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Effects of Speaker's Voice Pitch Variation on Listener's Intellectual Concentration during Online Lecture

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ABSTRACT

With the popularization of e-learning and online lecture among universities around the world, the effect of distant education has aroused wide social concerns. Currently, although many studies have been focusing on the measurement method of students' attentiveness under the e-learning environment, it's difficult to find effective solutions that directly improve the intellectual concentration from the students' side. Therefore, the purpose of this study is to explore the effect of speaker's voice pitch variation generated by digital signal processing on listener's intellectual concentration during online lectures, where both objective and subjective evaluation have been used to evaluate listeners' intellectual concentration level. As the result, groups with pitch variation tended to share higher post-test scores, attention level based on EEG, and better subjective feelings.

Keywords: Online lecture, Distant education, Voice pitch variation, Intellectual concentration

INTRODUCTION

With the development of media technology, e-learning has been getting popular around the world. Especially under the Covid-19 pandemic, most universities all over the world had to suspend their face-to-face lectures and adopted online courses instead. Some surveys have revealed that while this new educational format has advantages of convenience and flexibility, there also exist some problems, such as students' increased fatigue and lower intellectual concentration.

According to this problem, some studies committed to proposing effective methods to measure and monitor students' intellectual concentration levels during online lectures (Shah et al. 2021), (Revadekar et al. 2020). However, currently it's difficult to find any effective solutions that can directly improve their intellectual concentration.

To achieve this goal, this study has been focusing on the online course system and trying to explore the possibility to improve students' intelligent concentration through the sound interface. From the viewpoint of cognitive psychology, sound is one of the essential factors that can influence people's intellectual concentration (McAdams et al. 1993), and the speakers' voice is

one of the most important parts of the sound source in online courses. Besides, pitch variation has been verified effective to improve people's cognitive processing of a complex communicative message (e.g., radio ads) (Rodero et al. 2017). Therefore, the purpose of this study is to explore the influence of speakers' pitch variation on listeners' intellectual concentration during online lectures.

EXPERIMENTAL METHOD

Sound Stimulus for Improving Intellectual Concentration

Since this study is mainly focusing on the online lecture system and especially its auditory settings, a similar condition should be simulated in the experiment. In this study, audios recorded by Siri voice assistant (Apple, 2022) were used as the sound stimulus. Furthermore, to make it closer to the university course-level, we used the passages of the Reading part in TOEFL iBT examination as the content, because they are similar to the textbook of introductory courses in universities.

Meanwhile, to alleviate the influence of different English levels between each participant, all the contents have been translated into Chinese because all the participants were native Chinese speakers.

Evaluation Method

Objective evaluation

Post-test

After listening to each audio, participants were asked to answer the post-test including one question based on the audio content. The question requires them to select all the correct answers from 5 options, which can express the important ideas of the passage. The score would be scaled from 0 to 5, which can reflect participants' overall grasp of each audio content.

Attention level

EEG (electroencephalogram) data measured by a single channel device, NeuroSky Mind Wave Mobile 2 headset (NeuroSky, 2015), was used as an auxiliary reference to quantify and analyze students' intellectual concentration level during online lectures. The reason choosing this device was that it was verified usable in many conventional studies (Crowley et al. 2010) but also low-price and convenient to use.

In specific, the software named NeuroView (NeuroSky, 2020) developed by NeuroSky company can output an index called 'Attention', calculated by the NeuroSky built-in algorithm, which reflects intellectual concentration, and the value ranges from 0 to 100.

Subjective evaluation

Post-questionnaire

As shown in Table 1, two questions were asked after the experiment to investigate participants' subjective feelings towards the pitch variation condition.

Table 1. Questions of post-questionnaire

Questions
1. Which kind of audio do you think makes you more focused?
A. Without pitch variation
B. With pitch variation
2. Did you feel awakened at the moment of the pitch variation?
A. Yes
B. No

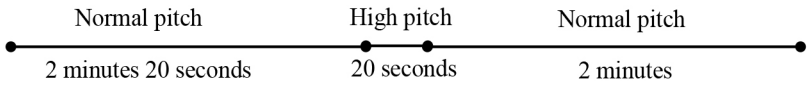

Figure 1: Pitch variation sequence.

