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Physiopsychological Evaluation of the Effect of Music on Autonomic Nervous Activity Using a Newly Developed Wavelet Analysis of Heart Rate Fluctuation.

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Abstract

The effect of music on autonomic nervous activity was studied with a newly developed Wavelet system analyzing the power spectrum of heart fluctuation (Fluclet®).

Autonomic nervous activity (the High Frequency component and the ratio of the Low Frequency component to the High Frequency component) was measured twice, before and after listening to music, in 16 healthy volunteers. A musical box playing "Pachelbel's Canon" was employed.

After listening to music in the first trial, no change of the High Frequency component among our subjects was predominant (68.8%), and half of the subjects showed mild suppression of the ratio of the Low Frequency component to the High Frequency component.

Our results suggest that music had a mild effect on sympathetic nervous activity and "Fluclet®" is useful for assessing the precise power spectrum of heart rate fluctuation.

Keywords: Autonomic nervous activity, Wavelet system, Music, Power Spectrum of Heart Rate Fluctuation, Healthy Volunteers

抄　　録

新しく開発された心拍数のパワースペクトラムを解析するウエーブレット・システム（商品名：フラクレット）を用いて自律神経系の活動への音楽の効果が研究された。

16人の健常ヴォランティアを対象として、音楽聴取前後2回、計4回自律神経系活動（High Frequency 要素および Low Frequency 要素と High Frequency 要素の比）を測定した。音楽はオルゴールによる「パッヘルベルのカノン」が用いられた。

音楽聴取後、High Frequency 要素に変化がみられなかったものが最も多く、全体の68.8％であり、対象者の半数では Low Frequency 要素と High Frequency 要素の比の軽度の抑制が認められた。

われわれの結果は、交感神経系への音楽の軽度の効果のあることと、フラクレットが心拍数のパワースペクトラムを評定するために有用であることを示唆した。

キーワード：自律神経系活動，ウェーブレットシステム，音楽，心拍数パワースペクトラム，健常ボランティア

I Introduction

Since the era of the legend of King Solomon in ancient Israel or of anecdotal ancient Greek myths, music has been well known as one of the most effective management system in the psychiatric domain.

However, there are still only a few studies, which demonstrate a causal relationship between music and physical functions, including autonomic nervous activity (Mori and Yasumoto 1998, Rauscher et al. 1993).

In this study we aimed to elucidate the relationships between music cognition and autonomic nervous activity, and to evaluate the usefulness of a newly developed instrument using the Wavelet system continuously to measure the power spectrum of heart rate fluctuation.

II Methods

Our subjects were 16 healthy volunteers aged between 20 and 38 (male 6 : female 10), who were requested to observe the following conditions;

(a) No food and no excessive exercise within three hours of the performance,

(b) No alcohol, no smoking and no caffeine from the day before.

We regarded a high frequency component of 0.2Hz and higher (HF) as the index of parasympathetic nervous activity and the ratio of the low frequency component less than 0.2Hz (LH) to the high frequency component (LH / HF) as one of sympathetic activity in the power spectral analysis.

In order to continuously analyze the power spectrum of heart rate fluctuation, we utilized a newly developed instrument using the Wavelet system by Dainippon Pharmaceutical Company, called "Fluclet®" (Nagai and Nagata 1995, Nagai and Nagata 1996, Fig. 1).

A musical box playing the famous Baroque tune of "Pachelbel's Canon" was employed because of the simplicity and the tranquility of its harmony and melody. We designed two consecutive trials (so-called A-B-A-B method), and the autonomic nervous activity (HF and LF) was measured twice, before and after listening to the

