Effectiveness of Analysis with Near-Infrared Spectroscopy for EFL Learners in Japan

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Abstract. This study examined the effectiveness of analysis with near-infrared spectroscopy (NIRS) for English as foreign language (EFL) training, from a brain science perspective. The experiment presented in this paper analyzed the amount of blood flow in the brain while learners were training to improve their English listening skills. The experiment attempted to ascertain the preferable combinations of learners' characteristics and teaching materials when learners are completing training in English listening. This was done by comparing the brain activities of learners from different English proficiency levels. The data suggests that the analysis, using Functional Near-Infrared Spectroscopy (fNIRS), enabled the proposition of an effective course design for EFL learners.

Keywords: NIRS (Near-Infrared Spectroscopy) · fNIRS (Functional Near-Infrared Spectroscopy) · Brain activities · EFL · English conversation skill · ATI (Aptitude-Treatment Interaction)

1 Introduction

In light of the ever increasing globalization of our society, the development of English communication skills is considered crucial in Japan. However, recently it has been noted that Japanese students' English skills have been declining [1]. Therefore, designing and developing an effective course design to meet ELF goals for the acquisition of English communication skills has become a critical need. To solve this dilemma, this study examined the effectiveness of analysis using NIRS (fNIRS) for EFL listening training, from the perspective of brain science in order to propose a well-matched combination of learners' characteristics and listening training. The goal of the analysis is to create an effective course design for EFL learners.

2 Instructional Strategy

In the field of educational technology, Aptitude-Treatment Interaction (ATI) is an important element in the planning stages of developing an effective course design. As ATI's concept and theoretical framework suggest that the effectiveness of instructional strategies' for individuals is dependent on their specific abilities, optimal learning is achieved when the course design matches the learner's aptitude [2]. As such, appropriate training is required for the less motivated EFL learners [3].

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Although the effectiveness of various teaching methods and materials has improved overall in Japan, assessments that are based on traditional paper and pencil tests have limitations [4]. Recently, brain activity has become subject to monitoring by technologically innovative instruments [5]. These technologies provide data that reveals the results of teaching and learning; therefore, it could be said that this data can be utilized to assess the effectiveness of EFL teaching in Japan. Alongside this newly developed technology, this study examined the effectiveness of analysis using Near-Infrared Spectroscopy (NIRS) for EFL listening training from the perspective of brain science, in order to propose a well-matched combination of listening materials and training methods for EFL learners [6].

3 Application of NIRS to Course Design

The present study used NIRS to analyze the amount of blood flow in the brain while learners are training in English listening skills. It then examined the relationship between brain activity and learning outcomes in order to identify the most effective combinations of learners' characteristics and, consequently, English listening teaching materials.

NIRS is widely recognized as a practical, non-invasive optical technique that is used to detect the hemoglobin density dynamics response during functional activation of the cerebral cortex, as shown in Fig. 1. The primary application of NIRS to the brain uses the fact that the transmission and absorption of NIR light in human body tissues contains information about the changes that occur in hemoglobin concentration. When a specific area of the brain is activated, the localized blood volume in that area quickly changes [7].

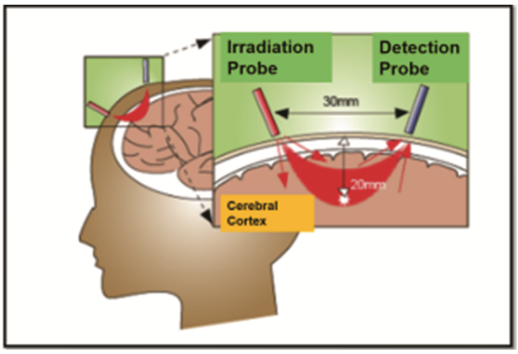

Fig. 1. Route of near-infrared (Source: modified from Shimadzu)

The greater the amount of blood flow, the greater the hemoglobin oxygenation increases. Measuring the amount of blood can thus indicate the state of brain activation caused by differences among teaching materials and learners' characteristics. This experimental technique indicated a well-matched combination of listening materials and training for EFL learners. As these new technologies could improve the accuracy in terms of evaluating the integration of English materials and methods, such technologies have further potential for improving effectiveness when it comes to curriculum development.

4 ATI Based Experiment Using FNIRS

The purpose of this study was to examine the effectiveness of analysis with fNIRS by comparing the activity of cerebral parts for more effective course design for EFL learners. This study proposes well-matched combination of EFL learners' characteristics and English listening trainings. fNIRS is the use of NIRS for the purpose of functional neuroimaging and in this study FOIRE-3000 (SHIMADZU, fNIRS) was used to measure 45 channels including Broca's area and Wernicke's area within the Broadmann area, which are all related to language learning [8, 9] [Appendix 1, 2 and 3].

To resolve the purpose, an ATI-based experiment was planned and conducted to examine the interactions of learners' aptitudes, materials and tasks, as per Fig. 2.

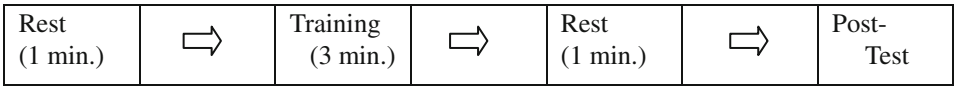

Fig. 2. Experimental Protocol

Ten healthy subjects participated in (mean age 20.6 years old; all males; 9 right-handed and 1 left-handed) the experiment, which was conducted with the consent of each participant. They were divided into two groups; group A as higher level of proficiency (5 males) and group B as lower level of proficiency (5 males) as assessed by a listening comprehension test given one week before the experiment. After setting the holder and probes, each participant was given the same experimental listening task and post-test.

