Measurement of Hand Raising Actions to Support Students' Active Participation in Class

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Abstract. In recent years, teachers have been making an effort to improve positivity in students' participation in class. However, this can be difficult because active participation depends on both communication skills and classroom atmosphere. In this study, we focus on hand-raising motions, which play an important role in interaction. Based on this, we measured and analyzed hand-raising motions in various situations.

Keywords: embodied interaction, education support, hand raising, motion analysis.

1 Introduction

In recent years, teachers have been making an effort to improve positivity in students' participation in class. For example, rather than traditional one-way communication from teacher to students, participating classes, in which students participate more positively, are receiving attention. However, it is not easy to promote participating classes as their success depends on classroom atmosphere and the skills and abilities of teachers and students.

Fuse et al. posited that positive attitudes are expressed through gaze, attentive hearing, hand raising, utterance, preparation, and homework completion [1]. They also proposed that teachers recognize such attitudes as a measure of the positivity of students' class participation. By focusing on the importance of communicative motions and actions such as nodding, the authors have developed an embodied entrainment system with speech-driven computer graphics (CG) characters called InterActors superimposed on images, and demonstrated that such communicative motions are effective for learning support [2].

In this study, the authors focus on hand-raising motion, which plays an important role in interaction and context in class [3], as the use of hand motion is much more common than gaze or attentive hearing and may have a direct impact on class participation.

S. Yamamoto (Ed.): HIMI 2014, Part I, LNCS 8521, pp. 199–207, 2014.

From this viewpoint, Fujiu modeled the procedure on teachers' questioning and students' hand raising and attempted to clarify the psychological states involved in hand raising based on educational psychology [4]. However, aside from Fujiu's study, there is almost no systematical research on this topic. We propose a concept to promote active participation in class by activating hand raising and using a novel approach to the study it, focusing on the fact that hand raising is a means of indication of intention and activates classroom participation. Following this, we measured and analyzed hand-raising motions in various classroom situations.

2 Concept

In this study, by focusing on the motions involved in hand raising, which play important roles in indicating active intentions, we propose a new concept for supporting active participation in class (Fig. 1).Many students do not feel confident in raising a hand to answer questions because of issues such as pressure and unease, which often lead to difficulties with active participation in class. Conversely, we propose that raising context, enhancing a sense of unity, and promoting the sharing of responsibility for hand raising are the keys to solving this problem. For example, one student's positive hand raising may trigger another student's hand raising because positive hand raising may produce motivation for hand raising in everyone. In addition, we posit that embodied media can facilitate active participation in class through hand raising. For example, using physical media such as CG characters and robots initiates students' hand raising. We measured and analyzed hand raising to examine this concept.

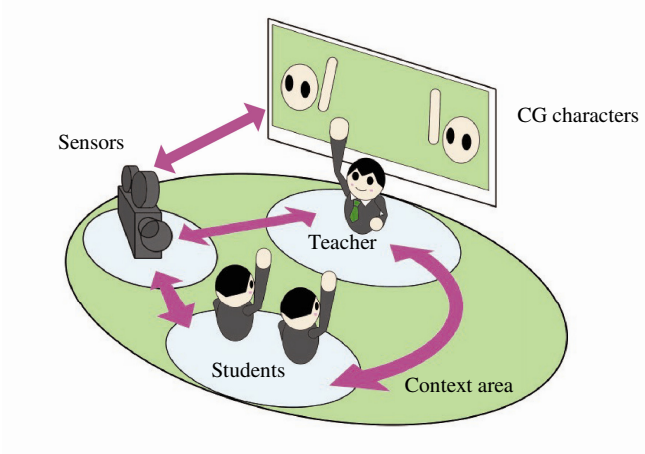


Fig. 1. Concept

3 Factors That Determine Hand Raising

3.1 Related Studies on Determinant Factors

Fujiu proposed that self-efficacy, outcome-expectancy, and outcome-value are determinant factors of hand raising. These factors determine the intention of hand raising and accompanying utterances. Specifically, when students experience self-efficacy in hand raising, they believe that they can raise their hands as often as they wish. When students experience positive outcome-expectancy, they feel that hand raising is welcomed by others in the class. When students experience high outcome-value, they feel that their actions and utterances are very important. These cognitive factors are the factors that determine hand raising.

3.2 New Framework of Determinant Factors

In this study, we defined feeling and motivation as parts of a new framework of factors to determine the assessment of hand-raising motions, in which feeling is a factor of the emotional state involved in hand raising (comfort or discomfort). Motivation is a factor of the decision-making process involved in hand raising and includes Fujiu's determinant factors. We examined the relationship between new determinant factors and hand raising in everyday life in a previous study [5].