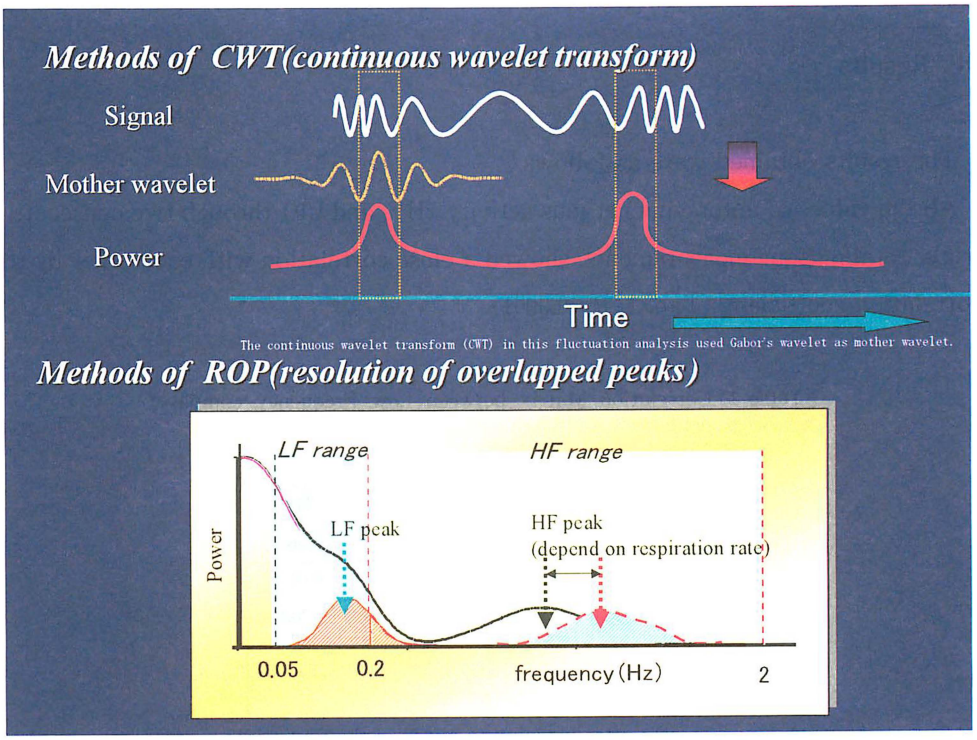

Figure 1. Methods of CWT (continuous wavelet transform) (presented by Dainippon Pharmaceutical Company)

music in each one as follows.

Initially, it was measured for 15 minutes at rest (A1), and then while listening to music for 5 minutes (B1), then measured again for 15 minutes at rest (A2), and finally, it was measured for 5 minutes after a 3 minute- interval following listening to music for 5 minutes (B2).

For statistical analyses, discrete data were reported as frequencies, while continuous data were reported as mean±standard deviation. We used the chi-square test or Fisher's exact test for discrete variables and the t-test, Wilcoxon test and correlation coefficient for continuous variables. All probability values were two-tailed, and a value of probability less than 0.05 was considered significant.

III Results

The results obtained were as follows.

All the values of autonomic nervous activity (HF, and LF) through two consecutive trials, totaling four measurements, showed a close correlation with each other by the correlation coefficient (Tab. 1, $P<0.0001$).

Table 1. Correlation Matrix between Low Frequency component (LF) and High Frequency component (HF)

	Low Frequency component			
	A1	B1	A2	B2
A1		0.996	0.968	0.963
B1	**0.956**		0.975	0.973
A2	**0.859**	**0.881**		0.987
B2	**0.887**	**0.867**	**0.963**	
	High Frequency component			

A1 : at rest, B1 : after listening to music in the first trial
A2 : at rest, B2 : after listening to music in the second trial
Upper : LF, **Lower : HF**

Evaluating changes of autonomic nervous activity after listening to the music, those who showed a change within±30% of HF among our subjects were predominant (no change group, 11/16 : 68.8%) in the first trial (Tab. 2 and Tab. 3). This result suggested less influence of music on parasympathetic nervous activity.

Table 2. Change of High Frequency component (HF) and the ratio of Low frequency component to High Frequency component (LH / HF)

	The First trial		The Second trial	
	HF	LF / HF	HF	LF / HF
EXITING	2	4	0	2
INHIBITORY	3	8	0	4
NO CHANGE	11	4	16	10

Table 3. Change of High Frequency component (HF: parasympathetic nervous activity) after music listening

A1	B1	A2	B2
45.12008	46.818	7.752741932	6.848336698
28.13192	22.55688	3.84093211	4.36618004
2.47808	1.568	1.295542101	1.461626662
15.27752	15.488	4.383624104	4.189358642
1.70528	3.32928	2.039553313	1.766861741
28.322	32.46152	5.952385374	6.017256829
3.56168	3.66368	2.054529354	2.532904312
10.31048	12.67232	3.800074613	3.628267444
13.31712	6.68168	3.432422951	4.099647589
23.328	16.12808	5.487830062	5.289901856
14.72328	13.51368	3.477739031	3.515125801
10.59968	16.05632	5.211160723	4.139231993
8.03912	5.70312	3.483742971	2.898585156
4.15872	3.90728	2.371370997	2.074228845
7.39328	7.05672	2.924065296	3.19099781
7.05672	7.29632	2.781070199	2.92642967
Mean			
13.97019	13.43131	3.768049071	3.684058818
Standard Deviation			
11.47061	11.70345	1.620698708	1.439031853

