Enhancement of Spatial Learning-Memory in Developing Rats via Mozart Music

Jian-Gao Yao, Yang Xia, Sheng-Jun Dai, Guang-Zhan Fang, Hua Guo, and De-Zhong Yao

Abstract—This paper studies the effect of musical stimulations on the capability of the spatial learning-memory in developing rats by behavioral and electrophysiological techniques. Rats, which are exposed to Mozart’s Sonata for Two Pianos in D Major, complete learning tasks of the Moriss water maze with significantly shorter latencies, and the power spectrum of alpha band of electrohippocampogram (EHG) significantly increase, compared with the control rats and rats exposed to the horror music. The results indicate that if given the stimulation of Mozart music in the developmental period of the auditory cortex, the capability of the spatial learning-memory can be significantly changed. The enhancement of alpha band of EHG may be related to the change of this function mainly.

Index Terms—Electrohippocampogram, Morris water maze, music, power spectrum.

1. Introduction

Developmental plasticity of structure and function of the central nervous system (CNS) is an important subject of neuroscience research. It is easily affected in the critical period of postnatal development, and demonstrates a high degree of plasticity. Music is well known to affect biological systems[1]. Listening to music can enhance cognition and learning[2][3], reduce blood pressure[4][5], and ameliorate various symptoms in epilepsy[6], Alzheimer’s disease[7].

Especially, listening to the Mozart’s Sonata for Two Pianos in D Major for 10 minutes resulted in a subsequent short-term enhancement of spatial-temporal reasoning in college students[8][9]. This is the so-called “Mozart effect” that listening to classical music can enhance memory and improve intelligence.

In recent years, scientists have studied the effect of music on the capability of the spatial learning-memory and its mechanism by animal models (including rat, mice, etc.). Peter’s study showed that mice, which were exposed to Mozart’s Sonata for Two Pianos in D Major for 10 weeks, completed T-Maze tasks with significantly lower working time and committed fewer errors[10]. These studies indicate that the effect of the exposure to the Mozart’s Sonata is, in essence, to enhance higher brain function.

Furthermore, musical training has long-term influences on non-musical abilities[11]. Indeed, adults who received music training before the age of 12 had a better memory for spoken words than those who did not[12]. These findings indicate the possibility that music has some effect on neural plasticity, which is more efficient at early developmental stages.

In our study, we examine the capability of spatial learning-memory by Morris water maze at different developmental stages, and record the electrohippocampogram (EHG), which is related to the capability of spatial learning-memory. For power spectrum analysis at last, we study the neural mechanisms by which the musical stimulation promotes changes of plasticity.

2. Materials and Methods

2.1 Animals and Treatments

30 Sprague-Dawley rats were purchased from Institute of Blood Transfusion, Chinese Academy of Sciences, half of which were female. At postnatal day 21 (P21), they were randomly assigned to three groups in different rooms and trained by music:

1) The control group, maintained in silence (C group);
2) The Mozart music group, exposed to Mozart’s Sonata for Two Pianos in D Major (K. 448) for 70 days (M group);
3) The horror music group, exposed to a horror music which is similar to the horror film’s background music for 70 days (H group).

The music was played repeatedly for 10 hours everyday by computers. The time of training was from 22:00 to 8:00 of the next day. The sound level of the C group was about 55 dB (ambient noise), M group from 65 dB to 75 dB, and
H group from 47 dB to 80 dB.

2.2 Morris Water Maze Test

The comprehensive tracking system of MT-200 Moiriss water maze (Tai Meng Science and Technology Co., Ltd, Chengdu) was used to test the capability of the spatial learning-memory in developing rats. Put the platform in the maze, and didn’t move it. At postnatal day 56 (P56), rats were put into the maze to search for the platform within 2 min repeatedly for 4 times. If they can’t find the platform after 2 min, the task failed. Through this training period, rats were habited to the maze.

The tests of Morris water maze include two studies:

1) Place navigation test, used to measure the capability of learning and accessing memory. At P58, P62, P66, P70, P74, P78, P82 and P86, each rat processed place navigation tests within 2 min for 4 times, and the latencies were recorded. If they can’t find the platform within 2 min, the latency was recorded as 2 min.

2) Spatial probe test, used to measure the capability of maintaining memory. At P90, remove the platform from the maze. Six rats of each groups processed spatial probe tests, and the times of passing through the platform within 2 min were recorded.

2.3 EEG Acquisition

EEG signals were acquired from multi-channel physiological signal acquisition system RM6240C (Chengdu Instrument Factory). Acquisition parameters were as follows: sampling rate 800Hz, low-pass filter 30Hz, time constant 1 s (0.16 Hz), and 50 Hz notch was opened.

EEG was divided into five bands for analysis: δ rhythm (0.5 Hz to 4.5 Hz), θ rhythm (4.5 Hz to 8 Hz), α rhythm (8 Hz to 12 Hz), δ rhythm (12 Hz to 16 Hz), β rhythm (16 Hz to 30 Hz).

At P87, 3 rats of each group were randomly selected to be operated, in order to acquire the EHG. Rats were anesthetized with sodium pentobarbital, and the recording electrode was embedded into hippocampus CA1 location. Then electrodes were fixed on the skull of rats with dental cement. The locations of electrodes were as follows: reference electrode (A/P: 5, M/L: −2.5, D/V: −1); recording electrode (A/P: −5.2, M/L: 3, D/V: −3).

