ORIGINAL ARTICLE

The Cardiovascular Effect of Musical Genres

A Randomized Controlled Study on the Effect of Compositions by
W. A. Mozart, J. Strauss, and ABBA

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SUMMARY

Background: The effect of different musical styles on serum cortisol levels, blood pressure, and heart rate is currently unknown.

Methods: 60 subjects were randomly assigned to three groups that listened to various compositions by W. A. Mozart, J. Strauss Jr., or ABBA for 25 minutes. Their serum cortisol concentrations, heart rate, and blood pressure were measured before and after the listening session. The same variables were measured in a control group of 60 subjects who did not listen to music but rested in silence.

Results: Music by Mozart and Strauss markedly lowered the subjects' blood pressure (systolic: -4.7 mm Hg, 95% confidence interval $[-6.9; -2.5]$ and -3.7 mm Hg $[-6.1; -1.4]$; diastolic: -2.1 mm Hg $[-3.8; -0.4]$ and -2.9 mm Hg $[-4.9; -0.9]$, $p < 0.001$), while music by ABBA did not (systolic: -1.7 mm Hg $[-3.9; 0.6]$; diastolic: -0.1 mm Hg $[-2.0; 1.8]$). Similar findings were made with respect to heart rate. There were no such changes in the control group. Serum cortisol levels decreased in all groups (Mozart: -4.56 $\mu\text{g/dL}$ $[-5.72; -3.39]$, Strauss: -4.76 $\mu\text{g/dL}$ $[-5.94; -3.58]$, ABBA: -3.00 $\mu\text{g/dL}$ $[-5.28; -2.69]$, silence: -2.39 $\mu\text{g/dL}$ $[-3.26; -1.52]$, $p < 0.001$). The observed effects were not correlated with the style of music individually preferred by the subjects.

Conclusion: Music by Mozart and Strauss lowered the subjects' blood pressure and heart rate, while music by ABBA did not. Mozart's music had the strongest effect; the piece used was his Symphony No. 40 in g minor (KV 550).

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It has been known for centuries that music has an effect on human beings (1, 2). In antiquity, music was used to improve performance in athletes during the Olympic Games, and narrative anecdotes also contain indications of its effects (3). Studies have investigated the influence of music in the setting of different clinical symptoms/conditions, surgical procedures, or in pain management and palliative medicine (4–6). In 2009, Bernardi et al. published a study that met with much attention, which had analyzed the effect of music on cardiocirculatory parameters in 24 volunteers (7). Systematic prospective randomized studies that investigated different musical genres (music from the era of Viennese Classicism, music from the Romantic period, or contemporary classical music) with a view to their influence on different cardiocirculatory parameters in larger cohorts are lacking.

Study design

All subjects were examined according to a strictly defined study protocol (*eTable 1, eBox*).

Participants

A total of 120 participants were included in our prospective randomized controlled study, of whom 60 were allocated to the study group (“listening to music”) and 60 to a control group without music (“silence”). The following inclusion criteria were applied: the male or female participants aged between 25 and 75 years had to be cardiologically healthy (normal cardiological history, normal clinical findings, ECG and blood pressure in the normal range) and had to be medication-free. Normal blood pressure values were defined as measurements below 140/90 mm Hg (8). Subjects with known labile or stable arterial hypertension were excluded from the study.

Interventions using music: Mozart, Strauss, or ABBA

Our study compared a group listening to instrumental music from the Classical and Romantic periods and pop music with a control group not listening to music. The selected music consisted of highly popular and well known pieces and songs: Symphony No 40 in g minor (KV 550) by Wolfgang Amadeus Mozart (1756–1791), dances by Johann Strauss Jr. (1825–1899), and songs by the Swedish pop band ABBA. The total duration of

