –→

3.3. *Evaluation of the hypothesis that the hedonicity of music modulates the tolerance for cognitive dissonance (Table 6)*

To isolate the effect of CD-stress on reducing durations, we compute regression of Duration on two variables, the 1st measuring difficulty for each student (estimated as either subjective Difficulty, or Expected grade, or Grade) and the 2nd Stress. To get data independent of units of measurements, we consider normalized variables, mean values are subtracted for every variable and the results are divided by standard deviations. For normalized variables regression equation looks like follows [29]:

$$\text{Duration} = a1 \times \text{“Difficulty”} + a2 \times \text{Stress}$$

The advantage of using normalized variables is that results are independent of units of measurements of individual variables. Coefficient $a1$ gives a dimensionless isolated effect of “Difficulty” on Duration, and coefficient $a2$ gives a dimensionless isolated effect of Stress on Duration. “Difficulty” an be estimated as (subjective Difficulty), or as (−Grade), or as (−Expected Grade). A higher grade measures “easiness” rather than “difficulty”, therefore to measure “difficulty” we took negative values (−Grade, or −Expected Grade). We computed all three regressions for each condition, and evaluated statistical significance of the effects of “difficulty” and stress on duration for each condition, as given by the coefficients $a1$ and $a2$, dimensionless measures of “Difficulty” and Stress effects on Duration, isolated from each other. The results are summarized in Tables 6 and 7 and Fig. 1 (only using subjective Difficulty).

Table 5
Stress rating was lower for Pleasant condition than for the other two. These differences are of low statistical significance for Pleasant vs. UnPleasant conditions, and of much lower (then $p=0.05$) statistical significance for the other two pairs of conditions.

	Pleasant	UnPleasant	UnHedonic
Median	2.50	4.00	4.00
Mean	3.07	4.48	4.00
St. dev.	2.36	2.66	2.68
Pleasant > UnPleasant	←– $p_{MW}=0.08$; $p_T=0.03$ –→		
Pleasant > UnHedonic		←– $p_{MW}=0.35$; $p_T=0.14$ –→	
UnPleasant vs. UnHedonic			←– $p_{MW}=0.79$; $p_T=0.31$ –→

Table 6
The coefficient $a1$, a dimensionless isolated measure of “difficulty” effect on Duration, for each measure of “difficulty,” and its statistical significance (p, a probability of accepting $a1=0$).

	Pleasant	UnPleasant	UnHedonic
The coefficient $a1$			
Difficulty	0.314	−0.179	0.877
(−Grade)	0.221	0.037	0.639
(−Expected_Gr)	0.159	0.045	0.569
Statistical significance of $a1$: p			
Difficulty	0.04	0.28	0
(−Grade)	0.23	0.94	0
(−Expected_Gr)	0.59	0.91	0

4. Discussion

The first fundamental result of the current report demonstrates that music affects performance.

Table 1 shows that the test performance as measured by Grades confirmed the hypothesis: Grades for Pleasant music condition are higher than for UnPleasant or UnHedonic conditions.

These differences are statistically significant.

Similar differences in the past were called the ‘Mozart effect’ and eventually dismissed as short-term effect, non-specific to music [14]. However, confirmation of our second hypothesis discussed below demonstrates that the effect of music on performance can be expected short-termed, yet might be related to fundamental psychological mechanism: overcoming the morbid consequences of CD.

The second fundamental result of the current report deals with the cognitive function, origin, and evolutionary causes of music: music helps overcoming morbid consequences of CD. Since

Table 7
The coefficient $a2$, a dimensionless isolated measure of Stress effect on Duration for each measure of “difficulty,” and its statistical significance (p, a probability of accepting $a2=0$).

	Pleasant	UnPleasant	UnHedonic
The coefficient $a2$			
Difficulty	0.176	0.221	−0.897
(−Grade)	0.254	0.094	−0.444
(−Expected_Gr)	0.235	0.082	−0.545
Statistical significance of $a2$: p			
Difficulty	0.28	0.37	0
(−Grade)	0.19	0.73	0
(−Expected_Gr)	0.22	0.76	0

