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The Effect of Beat Sound on English Rhythm Acquisition:How Are the Brains of Japanese Learners of English (JLE) Activated?

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Abstract

Using electro-encephalography (EEG), brain activation of Japanese learners of English (JLE) was observed when rhythm instruction material (RIM) modified from Jazz Chants and including beat sound was conducted on a treatment group (Beat G.), an another type of RIM not including beat sound was conducted on a contrast group (No-beat G.).

During rhythm learning, proficiency in rhythm (PR) was examined, counting how many rhythm patterns the subjects of the experiment repeated correctly after a CD using the following formula:

PR = (number of rhythm patterns repeated correctly) / (total number of rhythm patterns in RIM)

The results showed that the difference in PR for Beat G. between day1 and day5 was larger than that for No-beat G.These results suggest that beat sound enhances the ability of JLE to learn English rhythm.

In the pre- and post-test, three sets of sentences were read aloud and the duration of inter-stressed intervals (ISIs) in four types of rhythm patterns, including one-four unstressed syllables, and that of each sentence (T), were measured. The results revealed that the difference in ISI /T between pre-test and post-test for Beat G. was significant, while that for No-beat G.was not. This suggests that beat sound enhances the ability of JLE to store stress-timed rhythm patterns in their long term memory more efficiently.

During the experiment, brain waves of the JLE were recorded and analyzed. The results revealed that θ wave power recorded at the frontal midline region for Beat G. was significantly correlated to their PR, but no correlation was found in other brain activity. In addition, no correlation between brain wave activity and PR was found for No-beat G. These results suggest that beat sound might enhance English rhythm learning and acquisition, and Fmθ is correlated to rhythm acquisition.

1. Introduction

Japanese language has been widely accepted as mora-timed, while English as stress-timed. This phonological difference in rhythm is one of the difficulties for JLE when speaking English. Mochizuki-Sudo and Kiritani (1991) [1] stated that differences in the duration of the inter-stress interval (ISI), as compared with native speakers, contribute to the formation of unnatural-sounding English, as produced by non-proficient Japanese. The first author designed some RIM (see Appendix 1) modified from *Jazz Chants for Children*[2], which include audio recordings and text with rhythmic symbols. A test group of students then underwent a weekly 20-minute period of rhythm instruction (RI) for a one-month period. Pre-test and post-test oral readings aloud were audio-recorded and the duration of the ISI of each recording was measured. The results showed the students' ISI had shortened following the RI, indicating that the materials had been effective in enabling the JLE to acquire English rhythm patterns[3].

In the present study, we recorded the electroencephalogram (EEG) of nine JLEs who were undergoing RI with RIM, in order to explore the relationship between EEG activity and the acquisition process of English rhythm. EEG measures electrical activity resulting from ionic current flows within the neurons of the human brain, allowing us to monitor changes in electromagnetic activity coming from various cortical (and some subcortical) areas. By examining how these changes are correlated with the behavior of interest, recognizing a visual stimulus as a word, accessing its meaning, and determining its role in the sentence structure, we can begin to map out how cognitive processes are instantiated in the electrochemical medium of the brain [4].

Brain waves are classified by frequency. Theta rhythms are related to memory processing in the brain and have a frequency between 4 and 8 Hz. Alpha rhythms appear when our brain is relaxed and are between 8 and 13 Hz, and beta rhythms are produced when there is mental activity, and have a frequency above 13 Hz. It has previously been shown that rhythmic theta activity often appears over the midfrontal region on EEG during various mental tasks in normal subjects[5]. Such rhythmic activity was named *frontal midline theta rhythm* (Fmθ) and found to be related to some type of memory[6].

2. Research Questions

The authors' research questions (RQs) were as follows**:**

1. How do JLEs improve their English?
2. Can JLEs store stress-timed rhythm patterns in their long term memory?
3. How are the brains of JLEs activated when they are learning stress-timed rhythm using RIM?