TABLE 1

Demographic characteristics

	Intervention group	Control group
Number of subjects	60	60
Mean age (years)	46.4 ± 13.5	45.9 ± 14.1
Mean height (cm)	172.4 ± 9.7	172.8 ± 9.7
Weight (kg)	74.4 ± 15.7	74.2 ± 15.8
BMI (kg/m ²)	24.8 ± 3.6	24.7 ± 3.7
RR systolic (mm Hg)	128.9 ± 12.9	128.7 ± 19.1
RR diastolic (mm Hg)	77.5 ± 8.9	79.9 ± 6.3
Heart rate (min ⁻¹)	70.9 ± 12.3	68.6 ± 10.1
Men		
Number of subjects	30	30
Mean age (years)	47.2 ± 13.6	47.1 ± 13.9
Mean height (cm)	179.4 ± 7.3	179.6 ± 7.2
Weight (kg)	84.4 ± 14.5	84.4 ± 14.5
BMI (kg/m ²)	26.2 ± 3.9	26.1 ± 3.9
RR systolic (mm Hg)	123.9 ± 10.6	120.1 ± 8.8
RR diastolic (mm Hg)	79.4 ± 7.4	80.3 ± 6.4
Heart rate (min ⁻¹)	69.1 ± 10.5	68.6 ± 10.4
Women		
Number of subjects	30	30
Mean age (years)	45.8 ± 13.6	44.6 ± 14.4
Mean height (cm)	165.4 ± 6.1	166.1 ± 6.7
Weight (kg)	64.3 ± 9.0	64.1 ± 9.1
BMI (kg/m ²)	23.5 ± 2.7	23.2 ± 2.8
RR systolic (mm Hg)	125.2 ± 9.3	125.1 ± 9.8
RR diastolic (mm Hg)	80.2 ± 5.7	79.4 ± 6.4
Heart rate (min ⁻¹)	69.1 ± 9.9	69.0 ± 9.5

BMI, body mass index; cm, centimeter/s; kg, kilogram/s; min, minute/s; mm, millimeter/s; RR, blood pressure (Riva-Rocci)

the musical pieces played came to roughly 25 minutes in each intervention group (*eTable 2*). The sequence in which subjects listened to the three sonic scenarios was set according to a randomization plan. For each intervention with music and for the control group, we defined clear entry points (normal cardiological findings, normal blood pressure [RR]) and end points (running the complete study protocol), which remained unchanged during the course of the study (8). All investigations took place in a study room, where subjects were lying on a lounge, in a relaxing environment with a room temperature of 23 degrees Celsius, listening to music through headphones or spending the time in silence (control group).

Randomization and block randomization

The study participants were recruited by means of notices put up in Marienhospital Herne and in the MA

building at the Medical Faculty at Ruhr University Bochum. We targeted healthy volunteers, not patients. All subjects were examined according to a strictly defined study protocol consisting of six phases (*eTable 1*). The music sequences were randomized before the start of the study by means of computerized random number generation. 60 subjects (30 men and 30 women) were included in the intervention group, of whom half were younger than 50 and the other half older than 50 years of age. The age and sex distribution of the control group was identical. Random allocation was undertaken before the start of the study by the principal investigator (HJT); the study doctor (GV) admitted participants into the study and, on the study day, allocated them to the respective interventions (musical genres).

Statistical methods

The statistical analyses were done using the programs SAS 9.2 and Stata/IC 11.2. In order to compare the distribution of a metric variable in two independent samples, the Shapiro–Wilk test was initially used. If the assumption of a normal distribution was not refuted, the comparison was done by using the *t* test for linked samples. Where the population could not be assumed to be normally distributed, the Wilcoxon signed rank test was used.

Results

Clinical characteristics

We screened 139 subjects, of whom 19 had to be excluded because of previous cardiac conditions, medication use, or high blood pressure measurements (*eFigure*). Altogether, 60 subjects were allocated to the intervention using music and 60 were included in the control group. The study started on 1 May 2012 and ended on 25 March 2013. It was conducted without any problems in all subjects and did not have to be interrupted or terminated early. No differences existed between the intervention and control groups regarding age, height, weight, and body mass index (BMI) (*Table 1*).

Systolic blood pressure

Music by Mozart and Strauss resulted in lower systolic blood pressure (*Table 2*). In participants listening to Mozart, systolic blood pressure fell by an average of 4.7 ± 8.6 mm Hg, in those listening to Strauss by 3.7 ± 9.2 mm Hg (*p* < 0.001 and *p* = 0.003). In participants listening to ABBA, no relevant changes in systolic blood pressure were observed; it fell by only 1.7 ± 8.8 mm Hg. Under conditions of silence (control group), blood pressure also fell, at a mean of 2.1 ± 7.5 mm Hg (*p* = 0.038), but much less so than with Mozart or Strauss.

When comparing the different musical genres, it is obvious that the effects of Mozart and Strauss are similar, whereas the music of ABBA resulted in a notably smaller fall in blood pressure (Mozart versus Strauss: 0.93 ± 11.13 mm Hg; 95% confidence interval: [−1.94 to 3.81], *p* = 0.519; Mozart versus ABBA:

-3.02 ± 10.69 mm Hg [-5.78 to -0.25], $p = 0.010$; Strauss versus ABBA: -2.08 ± 10.96 mm Hg [-4.92 to 0.75], $p = 0.146$).