EVALUATION EXPERIMENT

More details of the evaluation experiments will be introduced in this part, including the experimental conditions and the procedure.

Experimental Condition

Before this experiment, two preliminary experiments have been conducted to find the optimal pitch level and suitable contents. Specifically, in preliminary experiment 1, male's and female's voice with 3 pitch levels (low, normal, high) has been evaluated with 6 students of Kyoto University (3 males and 3 females), and the results showed that female voice with normal pitch had the best performance which gave no harm on keeping listeners' intellectual concentration nor increasing their cognitive fatigue under the online course system. Besides, to alleviate the influence of different contents, in preliminary experiment 2, we selected 6 contents with similar difficulties among 12 contents, in order that the difference of the contents do not affect the score of the post-tests.

The formal experiment aimed to explore the influence of speaker's voice pitch variation on listener's intellectual concentration during online lectures. This experiment was conducted twice, each time with 4 students of Kyoto University (5 males and 3 females in total), and all of them are native Chinese speakers. As the pitch variation pattern, females' voice with high pitch level have been used as the variation target, because high pitch tends to be more effective on awaking and alarming. Figure. 1 shows the pitch variation strategy in this experiment. Audios with pitch variation were edited by shifting the pitch of the 20 seconds in the middle of the audio to +4 semi-tones, via the Pitch Shifter effect of Adobe Audition (Adobe, 2021).

Table 2 shows the outline of the experimental procedure, and Table 3 shows the details of each session. First, the participants were asked to take a practice session including 3 trials to get familiar with the post-tests, after that they were asked to take session 1 and 2, each session including 3 trials. Within each trial, they need to listen to an audio of 4-5 minutes, and then answer a post-test.

Table 2. Outline of experimental procedure.

Process	(min)
Practice Session	20
Rest	15
Session 1	20
Rest	15
Session 2	20
Questionnaire	2

Table 3. Procedure of each session.

Practice Session	Session 1	Session 2
Practice 1	Trial 1	Trial 4
Practice Test 1	Test 1	Test 4
Practice 2	Trial 2	Trial 5
Practice Test 2	Test 2	Test 5
Practice 3	Trial 3	Trial 6
Practice Test 3	Test 3	Test 6

Table 4. Order of audio contents and pitch variation conditions.

ID	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
P1	**PitchV (A)**	Normal (B)	**PitchV (C)**	Normal (D)	**PitchV (E)**	Normal (F)
P2	Normal (A)	**PitchV (C)**	Normal (B)	Normal (D)	**PitchV (F)**	Normal (E)
P3	**PitchV (B)**	Normal (C)	**PitchV (A)**	**PitchV (E)**	Normal (F)	**PitchV (D)**
P4	Normal (C)	**PitchV (B)**	Normal (A)	**PitchV (F)**	Normal (E)	**PitchV (D)**
P5	**PitchV (A)**	Normal (B)	**PitchV (C)**	Normal (D)	**PitchV (E)**	Normal (F)
P6	Normal (A)	**PitchV (C)**	Normal (B)	Normal (D)	**PitchV (F)**	Normal (E)
P7	**PitchV (B)**	Normal (C)	**PitchV (A)**	**PitchV (E)**	Normal (F)	**PitchV (D)**
P8	Normal (C)	**PitchV (B)**	Normal (A)	**PitchV (F)**	Normal (E)	**PitchV (D)**

Additionally, while they were listening to the audios, their attention levels were measured by NeuroSky Mind Wave Mobile 2 headset and recorded by NeuroView software mentioned in 2.2 section. Finally, after finishing all the sessions, they need to answer a short questionnaire as shown in Table 1.

To further avoid the influence of contents and the order of experimental situation, conditions for each participant have been carefully designed. Table 4 shows more details of the experimental condition for each participant. "PitchV" in the table means audios with pitch variation, and "Normal" means audios without pitch variation. Besides, selected through the preliminary experiment 2, six different contents were used in this experiment and the alphabet in the brackets shows the content ID. Table 4 shows the experiment conditions for participant 1 to 8.