(No. of subjects=16) statistically not significant

A1 : at rest, B1 : after listening to music in the first trial
A2 : at rest, B2 : after listening to music in the second trial

In the first trial, half of the subjects showed a reduction of over 30% in the ratio of LF / HF through peaceful music, which was most likely to reveal a mild suppression of sympathetic nervous activity (Tab. 2 and Tab. 4)

In the second trial, our subjects revealed no outstanding alteration of heart rate fluctuation by the power spectrum analysis, mainly because of the probable response of the accommodation mechanism.

Table 4. Change of The ratio of Low Frequency component to High Frequency component (LF / HF: sympathetic nervous activity) after music listening

A1	B1	A2	B2
0.373537	0.297119	0.905249	0.71342646
0.169009	0.059849	0.673247	0.216166
0.020363	0.126515	1.851604	1.146927
0.285244	0.126215	1.957505	1.164591
474.9347	144.3357	29.35066	33.9634
4.46643	3.571182	2.93574	2.740197
3.343426	0.655079	3.187495	2.728655
0.773157	1.270441	1.543258	2.509612
0.078503	0.036781	0.668807	0.60169
1.419897	2.295414	2.630095	3.261636
0.626208	0.713948	1.482003	1.658483
0.172365	0.277484	1.454099	1.633951
2.567313	2.49515	3.328108	3.618486
0.176164	0.120272	3.505782	1.014487
0.264404	0.076735	0.552514	0.944413
0.483643	0.117431	0.711485	0.840396
Mean			
30.63465	9.785957	3.546103	3.672282
Standard Deviation			
114.7248	34.75593	6.735219	7.883382

(No. of subjects=16) statistically not significant

A1: at rest, B1: after listening to music in the first trial
A2: at rest, B2: after listening to music in the second trial

IV Discussion

Recent advances in the study of the higher brain functions have shown the influence of music on some activities controlled by the brain.

Rausher et al. (1995) reported that subjects performed better on abstract / spatial reasoning tests after listening to Mozart than after listening to either a relaxation tape or to nothing in their study on the "Mozart-Effect".

Ito (1999) concluded from the results of POMS (Profile of Mood State) that a relaxation tape was effective in consolating patients with anxiety-depressive states.

Mori and Yasumoto (1998) alleged that measuring 1 / f fluctuation was useful for assessing the effect of music cognition.

1. Effect of music on autonomic nervous activity

Our results indicated that peaceful music (Pachelbel's Canon in this study) had a temporal effect of some suppression of sympathetic nervous activity (relaxation effect), while it had less influence on parasympathetic nervous activity.

In general, the more exciting parasympathetic nervous activity is, the more the level of vigilance lowers (the state of drowsiness), and this phenomenon is often found when taking tranquilizers as an adverse effect of pharmacological blockade (Inoue 2000).

Therefore, music has a temporal mild effect on suppressing the state of excitement, while not inducing drowsiness like many tranquilizers. Hence, music is expected to be effective complementary and alternative management systems without inducing an unpleasant state drowsiness.

2. A newly developed instrument using the Wavelet system of "Fluclet®"

Several characteristic features of the Wavelet system, which called "Fluclet®" (Nagai and Nagata 1995, Nagai and Nagata 1996) include;

(a) The improvement of time- resolution rather than fast Fourier transforms effectiveness at the peak of quick reactions,

(b) Introduction of the non-linear optimization method enables correct resolution of overlapping frequency components in the periodogram,

(c) Rejection of artifacts by body movement.

Our study showed that "Fluclet®" was highly reliable (repeatability) and it was therefore a very useful instrument for assessing the precise heart rate fluctuation, easily and quickly.

V Conclusion

Peaceful music has the temporal effect of some suppression of sympathetic nervous activity, while it has less influence on parasympathetic nervous activity suggests its advantage in not lowering the level of vigilance.

Therefore, music is expected to be an effective management system in complementary and alternative medicine without unpleasant symptoms.

"Fluclet®" is a very useful instrument for assessing the power spectrum of the heart rate fluctuation, easily and quickly.

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