4 Method

We conducted an experiment that participants answered questions regarding hand raising in various situations. Here, we tried to make clear the characteristics of hand-raising motions and the factors that may affect feeling and motivation in hand raising. In the experiment, we assumed that the atmosphere in the classroom and the difficulty of the questions may have affected feeling and motivation. Therefore, we set up questions that were selected from a workbook according to difficulty level (easy or difficult) [6]. In addition, we formulated two conditions representing the experimental system's reactions to hand raising (positive or negative). For positive reactions, we played a clapping sound through a speaker and presented a positive image to promote hand raising. For negative reactions, we played booing sound through a speaker and presented a negative image to discourage hand raising. In this study, we presented a question and a classroom scene on a screen at the front of the room and asked participants to raise their hands to answer the question (Fig. 2). In addition, we directed the participants to answer all questions after raising a hand.

We show experimental procedure. (i) We instructed participants to raise a hand several times to relieve tension and embarrassment. In addition, each participant raised a hand and answered the practice question three times. (ii) We set up positive or negative reactions. (iii) We presented a question. After participants had answered the question, the system provided a positive or negative reaction. (iv) Following this, participants answered oral questionnaires about their confidence and the difficulty

levels of the question. (v) we performed (iii) and (iv) at five times. (vi) Participants completed a paper questionnaire regarding seven-point bipolar ratings. We reversed the positive and negative reactions and repeated the procedure (iii) to (vi).

We projected an image on a screen located 250 cm from a projector (EPSON, EB-1735W) connected to a notebook computer, the HP Elite-Book 8730w, and the system played the sounds through a speaker (ONKYO, GX-D90(B)) placed underneath the screen. We measured the positions of participants' wrists, fingertips, elbows, and heads with a motion-capture system (VICON, VICON MX) (Fig. 3). Participants were Japanese students (16 men and 16 women) aged 18–25 years.

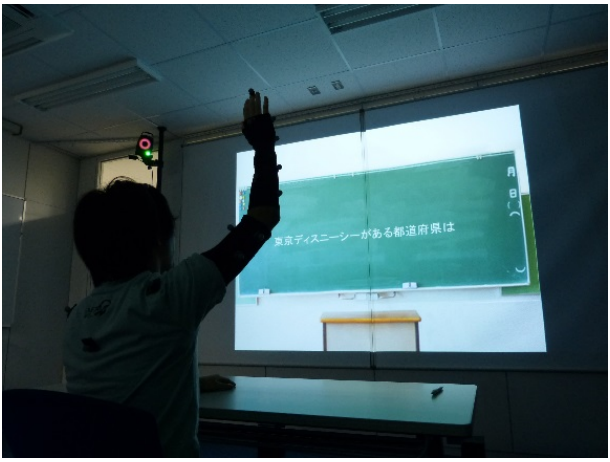


Fig. 2. Experimental scene

Fig. 3. Marker positions for motion capturing

5 Results

5.1 Results of Questionnaire Analysis

Fig. 4 shows the seven-point bipolar ratings. Results of a Wilcoxon signed-rank test showed that there were significant differences between all items. There were significant differences between (1), (2), (3), and (5), with significance levels of ≤ 1 %. With respect to (1) and (2), several participants replied that if a reaction was negative and they could not raise a hand comfortably, they were negative about hand raising. In (3) and (5), the positive classroom atmosphere made participants feel more comfortable about hand raising than when the atmosphere was negative.

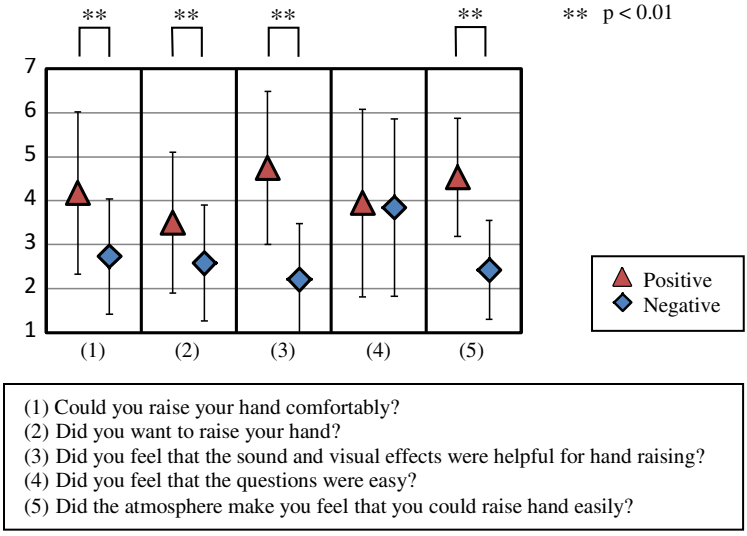


Fig. 4. Results of the seven-point bipolar ratings

5.2 Analysis of Hand-Raising Imotions

We set up height, speed and angle factors (Fig. 5). Height was measured as the height of the topmost fingertip position in each trial divided by the greatest fingertip position height. Speed was measured as the maximum speed estimated from the moving distance of the fingertip per frame. Angle was measured as the angle of the elbow at the greatest height.

