Proceedings of the International MultiConference of Engineers and Computer Scientists 2017 Vol I,
IMECS 2017, March 15 - 17, 2017, Hong Kong

Analyzing Relationship between Upper Body Poses and Emotions Using Multiple Regression Analysis

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Abstract—**In the communication of human feelings and attitudes, in addition to verbal communication, nonverbal communication (facial expressions and body movements) has a significant impact. Upper body gestures and poses are considered to play an important role in the interpretation of emotions. In our previous study, the evaluation grid method (EGM) was used to investigate the relation between emotions and upper body poses using stick figures. In this study, multiple regression analysis is applied to the evaluation hierarchical maps obtained by the EGM to evaluate the statistical relation between upper body poses and emotions. Moreover, we focus on the upper body poses concerning "*fear*" and report the results of our analysis.**

Index Terms—**upper body, emotions, multiple regression analysis**

I. Introduction

WHEN communicating feelings and attitudes, in addition to verbal communication, nonverbal communication (facial expressions and body movements) has a significant impact [1]. Most research on nonverbal communication has been based on Ekman's theory of basic emotions [2] and Wundt's tridimensional theory of feeling [3], particularly studies on the relations between facial expressions and emotions. In addition to facial expressions, other forms of nonverbal communication can convey emotion. For example, theme park mascots skillfully express emotions using their entire body. This means that gestures and poses (hereafter collectively referred to as "poses") play an important role in nonverbal communication to convey emotion.

To date, we have investigated the relation between emotions and upper body poses using the evaluation grid method (EGM). The EGM represents a subject's impressions about an object with a path diagram called an evaluation hierarchical map. In our previous study [4], we created evaluation hierarchical maps for "*surprise*," "*fear*," "*anger*," and "*joy*" by presenting images of subjects' upper bodies. The results showed that each emotion had relevance to certain postural features. However, the previous study did not investigate the quantitative relation between those emotions and upper body poses.

In this study, multiple regression analysis is applied to the evaluation hierarchical maps created in our previous study to reveal the statistical relevance between emotions and upper body poses. Moreover, we focus on the upper body poses related to "*fear*" and report the analysis results. The remainder of this study is organized as follows. Section II briefly explains the EGM and our previous study. Sections III and IV show the experimental method and results, respectively. Finally, Section V summarizes our conclusions and suggests future work.

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II. Previous Work Using Evaluation Grid Method

A. Evaluation Grid Method (EGM)

The EGM is an interview method that uses evaluation hierarchical maps to visualize a subject's impressions about objects described in their own words [5]. The EGM procedure is described as follows: First, the subject's first impressions (original constructs) are extracted by having the subjects compare pre-prepared objects. Next, laddering, i.e., the induction of associated evaluative constructs, is conducted. In laddering, questions are asked about all extracted evaluative constructs to derive highly abstract (higher level) and highly concrete (lower level) constructs. The induction of higher level constructs is called laddering up and that of lower level constructs is called laddering down. In the EGM, the diagram obtained from laddering is called the hierarchical evaluation map. This method is applied to represent the emotions reflected in the images as higher level constructs, the conditions shown in the images as original constructs, and the postural features of the images as lower level constructs.

B. Previous Work

In our previous study [4], we investigated the relation between emotions ("*surprise*," "*fear*," "*anger*," and "*joy*") and upper body poses using the EGM. The EGM was conducted for each subject as follows. First, stick figures expressing each emotion were presented to a subject. Fig. 1 shows an example stick figure used in the EGM. Next, we interviewed the subject about their first impressions (original constructs), mental states/situations (higher level constructs)

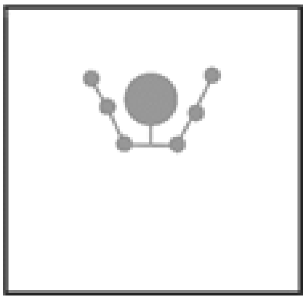

Fig. 1. Stick figure

inferred from the stick figures, and concrete postural features (lower level constructs) by which the subject obtained their first impressions. The result of the EGM was represented using an evaluation hierarchical map. Finally, for each emotion, we merged the evaluation hierarchical maps obtained from all subjects. Fig. 2 shows the merged evaluation hierarchical map for "*fear*."

Although these results revealed that constructs commonly appeared among different subjects for the respective emotions, the statistical relevancies between the higher and lower level constructs were not shown.

III. Experimental Method

A. Analysis Preparation

In this experiment, we focus on the analysis and discussion of "*fear*." In our previous study, two evaluation hierarchical maps were obtained from "*fear*." In this study, these maps are called "*fear*-1" and "*fear*-2." The aim of this experiment is to generate a statistical model that expresses the relevance between the higher and lower level constructs. For this purpose, multiple regression analysis is applied to the two evaluation hierarchical maps for "*fear*-1" and "*fear*-2." To prepare for multiple regression analysis, we count the appearance frequency of the higher/lower level constructs in the evaluation hierarchical maps.

