Cardiovascular effects of music by entraining cardiovascular autonomic rhythms music therapy update: tailored to each person, or does one size fit all?

P. Sleight

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Abstract Music goes back a very long way in human experience. Music therapy is now used in many disparate areas—from coronary care units to rehabilitation after a stroke. But its widespread adoption has a poor scientific evidence base, founded more on enthusiasm than on proper evaluation in any controlled way. This has led to a lack of clarity about whether any particular type of music is superior, or whether different types of music should be tailored to differing individuals. We therefore conducted a series of controlled studies in which we examined the effects of different styles of music—from raga to jazz—presented in random order to normal young subjects (both musically trained or not). We found that contrary to many beliefs the effect of a style of music was similar in all subjects, whatever their individual music taste. We also found that this effect appeared to operate at a sub-conscious level through the autonomic nervous system. Furthermore, musical or verbal phrases of a 10 s duration (which coincided with the normal circulatory ‘Mayer’ waves) induced bigger excursions in blood pressure and heart rate (reciprocal of pulse interval) and so triggered more vagal slowing and feelings of calm. These findings need to now be tested in the clinical setting since, if confirmed, this would greatly simplify the practical use of this promising tool.

Keyword Neurology · Mayer waves · Cardiovascular control · Human baroreflex

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P. Sleight
Cardiovascular Medicine, University of Oxford, Oxford, UK

P. Sleight (✉)
Nuffield Department of Medicine, Level 6, West Wing,
John Radcliffe Hospital, Oxford OX3 9DU, UK
e-mail: peter.sleight@attglobal.net

Introduction

As so often happens, my research on music therapy arose out of quite unrelated studies on blood pressure and heart rate variability (HRV). I had begun to use HRV measures in the records of 24-hour intra-arterial BP [1], but did not fully understand the underlying physiology.

So, in 1992, I took a sabbatical in Italy to learn more about power spectral analysis of heart rate variability from Luciano Bernardi, a young researcher in the Medical Unit in Pavia, who had published data on HRV, largely in diabetic subjects. But when I got there I found that he did not fully understand the underlying physiology either!

Methods and results

So we then began to study young normal subjects (medical students) available outside his lab door. We began by carrying out the usual tests of autonomic function, such as mental arithmetic under time pressure. For some reason, which now escapes me, we did this stress not only speaking aloud, but also silently, writing the arithmetic results on a chalk board. We found that the results were quite different when said aloud, which slowed breathing to about 6 breaths/min or a 10-sec rhythm [2]. This 10-sec rhythm coincides with the Mayer waves in blood pressure (BP). We found that rhythm formulas that involve breathing at six breaths/min induced favourable psychological and physiological effects. Some prayers, as well as yoga mantras, caused striking, powerful, and synchronous increases in existing cardiovascular rhythms when recited six times a minute. Baroreflex sensitivity also increased significantly, from 9.5 (SD 4.6) to 11.5 (4.9) ms/mmHg, $P < 0.05$ [2].

So we looked then for some non-arousing prose which would be a control for the stressful calculations done aloud. We eventually used the Ave Maria prayer as a control, which

is familiar to all Italians and is repeated aloud about 50 times in a priest plus congregation response, in a completely ritual and non-arousing way [2].

We were very surprised to find that the 10-sec rhythm of the Latin prayer was able to entrain the inherent circulatory rhythm of BP waves (Mayer waves, 10 s). The Mayer waves are believed to originate in the ‘hunting’ in BP and pulse interval which arises from the fact that baroreflex corrections of BP changes travel by two efferent paths with different lag times. The faster vagal response occurs within 1 beat, but the slower unmyelinated sympathetic fibres take 2–3 s in man. So this is an imperfect control system which ‘hunts’ at a 6 breaths/min, 10-sec periodicity—the Mayer waves [3].

This then lead us to study the effects of music on circulatory rhythms [4].

HRV is an important prognostic marker. The more variability the longer you live: after a heart attack, or with heart failure, or with hypertension. HRV depends on the baroreflex, which increases vagal tone.

To our great surprise, when said in the original Latin, the priest—response sequence was a perfect 10-sec rhythm, with respiration set by the prayer at 6 breaths/min. This enhanced the BP Mayer waves, and the vagal peak in respiratory sinus arrhythmia. In Italian, French or English translations this did not occur so perfectly, because the modern translations were NOT 10 s. The same occurred with the slow breathing associated with yoga mantras, which also have a 10-sec rhythm.

We speculated that the induction of slow breathing or additionally increased vagal tone might induce calm, and more ‘receptiveness’ in the subject. Also the Ave Maria prayer evolved at about the time of the crusades, when European and Indian cultures intermingled in the Middle East. Could the Christian Church have adopted the yoga mantra breathing techniques to their own liturgies?

In 2004/5, we applied these techniques to the study of the effects of different types of music on blood pressure and other variables [4]. We tested classical, dodecaphonic, raga, techno and rap, presented in a random order. We tested 12 concert musicians versus 12 non-musicians. In our early study we used ‘synthetic’ (i.e. eliminating crescendos and large volume changes) 2-min recordings from these six differing types of music. We found that the effects on the variables we measured, particularly BP and heart rate (expressed as R-R interval), were mainly related to the tempo of each type of music with Indian raga as the most calming and Rap the most arousing.

Later [5] we used actual recordings (i.e. ‘non-synthetic’) of different styles of ‘real’ music: orchestral (Bach), operatic

arias etc. To our surprise we found that some highly emotional arias, particularly by Guiseppe Verdi, used a 10-sec rhythm!

Conclusions

Music now plays an increasing role in several disparate areas [6–9]. Music can reduce stress, improve athletic performance, improve motor function in neurologically impaired patients with stroke or Parkinsonism, or even perhaps improve milk production in cattle: the so-called Mozart effect. However, when one looks at what is published on this effect on milk yield it is very poor and incomplete—more myth than science!

Music has a very long history in man and was used by very early and primitive societies. I hope that this account illustrates how unexpected results in unexpected fields can come from studies which had very different aims from the final research. Chance (or serendipity) is an important ingredient in all research.

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