No crucial differences were observed between men and women or between younger and older participants, neither for systolic nor for diastolic blood pressure measurements, heart rate, or cortisol concentrations. The values for systolic blood pressure in the “silence” group fell by 2.1 ± 7.5 mm Hg ($p = 0.038$).

Diastolic blood pressure

The mean diastolic blood pressure at baseline relative to all subjects was 77.5 ± 8.9 mm Hg (Table 3). The music of Strauss and the symphony by Mozart lowered diastolic blood pressure by 2.1 ± 6.5 mm Hg and 2.9 ± 7.8 mm Hg ($p = 0.004$). Exposure to ABBA’s music did not have any notable effects. Diastolic blood pressure fell by 0.1 ± 7.3 mm Hg ($p = 0.888$). Diastolic blood pressure in the control group fell by 2.6 ± 7.7 mm Hg ($p = 0.013$). Compared with ABBA, diastolic RR values for Mozart and Strauss were lower (-1.97 ± 8.24 mm Hg [-4.10 to 0.16] ($p = 0.07$ and -2.75 ± 8.99 mm Hg [-5.07 to -0.43] ($p = 0.07$), respectively). For Strauss, the effect was slightly less pronounced than for Mozart (-0.78 ± 8.78 mm Hg [-3.05 to 1.48], $p = 0.49$).

Heart rate

The present study found that music had a positive influence on heart rate (Table 4). At baseline, before listening to music, subjects had a mean heart rate of 70.9 ± 12.3 beats per minute (bpm). All three types of music notably lowered subjects’ heart rate compared with baseline (baseline value versus Mozart $p < 0.001$; baseline versus Strauss $p < 0.001$; baseline versus ABBA $p = 0.003$). The greatest effect on heart rate lowering was observed for Mozart’s music: the mean fall in heart rate was 5.6 ± 9.8 bpm. Listening to Strauss’s dances lowered subjects’ heart rate by a mean of 4.7 ± 9.3 bpm. The songs of ABBA also lowered the heart rate, but to a less pronounced degree: 3.0 ± 7.4 bpm (Table 4). In the control group, the heart rate fell to 5.4 ± 8.1 bpm ($p < 0.001$).

Compared with ABBA, the music of Mozart lowered the heart rate to a greater degree (-2.62 ± 10.87 bpm [-5.42 ; 0.19], $p = 0.18$); the same was true for Strauss’s music (-1.67 ± 11.18 bpm [-4.55 ; 1.22], $p = 0.61$). For the music of Mozart compared with that of Strauss, heart rates were almost identical (0.95 ± 12.11 bpm [-2.18 ; 4.08], $p = 0.478$).

Serum cortisol concentrations

The baseline value for the calculations in the intervention group was the serum cortisol concentration measured on the first day before any exposure to music. In the study cohort the mean value was 15.3 ± 5.8 $\mu\text{g/dL}$ and the median value was 15.0 ± 6.0 $\mu\text{g/dL}$. The baseline measurement in the control group was taken at exactly the same time; the mean value was 14.68 ± 5.35 $\mu\text{g/dL}$ and the median value, 14.1 $\mu\text{g/dL}$. The baseline

TABLE 2

Changes in systolic blood pressure under exposure to the music of Mozart, Strauss, or ABBA, compared with controls

Systolic blood pressure calculations				
	Mozart	Strauss	ABBA	Silence
Baseline (mean) value	123.9 mm Hg (± 12.9 mm Hg)			
Difference after versus before exposure to music (mm Hg)	$-4.7 (\pm 8.6)$	$-3.7 (\pm 9.2)$	$-1.7 (\pm 8.8)$	$-2.1 (\pm 7.5)$
95% confidence interval for mean	$[-6.9; -2.5]$	$[-6.1; -1.4]$	$[-3.9; 0.6]$	$[-4.0; -0.1]$
p-value for comparison after versus before exposure to music	$<0.001^{*1}$	0.003^{*1}	0.151^{*2}	0.038^{*1}
p-value for comparison music versus silence	0.080^{*1}	0.280^{*1}	0.496^{*3}	–

^{*1} t test; ^{*2} Wilcoxon signed rank test; ^{*3} Mann-Whitney U test

TABLE 3

Change in diastolic blood pressure as a result of exposure to the music of Mozart, Strauss, or ABBA, compared with controls

Diastolic blood pressure calculations				
	Mozart	Strauss	ABBA	Silence
Baseline (mean) value	77.5 mm Hg (± 8.9 mm Hg)			
Difference after versus before exposure to music (mm Hg)	$-2.1 (\pm 6.5)$	$-2.9 (\pm 7.8)$	$-0.1 (\pm 7.3)$	$-2.6 (\pm 7.7)$
95% confidence interval for mean	$[-3.8; -0.4]$	$[-4.9; -0.9]$	$[-2.0; 1.8]$	$[-4.5; -0.6]$
p-value for comparison after versus before exposure to music	0.004^{*2}	0.004^{*2}	0.888^{*1}	0.013^{*1}
p-value for comparison music versus silence	0.982^{*3}	0.864^{*3}	0.080^{*1}	–

^{*1} t test; ^{*2} Wilcoxon signed rank test; ^{*3} Mann-Whitney U test

cortisol measurements in both groups did not differ from one another ($p = 0.243$).

