COLLECTION AND ANALYSIS OF THE HISTORY OF BRAIN WAVE DURING PROGRAMMING LANGUAGE LEARNING FOR HIGH SCHOOL STUDENTS

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ABSTRACT

It is known that brain waves are closely related to emotions of human. The authors held “Matsudai science seminar” and gave lectures about computer programming for high school students living in Matsudai area of Niigata prefecture in Japan. In addition, we collected data about brain waves of the students learning computer programming and analyzed these data. In this paper, we firstly summarize results of previous questionnaires and tests, which the students firstly answered in this seminar. We secondly analyze relations between brain waves and the results of questionnaires and tests.

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ABSTRACT

It is known that brain waves are closely related to emotions of human. The authors held "Matsudai science seminar" and gave lectures about computer programming for high school students living in Matsudai area of Niigata prefecture in Japan. In addition, we collected data about brain waves of the students learning computer programming and analyzed these data. In this paper, we firstly summarize results of previous questionnaires and tests, which the students firstly answered in this seminar. We secondly analyze relations between brain waves and the results of questionnaires and tests.

Keywords: brain waves, programming education

1. INTRODUCTION

It is known that brain waves are closely related to emotions of human. Uwano et al. (2008) showed that brain waves could be used for quantitative evaluation of software usability. Especially, they found that the ratio of the α and β waves (β/α) could be used to estimate the hardness for users, which is how hard users feel when they use a certain software. Moreover, Yoshida et al. (2012) applied brain waves to education and showed that β/α could also be used to estimate the hardness for learners trying to solve problems of language and mathematics.

The authors held "Matsudai science seminar" and gave lectures about computer programming for high school students living in Matsudai area of Niigata prefecture in Japan (Umezawa et al. September 2016). Moreover, in this seminar, the authors collected data about brain waves of high school students learning computer programming. From analysis of these data, we confirmed that β/α is also effective to estimate the hardness for high school students practicing typing and computer programming (Umezawa et al. December 2016).

In this paper, we firstly report results of previous questionnaires about computer programming and previous tests about English, mathematics and Japanese. In the Matsudai science seminar, high school students answered the previous questionnaires and tests before learning computer programming. The previous tests about English, mathematics and Japanese were used to measure basic academic skills of each high school student. We secondly analyze relations between brain waves and the results of the previous questionnaires and tests. Especially, we discuss relations between β/α of students in learning computer programming and the results of the previous tests.

2. EXPERIMENTAL METHODOLOGY

2.1 Experimental Overview

In the “Matsudai science seminar”, the authors mainly gave lectures about computer programming. In addition, we collected data of brain waves for high school students solving problems of computer programming (Umezawa et al. September 2016).

In this seminar, Scratch and C language were used as programming languages. Also, MindWave Mobile headset manufactured by NeuroSky were used to measure brain waves of the students. With the MindWave Mobile headset, the δ wave (0.5-2.75Hz), the θ wave (3.5-6.75Hz), the low-α wave (7.5-9.75Hz), the high-α wave (10-11.75Hz), the low-β wave (13-16.75Hz), the high-β wave (18-29.75Hz), the low-γ wave (31-39.75Hz) and the middle-γ wave (41-49.75Hz) could be measured. These power spectrums were recorded as a four-byte unit-less floating-point value per second.

In order to know trends of brain waves, the authors also collected data of brain waves for the students practicing typing (Umezawa et al. December 2016). In this experiment, each student practiced typing using easy mode and difficult mode of the same typing software, and the brain wave of the student were measured. From this experiment, we found that the value of β/α became higher when the students practiced typing using difficult mode than easy mode. In other words, we confirmed that β/α was effective to estimate the hardness for the students. This is the same result as previous works by Uwano et al. (2008) and Yoshida et al. (2012). Moreover, we analysed these data in detail and found that the ratio of the low-α wave and the low-β wave (low-β/low-α) was more effective to estimate the hardness than β/α. From the results of this experiment, we were convinced that the assumption that the low-β/low-α represents the hardness for the students was right. Therefore, under this assumption, we make discussion in what follows. Especially, we analyse the low-β/low-α of the students in solving computer programming problems, comparing with results of previous questionnaires and tests, which are described in next Section 2.2.