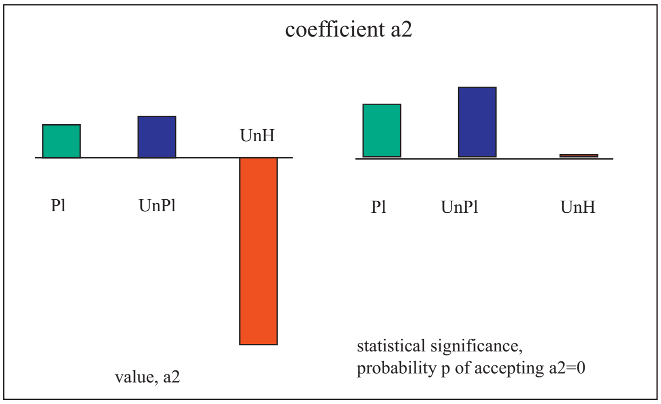

Fig. 1. The coefficient $a2$, a dimensionless isolated measure of Stress effect on Duration (for subjective Difficulty), and its statistical significance (p, a probability of accepting $a2 = 0$). Whereas values of $a2 = 0$ for Pleasant and Unpleasant conditions cannot be rejected (value of p is not very small), these values are different from negative value of $a2$ for UnHedonic condition with very high statistical significance (value of p is very small; this figure illustrates the second and sixth rows of Table 7).

multiple choice tests require holding and evaluating contradictory cognitions, students are expected to experience CD resulting in a stress [26–28]. Thinking, accumulating knowledge, and making choices involves CD, which causes stress. Thinking is stressful. This stress reduces time humans allocate to thinking. This conclusion is supported by the third column in Table 7: the coefficient $a2$ is negative, Stress reduces duration of tests. This effect is highly statistically significant, which is seen from the 3rd column in Table 7 ($p = 0$). These results are also illustrated in Fig. 1. Whereas naively one could expect that more stressful tests should require more time, these results demonstrate that when the effect of difficulty is separated, the effect of stress (without music effect) is opposite from this naïve expectation. Stress reduces duration because stress is unpleasant and tolerating stress is difficult. If humans in their evolutionary development would not be able to overcome this morbid consequence of CD, human culture would not evolve to more knowledge and to ability for thinking.

These results confirm the previously discussed hypothesis [7–9,24,25]: music evolved for helping to overcome this predicament. Pleasant music helped keeping in mind contradictory cognitions in stressful thinking. This is seen from the 1st column in Table 7: coefficient $a2$ for Pleasant music condition is positive. In other words with pleasant music students were able to tolerate stress and devote more time to stressful thinking. The 1st column in Table 7 shows a low statistical significance for rejecting value $a2 = 0$ (p is not very small), but the effects of Pleasant music were highly statistically significant when compared to negative values of $a2$ for UnHedonic condition ($a2 < 0$, and $p = 0$ in the 3rd column). In other words stressful thinking in UnHedonic cognition reduces duration with high statistical significance, and the effects of Pleasant music were highly statistically significant in terms of enabling stressful thinking.

The effect of UnPleasant music condition deserves future studies. The effect of stress on duration in UnPleasant condition is not statistically significantly different from $a2 = 0$ (no stress effect), and not significantly different from Pleasant condition. Still it is different from UnHedonic condition and this difference is highly statistically significant.

Evaluating results in Table 6, the effect of difficulty on duration, we would note that the mean value of the coefficient $a1$ is positive, 0.298, as well as its median value 0.221. As expected it is a positive value: difficulty increases duration (while $a1$ has low statistical significance, except one case, of subjective Difficulty, $p = 0.04$). In UnHedonic condition coefficients $a1$ are highly statistically significant ($p = 0$): more difficult tests take longer to solve. Linear correlation of difficulty and duration over conditions (0.163) is of low statistical significance because the relation is not linear; difficulty and stress have opposite effects on duration.

It must be underlined that the observed performance improvement, and therefore the usefulness of music, was present only with agreeable music and that unpleasant music tended to produce results that were often no different from controls. Such a result thus gives a new evidence of the role of pleasurable experience in decision making [20–22,30–36].

The Mozart effect was reported to be non-specific to music [13–15]. It would be interesting to establish which nonmusical activities help overcoming CD. This paper explored two important and fascinating areas of human mind: music, its cognitive function, its origin, and cognitive dissonances. Each area deserves studying its deep multifaceted cognitive mechanisms and functions.

The Mozart effect was reported specifically to facilitate the ability for spatial reasoning [12,14]. We expect that different types of music facilitate overcoming different types of cognitive dissonances and therefore different abilities. The current report however does not address this issue; all test questions address one type of ability as discussed above in the method section. This study reports results for three groups of students according to pleasant, unpleasant, and indifferent reaction to music, which is of course just a first step toward studying the expected multiplicity of emotions of cognitive dissonances and music. From theoretical arguments [7–9,37–41] one could expect that there are very many musical emotions that help overcoming different CD emotions. Does any pair of contradictory cognitions cause a different CD emotion? Does any musical phrase contain a different emotion? Whereas experiments reported here should be reproduced as a matter of confirming our results, the directions of research should be expanded. Future research should develop experimental means of measuring musical emotions as well as CD emotions, establish relations of musical and CD emotions, and their relations to basic emotions [31,41].