For all musical genres, a clear drop in cortisol concentrations was observed ($p < 0.001$). The largest difference was seen for the music of Strauss (mean fall of 4.76 ± 4.52 $\mu\text{g/dL}$) and Mozart (mean fall 4.56 ± 4.51 $\mu\text{g/dL}$) and the lowest for ABBA (3.99 ± 5.02 $\mu\text{g/dL}$) (Table 5). The difference between measurements was not substantial (Mozart versus Strauss [-1.15 ; 0.70], $p = 0.633$; ABBA versus Strauss [-1.74 ; 0.11], $p = 0.083$; ABBA versus Mozart [-1.53 ; 0.38], $p = 0.236$).

Notable differences were seen, however, in the comparison of cortisol concentrations between the intervention (music) and control (silence) groups. This

TABLE 4

Change in heart rate during exposure to the music of Mozart, Strauss, or ABBA, compared with controls

Heart rate calculations				
	Mozart	Strauss	ABBA	Silence
Baseline (mean) value	70.9 bpm (± 12.3 bpm)			
Difference after versus before exposure to music (bpm)	-5.6 (± 9.8)	-4.7 (± 9.3)	-3.0 (± 7.4)	-5.4 (± 8.1)
95% confidence interval for mean	[-8.2; -3.1]	[-7.1; -2.3]	[-4.9; -1.1]	[-7.5; -3.2]
p-value for comparison after versus before exposure to music	<0.001	<0.001	0.003	<0.001
p-value for comparison music versus silence	0.975	0.864	0.080	–

* Wilcoxon signed rank test; bpm = beats per minute

comparison is important in order to rule out that the drop in cortisol concentrations over the study period is of a purely physiological nature. Time spent resting in silence resulted in a fall in cortisol concentrations of 2.39 ± 3.36 $\mu\text{g/dL}$. When comparing the effects of music of different genres with those of the silence period it is obvious that the influence of music is much greater than that of silence (Mann–Whitney U test: silence versus ABBA $p = 0.037$; silence versus Mozart $p = 0.005$; silence versus Strauss $p = 0.003$).

Sex mattered in the effect on cortisol concentrations: men reacted to all three musical genres with a larger fall in cortisol concentrations than women; the difference between sexes was most pronounced for the music of Strauss and Mozart (Mozart: men: -5.41 ± 4.12 $\mu\text{g/dL}$, women: -3.71 ± 4.79 $\mu\text{g/dL}$, $p = 0.065$; Strauss: men: -5.87 ± 4.21 $\mu\text{g/dL}$, women: -3.61 ± 4.758 $\mu\text{g/dL}$, $p = 0.053$; ABBA: men: -4.44 ± 4.05 $\mu\text{g/dL}$, women: -3.53 ± 5.88 $\mu\text{g/dL}$, $p = 0.56$).

Listening habits and musical sensibilities

All subjects were asked what their listening habits and musical sensibilities were (eTable 3, eTable 4). Any association of musical genres (Mozart, Strauss, ABBA), listening habits (never, rarely, occasionally, often, regularly, daily), and measured values did not show statistically significant effects.

Discussion

The question of whether and how music affects human beings has long been a topic of interest for academic studies (1, 9). Individual studies have been presented that showed measurable effects in people. But these studies were based on individual observations that made comparisons of the identified effect directions between studies impossible. The focus was not on the musical genres and the associated immediate effects.

The literature contains very little on such effects—be they the effect of specific compositional schemes, the use of language, or the influence of specific listening habits.

The results of our prospective study enable us to answer some of the questions and have shown that the music of Mozart and Strauss prompted falls in systolic and diastolic blood pressure, but the music of ABBA did not. In this setting it is obviously the musical genre that is of relevance to the observed effects, and the composer is of only secondary relevance.