2.2 Previous Questionnaires and Tests

In the “Matsudai science seminar”, the students firstly answered previous questionnaires and took previous tests. In the previous questionnaires, the students answered 16 questions about computer programming and PC.

In the previous tests, the students solved problems about English, mathematics and Japanese, where the perfect score of each subject was 100. These 3 subjects are though as the most basic academic skills in Japan, so most of Japanese high school students usually study them. Therefore, the results of the previous tests are used for measuring basic academic skills of the students in what follows.

2.3 Problems of Programming

In the “Matsudai science seminar”, the students solved 6 problems about computer programming. In this paper, each problem is called as Table 1. For example, “C language difficult 2” was a problem to write a C programming source code to calculate the sum of odd numbers from 1 to n, given a sample source code to calculate the sum from 1 to n.

Table 1. Problems of Computer Programming

A	Scratch easy	Scratch difficult
B	C language easy 1	C language difficult 1
C	C language easy 2	C language difficult 2

In order to proceed with the seminar smoothly, the students were divided into 3 groups, A, B and C. All students in each group certainly solved 2 problems, easy and difficult. In this time, "easy" and "difficult" were determined by the authors from their experiences as teachers. In each problem, we started to measure brain wave when a student started to read the problem, and stopped measuring when the student completely solved the problem.

3. EXPERIMENTAL RESULT AND DISCUSSION

3.1 Results of Previous Questionnaires and Tests

The results of the questions "Q1: Have you ever used Scratch?" and "Q2: Have you ever used C language?" are shown in Table 2, where numbers in Table 2 represent the number of the students who answered yes to each question. These two questions are the most related questions to this paper in the previous questionnaires. From Table 2, most of the students hardly had used Scratch and C language. Therefore, in what follows, we make discussion based an assumption that every student is not familiar with computer programming.

Table 2. Results of Previous Questionnaires

	I've never used it.	I've ever used it by myself.	I've ever used it in some class or seminar.	I often use it.
Q1	19	0	2	0
Q2	20	1	0	0

The result of the previous tests is shown in Figure 1. The horizontal axis of Figure 1 shows the average of English, mathematics and Japanese, and the vertical axis shows the number of students including each interval.