3. Experiment

The experiment was carried out with nine healthy male volunteers who were right-handers, aged from 23 to 24. Five participants underwent RI using materials with beat sound placed on stressed syllables (Beat G.), while another type of RIM without the beat sound was conducted on four participants in a control group (No-beat G.). While JLE were undergoing RI, EEG signals were recorded using electrodes attached to eight positions (Fz, F3, F4, Cz, Pz, T3, T4, and Oz) on their skulls, based on the 10-20 electrode system (Appendix 2). Measures were taken of theta, alpha and beta rhythms. The experiment was conducted daily on JLE for a period of 15 minutes over five days. A pre-test was conducted, in which they were asked to read aloud a set of rhythmically challenging sentences on day1 (Appendix 3). Then EEG activity was recorded during the period of RI. Finally, a post-test was conducted on them on day5. To assess whether any improvement in English rhythm had been achieved, oral reading during pre-test and post-test was recorded and the ISI of each sentence in the recording was measured using the software, SUGI Speech Analyzer (ANIMO Ltd.) (Appendix 4). EEG activity was also recorded while the JLE were reading aloud RIM while listening, and analyzed using the software, MemCalc (Suwa Trust Co. Japan).

4. Results and Discussion

Regarding RQ1: During rhythm learning, *PR* was examined, counting how many rhythm patterns JLE repeated correctly after a CD, using the following formula:

PR = (number of rhythm patterns repeated correctly) / (total number of rhythm patterns in RIM)

Table 1 shows *PR* in Beat G. and No-beat G. from day1 to day5. The results show that the difference in *PR* for Beat G. between day1 and day5 was significantly larger than that for No-beat G. ($^{*}p<.05$). *PR* for day1 in Beat G. was lower than that for No-beat G. because the beat in RIM kept closer control over the timing of JLEs' reading aloud, so that they might not have been able to do that as easily as No-beat G.

On day4 and day5, however, *PRs* in Beat G. were higher than those in No-beat G. Beat G. might have gradually learned English timing more efficiently than No-beat G., controlled by the beat sound. These results might suggest that beat sound enhances the ability of JLE to learn English rhythm.

Table1. *PR* in Beat G. and No-beat G.

	day1 (*SD*)	day2 (*SD*)	day3 (*SD*)	day4 (*SD*)	day5 (*SD*)	Difference(day5-day1) (*SD*)
Beat G. (n=5)	0.42 (0.12)	0.50 (0.08)	0.72 (0.01)	0.90 (0.02)	0.95 (0.03)	0.53 (0.14)*
No-beat G. (n=4)	0.68 (0.02)	0.79 (0.08)	0.84 (0.01)	0.89 (0.04)	0.92 (0.01)	0.25 (0.02)

$^{*}p<.05$

Regarding RQ 2: In the pre- and post-test, three sets of sentences were read aloud and the duration of *ISI* in four types of rhythm patterns and duration between the first and last vowel in each sentence *(T*) were measured (Appendix 4) to calculate *ISI* /*T,* to eliminate the effect of speech velocity. The results reveal that the difference in *ISI* /*T* between pre-test and post-test for Beat G. was significant ($p< 0.01$), while that for No-beat G. was not (Table 2). The participants read aloud newly-shown sentences in the pre- and post-test that were not included in RIM, which indicates that Beat G was able to learn and acquire English rhythm patterns and shorten the *ISI/T* in the post-test, but that No-beat-G. was not. This suggests that beat sound might enhance the ability of JLE to store stress-timed rhythm patterns in their long term memory more efficiently.

Table 2. *ISI/T* in Beat G. and No-beat G.

	Pre-test (*SD*)	Post-test (*SD*)	
Beat (n=60)	74.699 (9.800)	70.482 (9.152)	*p <.05
No beat (n=56)	75.961 (6.603)	75.911(9.303)	*N.S.*

Regarding RQ3: During the period of experiment, brain activity of the participants were recorded and analyzed. The results reveal that theta wave power recorded at F3, F4, Fz and the frontal midline region for Beat G. was significantly correlated to their *PR*, with correlation coefficients of 0.645, 0.799, and 0.887, respectively. No correlation, on the other hand, was found in their alpha and beta wave power. In addition, no correlation between brain waves and *PR* was found for No-beat G. These results also suggest that beat sound might enhance English rhythm learning and acquisition, and Fmθ is correlated to language cognitive activity, including rhythm acquisition.
Therefore, we conclude that the theta rhythm measured at the frontal midline region has a relationship to the process in which JLE acquire English rhythm.