Music and cardiovascular parameters

In 2009, Bernardi et al. reported a small randomized controlled study, which showed measurable effects on the vascular system and blood pressure for classical music (7). However, subjects' exposure to music was very brief and the number of subjects was small. The authors showed vascular dilatation and a drop in blood pressure in subjects listening to classical music. The most beneficial effects were observed for the music of J. S. Bach, whereas the music of Beethoven did not have such positive effects. The authors explained these phenomena with different changes in tempi, sound volumes, and the musical dynamics of Beethoven (7).

Blood pressure, heart rate, and different musical genres

In our study, listening to classical music resulted in lowered blood pressure and heart rate. These drops in blood pressure were clearly expressed for the music of Mozart and Strauss; no notable effect was seen for the music of ABBA. In the control group, lying down in a resting position also prompted a fall in blood pressure. The study of Bernardi et al. made mention of the compositional form as a crucial factor of influence and found the music of J. S. Bach especially beneficial (7). However, no specific characteristics exist for the effects of Bach's music (10). Indications that rhythms using six cycles per minute were beneficial were described, as were positive effects for uniform music (11, 12). Quiet music of a slow tempo, long legato phrases, and unchanging dynamics are regarded as beneficial for the cardiocirculatory system (13).

The music of Mozart and cardiovascular parameters

In recent years, many studies have investigated the music of Mozart (14–16). It was described how neonates whose mothers had been listening to the music of Mozart during their pregnancies were calmer and less aggressive after the birth (17, 18). Mozart's music has also been recommended as relaxation music (19–21). Hughes et al. undertook a computer analysis of compositional characteristics and found that the music of Mozart has an above-average degree of periodicity (22). Analyses of the musical scenarios of this study also hint at notable periodicity, repetitions, and effects of recognition. According to these insights, the symphony in g minor is particularly beneficial for the cardiocirculatory system because of the special arrangement of its compositional elements.

Strauss, blood pressure, and heart rate

In the present study, the music of Strauss prompted notable falls in blood pressure, heart rate, and the comparatively greatest fall in cortisol concentrations. In the case of Strauss, this effect can also be explained with compositional form. Strauss's dances are based on simple structures, catchy melodies, and periodically recurring forms. The dances were written for entertainment purposes, with catchy harmonic sequences and without any distinctive dissonances (23). Strauss adds graceful elegance to his works by means of rhythm and instrumentation (24, 25). Through his compositions he speaks to human emotions that have a crucial role in processing music (26, 27). It is therefore plausible that the dance element of Strauss's music may affect cardiocirculatory parameters.

What's different for ABBA?

The music of ABBA did not show any or only very small effects on blood pressure and heart rate. This may be due to emotional factors, but on the other hand the use of spoken words may have a negative role (28). Studies have shown that adding vocals to instrumental music activates different regions in the brain and may lead to different sensations. Adding vocals to sad music intensifies its emotional impact; cheerful music has a greater emotional impact without words (9, 10). Independently of the qualitative effect, increased neurological activation should be considered, which is triggered by the processing of the vocals/lyrics. The compositional idea, linearity, and melodic characteristic can be affected—and even disrupted—by the distribution of the vocals/lyrics (27). It is conceivable that the artificial generation of the ABBA sounds has a role, and that this is potentially crucial for the observed phenomena (28).

Conclusions

Music affects human beings and influences them in very different ways. Although several studies have shown the effect of music on cardiovascular parameters, no musical influencing variable with a direct effect on the cardiocirculatory system is known.

Interesting research objectives include studies of the question of which musical genres or even which concrete piece of music has optimal characteristics in terms of a relaxing effect, also with a view to long-term effects. Studies on influencing and changing cortisol concentrations are also important. The following factors seem to be relevant for the positive effect of a piece of music:

- A high degree of periodicity
- A catchy melody line
- A key that is experienced as pleasant
- Skillful composition
- Few changes in volume or rhythm
- Harmony sequences that are not rousing
- The absence of sung words
- A certain degree of prominence/fame and popularity of the musical genre.

TABLE 5

Change in serum cortisol concentrations as a result of exposure to the music of Mozart, Strauss, or ABBA, compared with controls

Cortisol level calculations				
	Mozart	Strauss	ABBA	Silence
Baseline (mean) value	15.29 µg/dL (± 5.81 µg/dL)			
Difference after versus before exposure to music (µg/dL)	−4.56 (± 4.51)	−4.76 (± 4.52)	−3.99 (± 5.02)	−2.39 (± 3.36)
95% confidence interval for mean	[−5.72; −3.39]	[−5.94; −3.58]	[−5.28; −2.69]	[−3.26; −1.52]
p-value for comparison after versus before exposure to music	<0.001	<0.001	<0.001	<0.001
p-value for comparison music versus silence	0.005	0.003	0.037	–

*1 dependent t test; *2 Mann–Whitney U test

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Registration

Our study was approved by the ethics committee at Ruhr University Bochum according to national legal requirements and the ICH-GCP guidelines, and it was registered under the register number 4221–12. The study was retrospectively registered in the German Clinical Trials Register (DRKS) (DRKS00009792).