Music could be fundamental to the human ability to accumulate knowledge, to overcome irrational decision-making caused by CD, and to sustain the human cultural evolution in the face of ever increasing pressure from CD to devalue knowledge. This is related to the fact that useful knowledge contradicts instinctual drives,[1] otherwise the instinctual drive would be sufficient and no knowledge would be needed. The same argument applies to any two elements of knowledge. Thus knowledge implies CD. So let us repeat, accumulation of knowledge and ability to think requires overcoming CD tendency to devalue knowledge.

It is interesting to note that Ancient Greeks knew about CD and the human tendency to devalue contradictory cognitions. In the Aesop's fable The Fox and the Grapes a fox sees high-hanging grapes. A 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 dissonances became a wide and well studied area of psychology. Let us repeat that tolerating cognitive dissonances is difficult, and people often make irrational decisions to avoid contradictions [16,43]. In 2002 this research was awarded Nobel Prize in economics emphasizing the importance of this field of research. Nevertheless the psychological status of CD emotions have not been addressed: are these emotions similar to basic emotions, such as fear or rage, or are they fundamentally different [30,37–39]? Are there few CD emotions, similar to basic emotions [30,44–46], or is there a virtual infinity of emotions [30], a very-high

[1] Here instinctual drives are defined according to [42] as inborn sensor-like neural mechanisms measuring vital needs of an organism.

dimensional emotional space corresponding to every pair of cognitions [7–9,40]?

The reported research has demonstrated that unhedonic students, reporting no emotions from music, have scored lower grades. This is interesting in itself, but it raises a deeper psychological and anthropological question in view of our main hypothesis that music is crucial for the entire human cultural evolution. This question is: how large should be expected cognitive differences between musical and amusical people? (A significant percentage of people, about 1 per 100, are amusical, reporting no emotions experienced during listening to music [47]). No doubt, this is an interesting question for future experimental studies. Here we would suggest a theoretical hypothesis that the main contribution of music to culture could be in creating musical emotions, overcoming CD devaluations of knowledge, and sustaining human cultural evolution. As knowledge, cognition, and culture have evolved and emotions are categorized in language, amusical people can participate in this cultural process. If insensitivity to music affects cognitive differences between musical and amusical people, these differences should be searched in specifically creative aspects of cognition, such as differences between decisions made using the knowledge instinct and using language-based heuristics [48].

Our results confirmed the fundamental role of pleasure in decision making. These results are extremely important to all teachers as pleasant music improves academic performance, a topic that haunts any teacher, since suggested by the 'Mozart effect' and then denounced as a short-term effect nonspecific to Mozart or music [11–15]. Yet we must also be aware that the unpleasant music might have had bad influence on academic performance, but the similar results obtained from UnHedonic and UnPleasant participants contradicts such a conclusion.

Let us repeat that our hypotheses stimulating this experiment have been that CD are implicit in any test [26–28] and have a major influence on performance, duration, and stress, while Pleasure has a fundamental role in decision making and overcoming negative effects of CD. Majority of people, including students taking the tests dislike contradictions in their knowledge, experience it as Stress, and do not want to keep it in the mind for long: more Stress less Duration.[2] This is reversed during the Pleasant music condition. *The fundamentally important result is that pleasant music helped tolerating stress for longer and resulted in better Grades. Pleasant music helps overcoming CD (stress) and helps keeping in mind contradictory cognitions.*

5. Conclusion

The current paper contributes to understanding two unsolved problems in psychology. The first is the origin and evolution of music. Consciousness is much evolutionary older than human music [49]. Why has music such a power over us and how could it emerge in evolution (if it did) [6–10]? Together with theoretical considerations [7–9,32] and experimental evidence [24,25] the current paper makes a significant contribution toward solving the problem of origin and cognitive function of music. The second unsolved problem is overcoming CD in cultural evolution: the current understanding of CD suggests that at the time of human emerging from animal kingdom, language and knowledge could not have evolved, because CD would lead to devaluing knowledge.

If the 'Mozart effect' is due to CD and the pleasure of listening to music helps to overcome CD-related stress and devaluation of knowledge, this suggests a natural explanation for short-term value of the 'Mozart effect.' Our paper suggests that long-term exposure to music and sensitivity to musical emotions are likely to be important for cognitive abilities, but this should be a separate field of study from the short-term 'Mozart effect.'

The current paper adds evidence to the emerging theory that music evolved jointly with language for the purpose of overcoming the morbid consequences of CD [7–9]. Educators and teachers invest much effort to minimize the emotion of examinations. The present results might lead to playing pleasant music in examination rooms.

[2] As known empirically by any teacher.

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