B. Multiple Regression Analysis

Multiple regression analysis assesses the association between a dependent value and two or more independent values (or explanatory values). The multiple regression equation is as follows:

$$y = a_1 x_1 + a_2 x_2 + \cdots + a_i x_i + \cdots + a_n x_n + a_0 \quad (1)$$

Here, y is the dependent variable, x_1, x_2, $\cdots$, x_n are the independent variables, a_1, a_2, $\cdots$, a_n are the standard partial regression coefficients, and a_0 is a constant term. In this experiment, a higher and a lower level construct are considered the dependent variable and independent variable, respectively. In multiple regression analysis, the correct multiple regression equation cannot be obtained if the number of independent variables is greater than that of the samples. Thus, we deleted the independent variables, i.e., the lower level constructs, obtained from at most four subjects. Moreover, multicollinearity among independent variables causes various problems in the computation process. Thus, we excluded one of two variables with a correlation coefficient

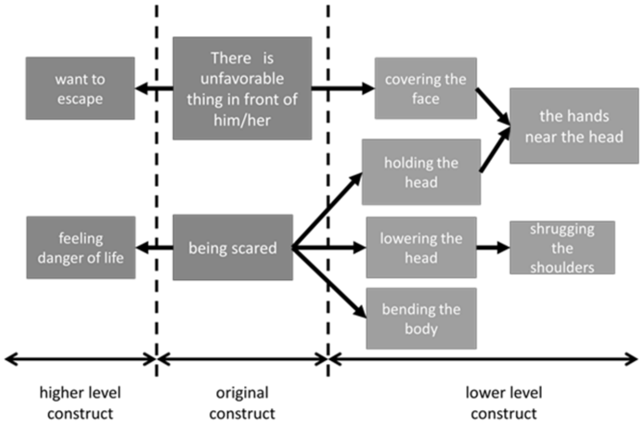

Fig. 2. Excerpt from the evaluation hierarchical map

greater than 0.9. Table I shows the input data for the multiple regression analysis, where y is a dependent variable (a higher level construct), x_1, x_2 … x_n are independent variables (the lower level constructs), and each element is the appearance frequency of the construct in the evaluation hierarchical map. Multiple regression analyses were applied to all input data created by replacing the dependent variables.

C. Model Optimization

Subsequently, the relation between the lower and higher level constructs is represented by a path diagram (model). First, we generate a complete model, as shown in Fig. 3, in which each independent variable is connected by directed edges to all dependent variables. In this model, it is assumed that each lower level construct is related to all higher level constructs. However, the complete model includes irrelevant edges. To delete such edges, edge pruning was conducted using probability (p-value) for testing the null hypothesis that the independent variable x_i has no relevance to the dependent variable y, i.e., the standard partial regression coefficient a_i is 0[6]. First, edges satisfying $p > \alpha$ are deleted, where α is the significance level. Then, re-pruning of the edges is performed after calculating the p-values for the remaining edges. The above procedure is repeated until the p-values of all edges are less than α.

D. Model Evaluation

The model obtained by edge pruning is represented using only statistically significant edges. Such a simplified model must include enough information to explain the real data sufficiently. In this experiment, the goodness of the model is evaluated using four indexes, i.e., goodness of fit index (GFI) [7], root mean square residual (RMR) [8], Akaike's information criterion (AIC) [9], and root mean square error of approximation (RMSEA) [10]. GFI represents the goodness of the model using a value from 0 to 1, and greater values indicate a better model. RMR is also an index for the goodness of a model, and an RMR value close to 0 indicates a better model. AIC is used to compare two or more models, and a model with the minimum value indicates the best model. RMSEA is an index to estimate the error of the model, and a model whose RMSEA is less than 0.05 is considered better. In this experiment, the models were compared before and after edge pruning using these four indexes.

ISBN: 978-988-14047-3-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

TABLE I
EXCERPT FROM THE EVALUATION HIERARCHICAL MAP

No	subjects	y	x_1	x_2	···	x_n
1	female 1	0	1	1	···	1
2	female 2	1	2	3	···	1
3	female 3	0	1	1	···	1
⋮	⋮	⋮	⋮	⋮	...	⋮
14	male 7	0	2	0	···	0
15	male 8	0	0	0	···	2