We used the following sound recordings:

Vienna Master Series: Wolfgang Amadeus Mozart. Symphonies No 40 and 41. Pilz Media Group KG München, CD 160 103.
Vienna Master Series: Johann Strauss. Unvergessene Melodien [unforgettable tunes] Vol 1. Pilz Media Group KG München, CD 160 303
Classic ABBA. 2009 Spectrum Music, Universal Music Group Company, LC05064

Conflict of interest statement

The authors declare that no conflict of interest exists.

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REFERENCES

- Menon V, Levitin DJ: The rewards of music listening: response and physiological connectivity of the mesolimbic system. *Neuroimage* 2005; 28: 175–84.
- Pallesen KJ, Brattico E, Bailey CJ, Korvenoja A, Gjedde A: Cognitive and emotional modulation of brain default operation. *J Cogn Neurosci* 2008; 21: 1065–80.
- Tainmont J: Medicine, ENT and music: a mythological approach. *B-ENT* 2011; 7: 147–54.
- Coppola G, Toro A, Operto FF, et al.: Mozart's music in children with drug-refractory epileptic encephalopathies. *Epilepsy Behav* 2015; 50: 18–22.
- Rosslau K, Steinwede D, Schröder C, et al.: Clinical investigations of receptive and expressive musical functions after stroke. *Front Psychol* 2015; 12: 768.

KEY MESSAGES

- Listening to music has an effect on blood pressure and pulse rate.
- The music of Mozart and Strauss resulted in lowered blood pressure and heart rate, whereas the music of ABBA did not have such an effect.
- Listening to music resulted in a notable lowering of serum cortisol concentrations, rest alone (control group) had only a small effect on cortisol levels.
- The drop in cortisol concentrations was more pronounced in men than in women, especially for the music of Mozart and Strauss.
- No association was found between musical genres, changes to blood pressure and heart rate, and subjects' listening habits.

6. Yuskaitis CJ, Parviz M, Loui P, Wan CY, Pearl PL: Neural mechanisms underlying musical pitch perception and clinical applications including developmental dyslexia. *Curr Neurol Neurosci Rep* 2015; 15: 574.
7. Bernardi L, Porta C, Casucci G, et al.: Dynamic interactions between musical, cardiovascular, and cerebral rhythms in humans. *Circulation* 2009; 119: 3171–80.
8. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC): 2013 ESH/ESC guidelines for the management of arterial hypertension. *Eur Heart J* 2013; 34: 2159–219.
9. Trappe HJ: The effects of music on the cardiovascular system and cardiovascular health. *Heart* 2010; 96: 1868–71.
10. Trappe HJ: Johann Sebastian Bach: Leben, Werke und seine Bedeutung für die Kardiologie. *DMW* 2014; 139: 1–7.
11. Grewe O, Nagel F, Kopiez R, Altenmüller E: How does music arouse "chills"? Investigating strong emotions, combining psychological, physiological, and psychoacoustical methods. *Ann NY Acad Sci* 2005; 1060: 446–9.
12. Khalfa S, Schon D, Anton JL, Liégeois-Chauvel C: Brain regions involved in the recognition of happiness and sadness in music. *Neuroreport* 2005; 16: 1981–4.
13. Hodges DA: Psychophysiological responses to music. In: Juslin PN, Sloboda JA (eds). *Handbook of music and emotion: theory, research, applications*. Oxford University Press, 2010: 279–311.
14. Attanasio G, Cartocci G, Covelli E, et al.: The Mozart effect in patients suffering from tinnitus. *Acta Otolaryngol* 2012; 132: 1172–7.
15. Lin LC, Lee MW, Wei RC, Mok HK, Yang RC: Mozart K.448 listening decreased seizure recurrence and epileptiform discharges in children with first unprovoked seizures: a randomized controlled study. *BMC Complement Altern Med* 2014; 14: 17–19.
16. Masataka N, Perlovsky L: The efficacy of musical emotions provoked by Mozart's music for the reconciliation of cognitive dissonance. *Sci Rep* 2012; 2: 694–6.
17. Keidar HR, Mandel D, Mimouni FB, Lubetzky R: Bach music in preterm infants: no 'Mozart effect' on resting energy expenditure. *J Perinatol* 2014; 34: 153–5.
18. Lubetzky R, Mimouni FB, Dollberg S, Reifen R, Ashbel G, Mandel D: Effect of music by Mozart on energy expenditure in growing preterm infants. *Pediatrics* 2010; 125: 24–8.
19. Smith JC, Joyce C: Mozart versus new age music: relaxation states, stress, and ABC relaxation theory. *J Music Ther* 2004; 41: 215–24.
20. Bangerter A, Heath C: The Mozart effect: tracking the evolution of a scientific legend. *Br J Soc Psychol* 2004; 43: 605–23.
21. Thompson WF, Schellenberg EG, Husain G: Arousal, mood, and the Mozart effect. *Psychol Sci* 2001; 12: 248–51.
22. Hughes JR, Fino JJ: The Mozart effect: distinctive aspects of the music—a clue to brain coding? *Clin Electroencephalogr* 2000; 31: 94–103.
23. Zatorre RJ: Musical pleasure and reward: mechanisms and dysfunction. *Ann NY Acad Sci* 2015; 1337: 202–11.
24. Bernardi L, Porta C, Sleight P: Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence. *Heart* 2006; 92: 445–52.
25. Bernardi L, Porta C, Spicuzza L, Sleight P: Cardiorespiratory interactions to external stimuli. *Arch Ital Biol* 2005; 143: 215–21.
26. Gray PM, Krause B, Atema J, Payne R, Krumhansl C, Baptista L: Biology and music. The music of nature. *Science* 2001; 291: 52–4.
27. Koelsch S: Brain correlates of music-evoked emotions. *Nat Rev Neurosci* 2014; 15: 170–80.
28. Peh WY, Roberts TF, Mooney R: Imaging auditory representations of song and syllables in populations of sensorimotor neurons essential to vocal communication. *J Neurosci* 2015; 35: 5589–605.