Fig. 6 shows the results of the motion analysis. We focused on hand-raising motions when participants were or were not confident. We also focused that the participants' replies were *correct* or *incorrect* and they reported that the question was *easy* or *difficult.* We also focused on reaction, which was either positive or negative, and difficulty level, which was either easy or difficult.

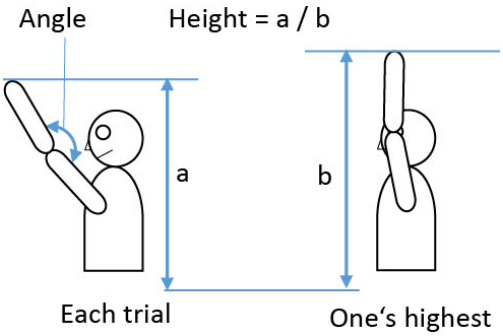


Fig. 5. Details of hand raising parameters

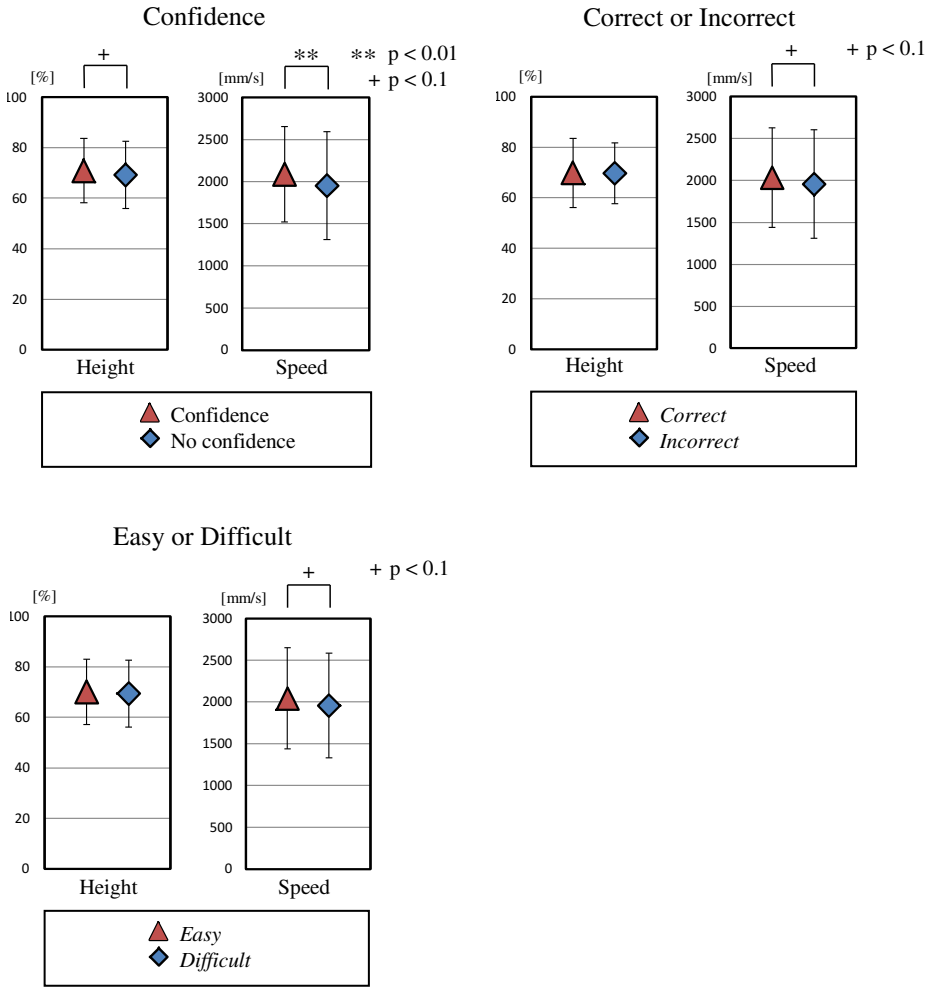


Fig. 6. Results of motion analysis

Speed in confident participants was approximately 2088.6 mm/s, and approximately 1951.6 mm/s in participants who were not confident; there was a significant difference between these two groups at a significance level of 1 %. Height in confident participants was approximately 70.8 % and in participants with no confidence, approximately 69.2 %; there was a marginally significant difference at a significance level of 10 %. Speed for *correct* responses was approximately 2043.2 mm/s and for *incorrect* responses, approximately 1959.3 mm/s; there was a marginally significant difference at a significance level of 10 %. Speed for responses of *easy* was approximately 2032.3 mm/s and for responses of *difficult*, approximately 1954.0 mm/s; there was a marginally significant difference at a significance level of 10 %. In contrast, positive and negative, and easy and difficult comparisons exhibited no significant differences in height or speed.

5.3 Analysis of Motion Characters

We analyzed hand-raising motion characteristics using video images and a motion capture system. Fig. 7 shows the results of the cluster analysis using Ward's method. Height and angle were used as variables. As a result, hand-raising forms were classified into six patterns. These were loosely grouped into straight form or bent form (Table. 1). For example, A, B, and C were straight forms, and D, E, and F were bent forms. Few participants changed form according to question difficulty level or reaction.

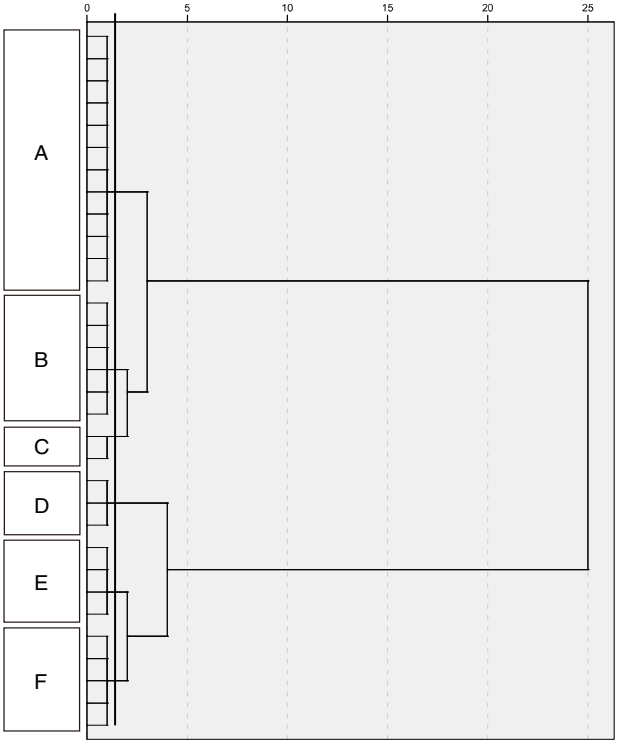
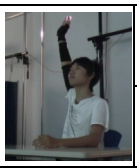
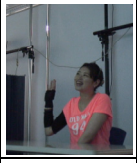