5 Results and Concluding Remarks

Comparing the average amount of change per second of deoxy-hemoglobin and oxy-hemoglobin in each channel during the training (see Fig. 3); several significant interactions between learners' characteristics and training were found, as shown in Table 1.

In Group A, regardless of their high score in the post-test results, if the material was too easy or not interesting for them, the brain activity showed up as moderate during the listening activity, as shown in Fig. 3(a). In contrast, if the material was rather difficult, more active brain activity was detected, as shown in Fig. 3(b). However, if the task was too difficult, brain activity was moderate in Group B.

Table 1. Significant Results

Proficiency	Brain activation	Average of post test score (/15)	Statistical analysis of post test score (t-test)
Group A: Higher	Moderate or None	7.8/15	$t(8) = 3.111$
Group B: Lower	Activate or Moderate	2.4/15	$p < .01$

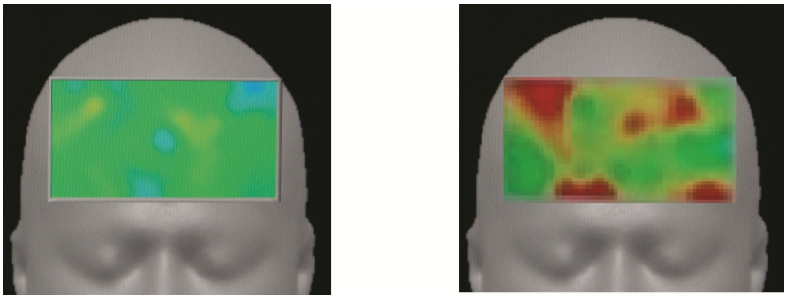

Fig. 3. Brain Activity : (a) Moderate Activity (b) Active Activiry

Comparing the average amount of change per second in deoxy-hemoglobin of Group B with that of Group A, significant differences can be seen, as per the colored channels in Fig. 4.

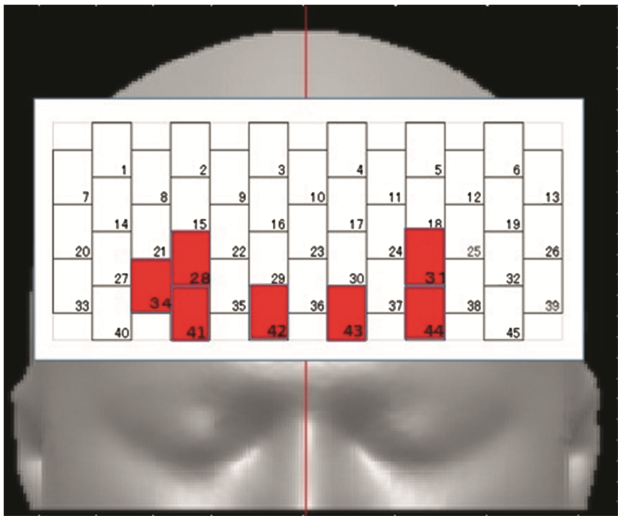

Fig. 4. The channels where significant differences were shown relating to the learners' characteristics.

These results demonstrated that the level of training and the content of materials should be considered, and using analysis of NIRS for EFL learners could be a useful method in the development of effective English courses. Moreover, teachers should consider the effectiveness of the interaction between learners' characteristics and materials, as well as the application of new technologies, in order to organize and utilize the available resources to develop the most effective curricula for EFL learners.

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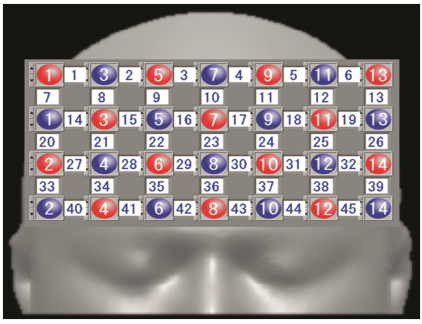
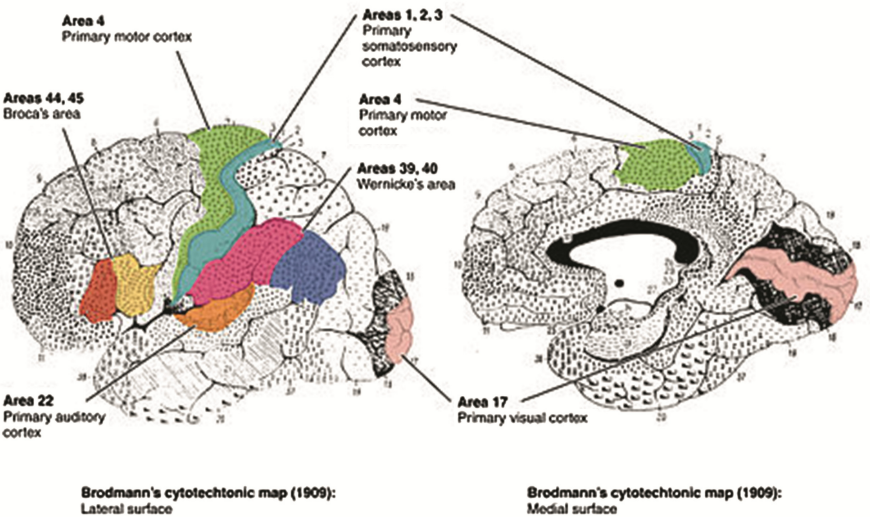
Appendix

Appendix 1. fNIRS (FOIRE-3000 by SHIMADZU) [7]

Appendix 2. Measured Channels



Appendix 3. Broadmann Area [9]



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