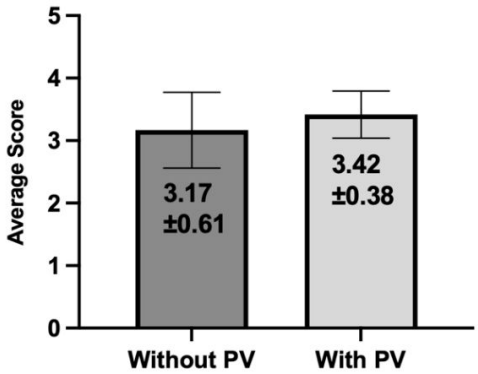

Figure 2: Average scores of post-tests under conditions with and without pitch variation.

Table 5. Results of the questionnaires.

Questions	(Person)
1. Which kind of audio do you think makes you more concentrated?	
A. Without pitch variation	1 (P8)
B. With pitch variation	7
2. Did you feel awakened at the moment of the pitch variation?	
A. Yes	7
B. No	1 (P8)

RESULTS AND DISCUSSION

As mentioned in section 2.2, objective and subjective evaluation indices have been used in this study and the results are introduced and discussed in this part.

Figure 2 shows the results of post-tests. The participants got an average score of 3.42 under the condition with pitch variation (PV), which is 0.25 point higher than that of 3.17 under normal condition with an improvement of 7.9%.

Since the refreshing effect of pitch variation tends to be short-time, we analyzed the data focusing on the average values of attention level in the 20 seconds during, before and after the pitch variation (PV). As shown in Figure 3, the attention level measured by NeuroSky device had the highest average value of 46.24 in the 20 seconds during the pitch variation, with the following of that of 44.65 in the 20 seconds after the pitch variation, and both of them are higher than that of 42.36 in the 20 seconds before the pitch variation.

Table 5 shows the results of the questionnaire. Seven out of eight participants thought the condition with pitch variation made them more concentrated on the audio content, and they also felt awakened at the instant of the pitch variation. Only 1 participant (Participant 8) had the opposite attitude.

Based on the experiment results, it can be found that the participants have better performance in the post-tests under the condition with pitch variation, and the attention level measured by NeuroSky device also showed

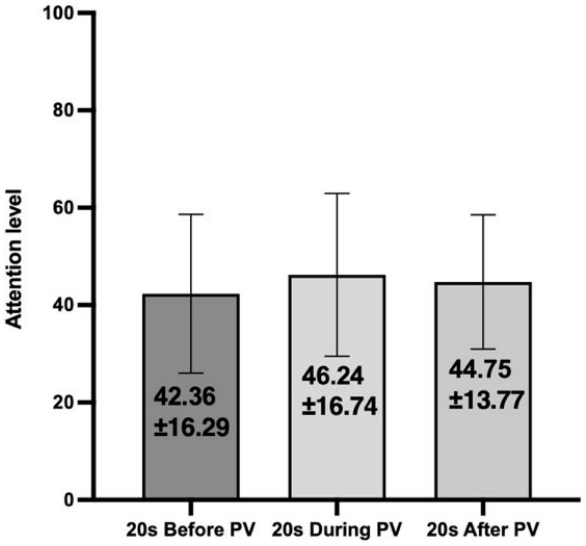

Figure 3: Average values of attention level in the 20 seconds during, before and after the pitch variation.

higher values in this situation. In addition, the results of subjective evaluation showed that most participants (7 out of 8) held positive attitudes towards the pitch variation condition and thought that it can help them more concentrated and keep sober.

SUMMARY

To solve the problem of lower intellectual concentration during online lecture, this study has been trying to verify the possibility of pitch variation of lecturer's voice. Evaluation results showed that compared with the normal condition, the participants got a 7.9% improvement in their post-tests under the condition with pitch variation. Moreover, their attention level also showed an increasing trend since the moment of the pitch variation. In addition, the subjective results of most participants felt there was positive effect helping them concentrate and keep awake under pitch variation condition. Therefore, as exploratory research, our study showed that the pitch variation tended to improve listeners' intellectual concentration.

Undoubtably, there were still some limitations in this study. The number of participants should be increased in the further experiments. The post-test consisted of only one question, and more questions should be used to improve the accuracy of objective evaluation. Besides, only one pattern of pitch variation has been used in the experiment, and more patterns should be evaluated.

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