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Supplementary material to:

The Cardiovascular Effect of Musical Genres

A Randomized Controlled Study on the Effect of Compositions by W. A. Mozart, J. Strauss, and ABBA

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Study course

eTABLE 1

Study course

Time	Phase		MUS Day 1	MUS Day 2	MUS Day 3	SIL
09:15	I.	Explanation and agreement	✓			✓
	II.	Entry examination	✓			✓
09:30	III.	Preparation	✓	✓	✓	✓
09:45		Silence (15 min)	✓	✓	✓	✓
09:55		Blood sample	✓			✓
10:00	IV.	Exposure to music	Music 1	Music 2	Music 3	Silence
10:35	V.	Blood sample	✓	✓	✓	✓
10:40		Post-processing and survey	✓	✓	✓	✓
10:45–13:00	VI.	HR and RR measurements	✓	✓	✓	✓

HR, heart rate; min, minutes; MUS, music; RR, blood pressure; SIL, silence

eTABLE 2

Music selection

Musical genre	Composer	Piece
Instrumental music from the Classical period	Wolfgang Amadeus Mozart (1756–1791)	Symphony No 40 in g minor KV550: 1 st movement: Molto Allegro
		2 nd movement: Andante
		3 rd movement: Menuetto, Allegretto
		4 th movement: Finale: Allegro assai
Instrumental music from the Romantic period	Johann Strauss (1825–1899)	Wiener Blut op. 354
		Annen-Polka op. 117
		Morgenblätter op. 279
		Eljen a Magyar op. 332
		An der schönen blauen Donau [at the beautiful blue Danube] op. 314
20 th century pop music	ABBA	Thank You For The Music
		The Winner Takes It All
		Fernando
		One Of Us
		Angel Eyes
		The Day Before You Came
		So Long