5. Conclusion

The present experiment shows that RI is effective in helping JLE acquire English rhythm, as found in Nakano's (1997) previous research[3]. In addition, EEG analysis suggests that theta rhythm, as measured a the frontal midline region, could help to see how an individual learner is really learning and play a part in the English rhythm acquisition process of JLE. Therefore, EEG analysis might possibly be used as an indicator to determine how well learners are really improving their English rhythm. EEG analysis can, therefore, make an important contribution to the study of second language acquisition. Further study is needed to search for relationships between brain activation and language learning, so that this field of research can be utilized for educational methodology, testing and teaching material design. Moreover, measuring θ wave power at the frontal midline region could help to see how an individual learner is really learning.

Acknowledgement

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References

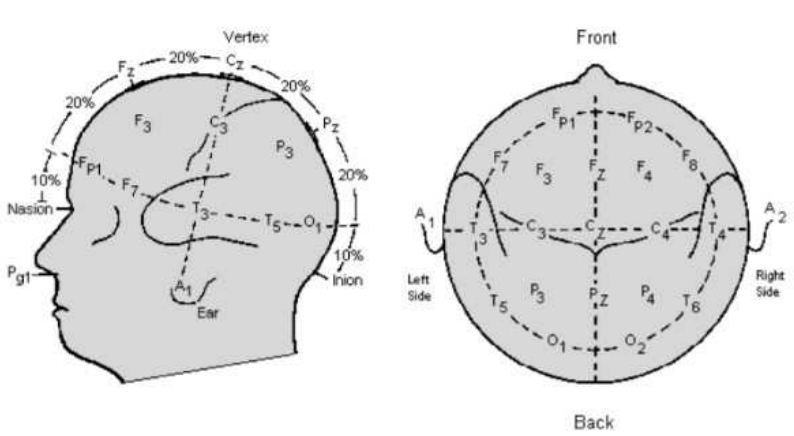
[1] Mochizuki-Sudo,M. & Kiritani,S. (1991).Production and perception of stress-related durational patterns in Japanese learners of English. Journal of Phonetics, 19, 231-248.
[2] Graham, C. (1979) Jazz Chants for Children. Oxford University Press.
[3] Nakano, H. (1997). The effect of rhythm instruction on production ability of Japanese EFL learners. Annual Review of English Language Education in Japan, 8, 81-91.
[4] Brown, M.C. & Hagoort, P. (Eds.) (1999) The Neurocognition of Language. Oxford University Press.
[5] Mizuki, Y. et al (1980) Periodic appearance of theta rhythm in the frontal midline area during performance of a mental task. Electroencephalography and Clinical Neurophysiology. 49, 345-351.
[6] Ishihara, T. et al (1972) Multivariate analytic study of EEG and mental activity in juvenile delinquents. Electroencephalography and Clinic Neurophysiology, 19, 305-308.
[7] Chulder, E.H. The "10-20 System" of Electrode Placement. Retrieved August 15, 2013 from Neuroscience for Kids website: http://faculty.washington.edu/chudler/1020.html .

Appendix 1. Partial scripts of RIM

Lesson 5 Grandma's Going to the Grocery Store

| ● ○| ●○ ○ ○| ●○○|●|	|● | ● | ● |●|
Grandma's going to the grocery store.	One, two, three, four.
| ● | ●○|	| ● ○ | ●○|
Who's going?	Grandma's going.
| ● ○| ●○|	|○ ○| ●○○| ●|
Where's she going?	To the grocery store.
| ● ○ ○○ ○| ● ○ ○| ●○○| ●|	| ● | ● | ● |●|
What's she going to buy at the grocery store?	One, two, three, four.
| ○○ ○| ● ○○ ○| ● | |○○| ● ○ | ● ○ ○ ○ | ● ○ ○ | ● |	
A loaf of bread, a bottle of milk. A big bag of cookies and a little can of peas.	

Appendix 2. The 10–20 International System for Placing Electrodes [7]



Appendix 3. Scripts of pre-test and post-test material

Set	ISI	Scripts of the Pre-test and Post-test
A	ISI-1	I think he does.
	ISI-2	I think that he does.
	ISI-3	I think that he will do.
	ISI-4	I think that he will have done.
B	ISI-1	I'm glad you come.
	ISI-2	I'm glad that you come.
	ISI-3	I'm glad that you can come.
	ISI-4	I'm glad that you will be coming.
C	ISI-1	I gave her socks.
	ISI-2	I gave her the socks.
	ISI-3	I gave her other socks.
	ISI-4	I gave her a pair of socks.

Appendix 4. Duration of ISI and T in the sentence "I'm glad you come."