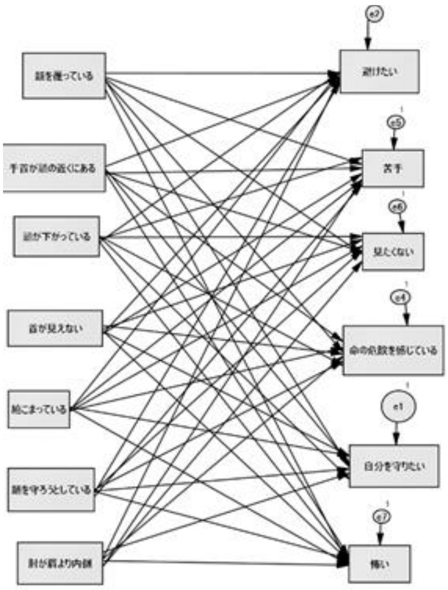

Fig. 3. The model of "*fear*-2" before the edge pruning

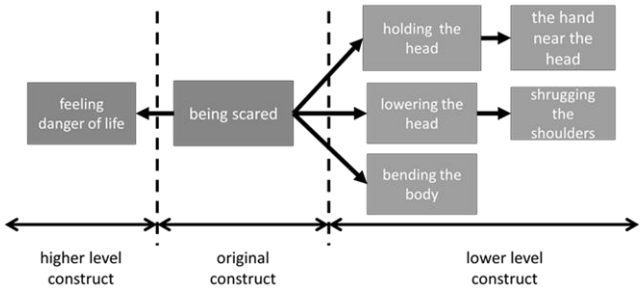

Fig. 4. Excerpt from the evaluation hierarchical map of "*fear*-2"

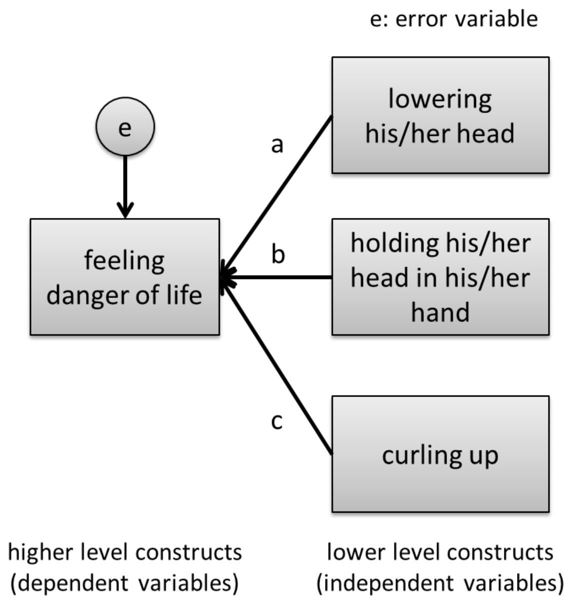

Fig. 5. Excerpt the model of "*fear*-2" after the edge pruning

IV. RESULTS AND DISCUSSION

A. Multiple Regression Analysis

This section discusses the analysis results of "*fear*-2." Fig. 4 shows an excerpt from the evaluation hierarchical map of "*fear*-2" obtained in our previous study. As shown in this figure, the previous study presented the relation between the lower and higher level constructs via the original constructs. The goal of the present study is to create a statistical model that represents the degrees of relevance between the lower and higher level constructs. Fig. 5 shows an excerpt from the model concerning the constructs in Fig. 4. As can be seen, by multiple regression analysis and edge pruning, the relation between the constructs is represented more simply, and the relevance degrees between them can be obtained.

Table II shows the standard partial regression coefficients and p-values for the edges (a, b, and c) of Fig. 5. From Table II and Fig. 5, we can see that the lower level construct "lowering the head" connecting to the higher level construct "feeling danger of life" shows a positive standard partial regression coefficient. This means that the "lowering the head" pose makes subjects imagine danger for the stick figure. On the other hand, the other two lower level constructs, i.e., "shrugging the shoulders" and "bending the body," show negative standard partial regression coefficients. Furthermore, the standard partial regression coefficients of these lower level constructs are −0.702 and −0.152, respectively. These results suggest that, if these two poses are more noticeable, it becomes more difficult for the subjects to imagine danger for the stick figure. In addition, its impact is more prominent for the "shrugging the shoulders" pose. These two poses may possibly have positive relevance with other mental states.

B. Model evaluation

Table III shows the goodness of the models before and after edge pruning for "*fear*-1" and "*fear*-2." For all indexes, goodness after edge pruning increases. This means that, by edge pruning, the model is not only simplified but can also successfully express the original data. However, no index shows ideal values because the data is very sparse owing to the small number of subjects.

V. CONCLUSION

In this study, we applied multiple regression analysis to an evaluation hierarchical map of "*fear*" and created a statistical model that represents the relation between postural features and the objects' mental states/situations. As a result, the degrees of relevance between the postural features and the objects' mental states/situations were revealed along with their positive/negative correlations.

In future, we will increase the number of subjects and analyze the evaluation hierarchical maps of "*surprise*," "*anger*," and "*joy*."

TABLE II
STANDARD PARTIAL REGRESSION COEFFICIENT AND P-VALUE

edges	standard partial regression coefficient	p-value
a	0.671	***
b	-0.702	***
c	-0.152	***

***:p<0.001

TABLE III
GOODNESS OF "*FEAR*-1" AND "*FEAR*-2" BEFORE AND AFTER EDGE PRUNING

model	edge pruning	GFI	RMR	AIC	RMSEA
fear-1	before	0.673	0.085	92.760	0.287
	after	0.739	0.049	46.352	0.160
fear-2	before	0.616	0.757	229.363	0.407
	after	0.629	0.711	181.626	0.336

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