When the rats recovered 4 days after surgery, we began to acquire EHG signals. The EHG of each rat was acquired for 60 min, repeatedly for 3 times.

3. Result

As show in Fig. 1 (a), one of the rats in M group searched for the platform in a place navigation test of Trial P86. The route was similar to a straight line. Another route was shown in Fig. 1 (b) that one of the rats in M group processed the spatial probe test for 2 min. The route focused in the vicinity of the platform which was removed.

To analyze the capability of the spatial learning, the latencies at different developmental stages are recorded. As shown in Fig. 2, the latencies of M group are shorter than C group and H group. These are significant differences at P62, P66, P70, P74, P82, P86 (p<0.05). But the differences between H group and C group aren’t significant in all the place navigation tests. From this result, we can see that Mozart’s K.448 helps to improve the capability of the spatial learning at early developmental stages. Maybe these are not enough tests, so that the differences aren’t significant at P58 and P78. But the effect of the horror music in this study is not significant.

The times of passing through the platform are as follows: C group: 5.67±1.86; M group: 8.17±2.14; H group: 4.17±2.31 (as shown in Fig. 3). The times of M group is significantly more than the other two groups (p<0.05). The result indicates that if exposed to Mozart’s K.448 at early
developmental stages, the capability of the spatial memory will be enhanced.

Table 1  Average power of EHG (x±s)

<table>
<thead>
<tr>
<th>Power (dB)</th>
<th>C group</th>
<th>M group</th>
<th>H group</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>1.46±0.7</td>
<td>1.67±0.16</td>
<td>1.32±0.14</td>
</tr>
<tr>
<td>β</td>
<td>0.69±0.46</td>
<td>0.77±0.06</td>
<td>0.83±0.06</td>
</tr>
<tr>
<td>δ</td>
<td>2.26±0.75</td>
<td>2.4±0.14Δ</td>
<td>2.07±0.04</td>
</tr>
<tr>
<td>θ</td>
<td>1.89±0.66</td>
<td>2.12±0.19Δ</td>
<td>1.78±0.06</td>
</tr>
<tr>
<td>σ</td>
<td>1.32±0.74</td>
<td>1.34±0.01Δ</td>
<td>1.03±0.04</td>
</tr>
</tbody>
</table>

* p<0.05, M group or H group vs C group; Δ p<0.05, M group vs H group

Table 1 shows that the power of M group’s EHG are higher than C group in all bands. In addition to the power of Beta band of EHG, M group are significantly higher than H group (p<0.05). Especially in alpha band, both differences are significant (p<0.05). Compared with the results of Moriss water maze tests, the improvement of the capability of the spatial learning-memory may be related to the enhancement of alpha band of EHG.

However, the difference of the power of alpha band of EHG between C group and H group, is also significant (p<0.05). And the power of beta band of EHG of C group is significantly lower than the other two groups.

4. Discussion

The animals or human exposed to Mozart’s K.448 can complete some special behavior tasks more successfully in the studies of Rausche[8] and Peter[10]. Our result is in line with them. It suggests that Mozart’s K.448 actually helps to improve the capability of the spatial learning-memory.

Our results also show that Mozart’s K.448 can improve the electrical activities of neurons of hippocampal CA1, which is an important part of emotional, behavioral, learning, memory, and other high-level neural activities. Especially in alpha band of EHG, the power of M group is significant higher than the other two groups. However, the power of alpha band of EHG from the control group is significantly higher than H group, while the performances show no significant differences between two groups in Moriss water maze tests. We guess that the enhancement of the capability of the spatial learning-memory by exposed to Mozart music may be related to the enhancement of alpha band of EHG.

In addition, the horror music and Mozart’s K.448 can enhance beta band of EHG significantly, but the degree of enhancement is smaller in Mozart’s K.448. This may be the reason that why the performances show no significant differences between the horror music group and the control group in Moriss water maze tests, while the power of alpha band of EHG is decreased significantly in the horror music group than the control group. It is suggested that beta band, the high-frequency part of EEG, will help to solve problems and work[14]. The horror music which enhances beta band of EHG, may improve the activities of neurons of the hippocampal CA1. As a result, the whole activity of the horror music group’s EHG is not weakened significantly and the performances of the horror music group are not significantly worse than the control group.

It is in line with Pavlygina’s study that listen to classical music can enhance the power spectrum of high-frequency EEG[15]. The Mozart’s K.448 helps to enhance the capability of the spatial learning-memory, and change the developmental plasticity in the developmental stage. It may be related to the enhancement of alpha band of EHG mainly.

But there is no recognized mechanism on Mozart music effect. Some studies have pointed out that music can stimulate cells to change the BDNF/TrkB signaling pathway. And it may be related to the expression level of NMDA[16]. More studies are needed to explore the secret of the brain music.

5. Conclusions

The study about the capability of the spatial learning-memory helps human to understand and develop potentials of the brain. However, some other studies showed that the “Mozart effect” does not exist. This may be related to the experimental designs and operations.

Through the musical stimulation, we may understand the musical function of the brain[17]. It also contributes to the understanding of other issues: (1) music is a complex stimulation of sound, which need various components of auditory cortex to deal with, and it will help to understand functions and structure of the auditory cortex; (2) the brain music is involved in cognitive processing, memory, emotions, and so on, so that it will help to understand the high-level function of the brain; (3) the training of music can also affect other cognitive functions, suggesting that the study of music is of great significance on understanding to human brain.

References

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