eTABLE 3

Listening habits, intervention group

Musical genre	Listening frequency	Number	%*
Classical music	Never	24	40.0
	Rarely	13	21.7
	Occasionally	16	26.7
	Often	4	6.7
	Regularly	1	1.7
	Daily	2	3.3
Opera	Never	42	70.0
	Rarely	14	23.3
	Occasionally	3	5.0
	Often	1	1.7
	Regularly	0	0
	Daily	0	0
Pop	Never	2	3.3
	Rarely	5	8.3
	Occasionally	12	20.0
	Often	15	25.0
	Regularly	10	16.7
	Daily	16	26.7
Rock/ heavy metal	Never	17	28.3
	Rarely	14	23.3
	Occasionally	20	33.3
	Often	4	6.7
	Regularly	1	1.7
	Daily	4	6.7
Schlager music	Never	12	20.0
	Rarely	13	21.7
	Occasionally	17	28.3
	Often	9	15.0
	Regularly	6	10.0
	Daily	3	5.0
Instrumental music	Never	13	21.7
	Rarely	14	23.3
	Occasionally	19	31.7
	Often	8	13.3
	Regularly	5	8.3
	Daily	1	1.7
Musical genre	Listening frequency	Number	%*
Electronic music	Never	23	38.3
	Rarely	11	18.3
	Occasionally	13	21.7
	Often	5	8.3
	Regularly	5	8.3
	Daily	3	5.0
Jazz	Never	27	45.0
	Rarely	11	18.3
	Occasionally	12	20.0
	Often	6	10.0
	Regularly	3	5.0
	Daily	1	1.7
Radio	Never	3	5.0
	Rarely	4	6.7
	Occasionally	5	8.3
	Often	2	3.3
	Regularly	5	8.3
	Daily	41	68.3
Active music making	Never	49	81.7
	Rarely	4	6.7
	Occasionally	2	3.3
	Often	1	1.7
	Regularly	3	5.0
	Daily	1	1.7
Music from musicals	Never	20	33.3
	Rarely	12	20.0
	Occasionally	23	38.3
	Often	4	6.7
	Regularly	1	1.7
	Daily	0	0

*The percentages relate to the complete study cohort (n = 60)

eTABLE 4

Assessment rates for sound scenarios

		Musical scenario							
		ABBA		Mozart		Strauss		Silence	
Variable	Assessment	Number	% ^{*1}	Number	% ^{*1}	Number	% ^{*1}	Number	% ^{*2}
How did you experience the music? As:	Very pleasant	36	60.0	17	28.8	29	48.3	32	53.3
	Pleasant	21	35.0	35	58.3	25	41.7	26	43.3
	Unpleasant	2	3.3	6	10.2	5	8.3	1	1.7
	Very unpleasant	0	0	0	0	0	0	0	0
	Unbearable	0	0	0	0	0	0	0	0
	No emotional impact	1	1.7	2	3.4	1	1.7	1	1.7
Did you know the music?	Yes	60	100.0	42	70.0	52	86.7		
	No	0	0	18	30.0	8	13.3		
Did you like the music?	Yes, very much	38	63.3	10	16.7	21	35.0		
	Yes, rather	17	28.3	26	43.3	22	36.7		
	No, rather	4	6.7	19	31.7	11	18.3		
	No, not at all	1	1.7	5	8.3	6	10.0		
	Don't know	0	0	0	0	0	0		
Do you like listening to such music in your leisure time?	Yes, very much	22	36.7	3	5.0	4	6.7		
	Yes, rather	19	31.7	13	21.7	16	26.7		
	No, rather	16	26.7	22	36.7	20	33.3		
	No, not at all	3	5.0	21	35.0	19	31.7		
	Don't know	0	0	1	1.7	1	1.7		
Associations/ memories	No	20	33.3	38	63.3	24	40.0		
	Yes ± free text	40	66.7	22	36.7	36	60.0		

^{*1} Percentages relate to the total study cohort (n = 60)

^{*2} Percentages relate to the total study cohort (n = 56; four subjects did not complete the questionnaire)

eBOX

Study design

- Explanation of the study
- No sports activity nor stimulating drinks on the study day
- Approved by Ruhr University Bochum's ethics committee (register no: 4221–12)
- Registration in German Clinical Trials Register (DRKS) (DRKS00009792)
- Demographic data collected, medical history taken, clinical examination
- 12-lead surface electrocardiogram recorded
- 9:30 am: Application of long-term ECG and long-term blood pressure monitors
- 9:45 am on each study day: sampling of venous blood for the purpose of measuring serum cortisol concentrations
- 10:00 am: Subjects start listening to music, randomized to each sound scenario
- Exposure to music to the end of the respective sound scenario (10.29–10.37 am)
- Once listening has finished: sampling of venous blood for the purpose of measuring serum cortisol concentrations
- 1:00 pm: Long-term ECG and long-term blood pressure monitors removed
- Recording of blood pressure and heart rate during the entire study period (10.00 am–1.00 pm) at 5-minute intervals
- Baseline measurements: T_0
- Final measurement after exposure to music: T_7
- Measurements and comparison: systolic RR blood pressure, diastolic RR blood pressure, heart rate before and after exposure to music
- Long-term ECG recording devices: PhysioQuant (Envitec)
- Long-term blood pressure recording devices: Lifecard CF-System (DelMar Reynolds GmbH)
- Listening to music and exposure to music: stereo headphones (Philips), mp3-Player, Odays S-8 2 GB, S-15, Odays)
- Sound level measurement ahead of listening: phonometer SLM 5, Optac