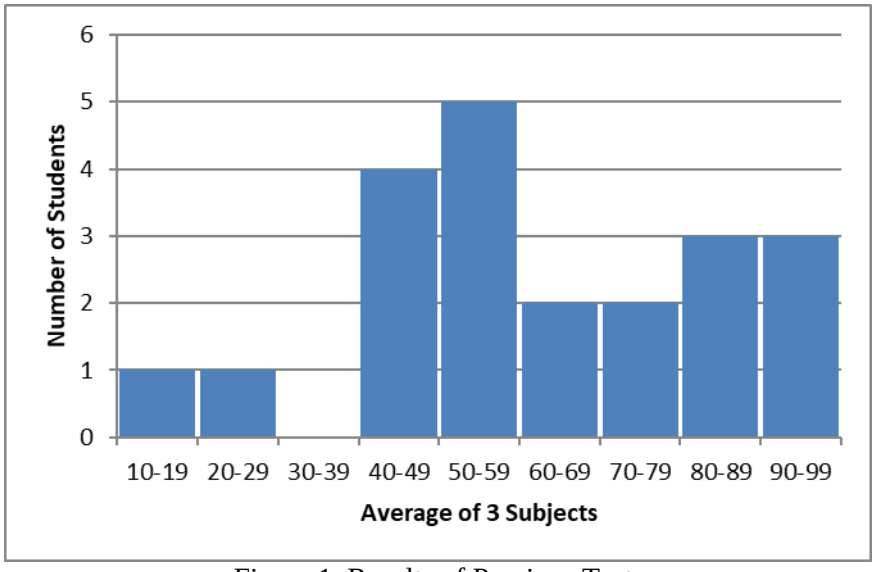

Figure 1. Results of Previous Tests

3.2 Correlation between Brain Waves Previous Tests

In this section, we make discussion under the assumption that the low-β/low-α represents the hardness for the students, which were described in Section 2.1. For each problem described in Table 1, the correlation coefficient between the low-β/low-α and the result of the previous tests is calculated. In this calculation, the average of low-β/low-α in all measurement time was used as the value of low-β/low-α. The results of these calculations are shown in Table 3. In most of the problems, the correlation coefficients are negative value. That is, the low-β/low-α of students who got high score in the previous tests become low. We consider that a reason of this result is as follows. Students who got high scores in the previous tests had high basic academic skill, so those students did not have psychological resistance to computer programming as well as English, mathematics and Japanese. Therefore, the low-β/low-α of those students became low because the low-β/low-α represents the hardness for students.

Table 3. Coefficients of Correlation

	Coefficients of Correlation
Scratch easy	−0.56
Scratch difficult	−0.47
C language easy 1	−0.25
C language difficult 1	0.22
C language easy 2	−0.31
C language difficult 2	−0.81

Moreover, the scatter diagram of “C language difficult 2” is shown in Figure 2. The absolute value of the correlation coefficient of “C language difficult 2” is the highest in all 6 problems described in Table 1. The horizontal axis of Figure 2 shows the average of English, mathematics and Japanese, and the vertical axis shows the value of the low-β/low-α. Each point in Figure 2 corresponds to each student. The “C language difficult 2” shown in Section 2.3 needs more logical thinking than other problems. Therefore, students who did not have high basic academic skills felt the problem more difficult and the absolute value of the correlation coefficient became higher.

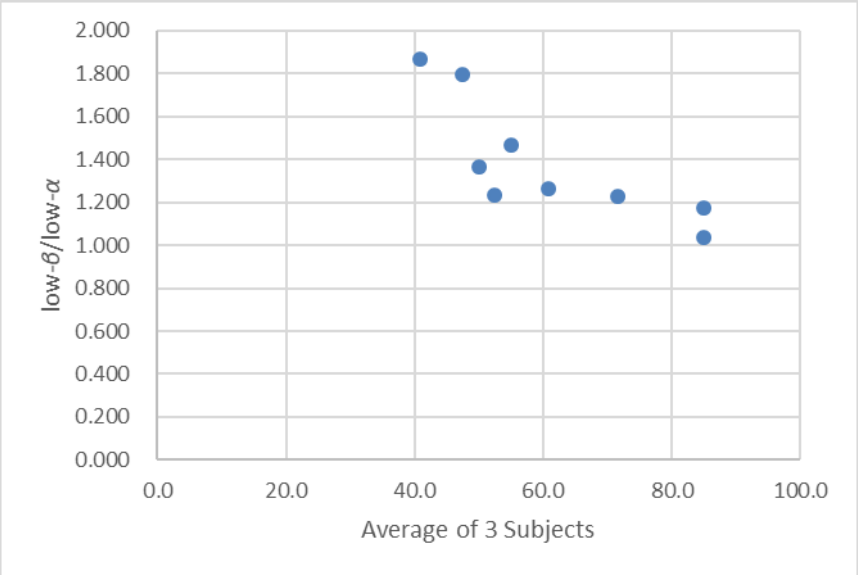

Figure 2. Scatter Diagram of “C language difficult 2”

4. CONCLUSION

In this paper, we summarized the results of the previous questionnaires and tests in "Matsudai science seminar". Moreover, we analyzed relations between brain waves and the previous questionnaires and tests. From the results, we found that there are negative correlations between low-β/low-α and how degree of basic academic skills students had. This is a reasonable result from the view point of teachers because it is generally hard for students who do not have high basic academic skills to master computer programming. Therefore, we can say that this result supports the rightness of the assumption that the low-β/low-α represents the hardness for the students. In other words, this is an interested result that supports the previous works (Umezawa et al. December 2016) from other points of view.

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