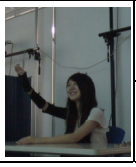


Fig. 7. Results of cluster analysis

Table 1. Patterns categorized according to cluster anasysis

Straight forms				Bent forms			
A		height	90.5 %	D		height	47.3 %
		angle	174.2 °			angle	51.6 °
B		height	81.6 %	E		height	58.5 %
		angle	134.0 °			angle	72.7 °
C		height	66.7 %	F		height	69.7 %
		angle	145.3 °			angle	109.8 °

6 Discussion

Analysis of the paper questionnaire responses revealed that if the reaction was negative, participants could not raise a hand comfortably and were negative about hand raising. In addition, motion analysis revealed that if participants did not have confidence, maximum hand-raising speed was slow and the topmost height of hand position tended to be low. Therefore, fear of failing may discourage hand raising. In contrast, we grouped hand-raising motions into six patterns according to height and angle. Hand raising mainly had two forms, straight or bent. In addition, hand-raising motions held many individual features, for example, motion of wrist and motion of hesitance.

This experiment revealed that the difficulty level of questions affected confidence, which is one of the factors of *motivation* and leads to changes in hand-raising motions. In addition, positive and negative reactions affected participants mentally, which is one of the factors of *feeling*. However, this experiment did not assume a situation in which students were chosen to answer by a teacher in a real class; therefore, concepts such as competition were not included. So, we assume that hand-raising motions in this experiment did not differ greatly. In order to investigate hand raising in more realistic situations in future, an experiment in which several participants freely raise a hand in the same classroom is required.

7 Summary

In this study, we focused on hand raising to support active student participation in class. We analyzed hand-raising motions in various situations and evaluated

emotional states. Results revealed that confidence and factors regarding various situations affect hand-raising motions and emotional states.

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