A Case Study of Stress Measurement Using a Cybernetics Approach; Study of Experimental Sequence with Video and Audio Viewing

Yuji Mizukami

College of Industrial Technology, Nihon University,
Chiba, Japan, e-mail: mizukami.yuuji@nihon-u.ac.jp

Abstract: *We focused on a non-contact type stress diagnosis system that mainly analyzes videos and examined its effectiveness. In the analysis, the subject was watched a video with sound and measured the change in stress level when watching a relaxing video and when watching a stressful video for 30 times. The results of the analysis suggest that the non-contact stress diagnosis system is capable of detecting stress conditions from images. However, the analysis in this paper is based on a very small sample of one subject.*

Keywords: *diagnostic imaging, vestibular reflex, support vector machines, vibraimage.*

1. Introduction

There are several methods of measuring stress, which can be broadly classified into subjective evaluation methods that directly question the subject's way of thinking and feeling, and physiological evaluation methods that measure the subject's biological responses. Physiological evaluation methods include those that measure endocrine changes in the subject's body and those that measure autonomic nervous system activity. One of the author's series of researches is to conduct remote stress diagnosis of employees in remote work. In this paper, a system that uses Vibraimage technology to measure autonomic nervous system activity is used as a candidate system for remote stress diagnosis. In the analysis, we watched a video with sound and measured the change in stress level when watching a relaxing video and when watching a stressful video. In this paper, we prioritized the performance evaluation of stress measurement and conducted 30 repeated measurements on one subject. The results of the analysis suggest that the non-contact stress diagnosis system used in this paper is capable of detecting stress conditions from movies. However, the limitation of this paper's argument is that it is based on a very small sample of one subject, so further experiments are needed to generalize and discuss the results.

2. Definition of Stress in This Paper

In psychology, rapidly changing characteristics are defined as "emotions" (Ekman, 1999), while slowly changing characteristics are defined as "personality or psychological type" (Jung, 2016; Spielberger et al., 1983). In terms of mental health, when the impact of a stressor is long-term or strong, it can be a factor that causes a change in personality

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or psychological type, for example, depression. The purpose of this paper is to identify the changes that occur when the impact of a stressor is short-term and limited to an emotional transformation, before a change in personality or psychological type occurs. Although mental and physical stressors are commonly cited as stressors, this paper will focus on mental stress.

3. Direction and Methodology of the Analysis

3.1. Experimental Sequence

Figure 1 shows the experimental sequence. The stressor was selected based on Nakano and Yamaguchi's (Yamaguchi et al., 2007) evaluation of the performance of existing contact-type stress diagnosis systems, which showed a high response in the mental stress condition IV, "When a mental stressor is given and is considered to be an unpleasant stress condition (distress). viewing" was selected. In the experimental sequence, we measured the change in stress level between the relaxed and stressed video viewing.

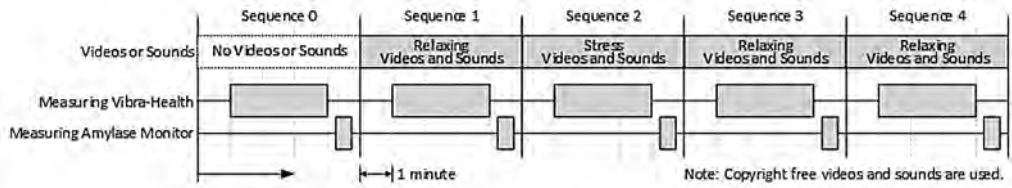

Fig. 1. *Experimental sequence of stress measurement by video viewing*

The application time of each stressor in the experimental sequence is 5 minutes based on Nakano and Yamaguchi (Yamaguchi et al., 2007), and consists of five sub-sequences: "No video (Sequence 0)" to understand the state before measurement, followed by "Relaxation video (Sequence 1)", "Stress video (Sequence 2)", followed by the relaxation video (Sequence 3), and finally the relaxation video (Sequence 4). It is assumed that audio is included in the video. The stress measurement is performed in two steps in each sequence: first, the non-contact type measurement is started one minute after the start of the sequence and completed three minutes later, and then the contact type measurement is started 15 seconds after the start of the sequence and completed 30 seconds after the start of the sequence.

In order to prevent operational differences in repeated measurements, the experimental sequence was created in advance as a single movie. In the experimental sequence, the explanation of the next step was superimposed 5 seconds before the next step in order to prevent the subject from lagging behind. In addition, ten different experimental sequences were prepared and randomly selected by a random function in Microsoft Excel. The relaxation videos are all the same, while the stress videos are 10 individual ones. The videos and audio were copyright free.

Since non-contact biomarkers are the target of measurement, it is considered necessary to verify the accuracy of the measurement using statistical methods. Therefore, the number of measurements should be increased and the variation of the measurement data should be evaluated together. A biomarker is an index that quantifies the biological response of a person by reading the concentration of biochemical substances contained in biological samples such as blood and urine (Yamaguchi et al., 2007).

3.2. Methods for Measuring Autonomic Nervous System Activity

As a method to measure autonomic nervous system activity, we used Vibra-Health Version 10.2 from Elsys, which uses Vibraimage technology. Vibraimage technology measures movement by a kind of reflex action called the "Vestibular-Emotional Reflex" (Minkin & Nikolaenko, 2008). The vertical position of a person's head is maintained by the continuous reflex action of the cervical muscles under the control of the vestibular system in the presence of the Earth's gravity. The Vibraimage technology measures the minute movements of the head and eyes. Figure 2 shows an example of the Vibra-Health measurement screen.

In psychology, it is customary to divide emotions into positive, negative, neutral, or physiological types (Russel, 1980; Scherer, 2005). In this paper, we aim to measure negative emotions; in Vibra-Health, the parameter groups of negative traits are Aggression, Stress, Tension (Anxiety), and Suspect (Suspicious). For these parameter groups, changes in the direction of decreasing parameter values from the statistical center characterize improvements in mental physiological status. Table 1 shows the parameter groups of negative characteristics of Vibra-Health.

Fig. 2. *Vibra-Health measurement screen.*
Note: The measurement was performed for 3 minutes in fixed contour mode

Table 1

Parameters of Vibra-Health

Emotional Type	Parameters	Variable name	Emotion or Personality	Description
Negative	Aggression	x1	Emotion	Lorenz's definition of «Aggression» (Lorenz, 1963)
	Stress	x2	Emotion	Canadian endocrinologist Selye's definition (Selye, 1936)
	Tension (Anxiety)	x3	Emotion	Moretti's definition (Moretti et al., 2013)
	Suspect (Suspicious)	x4	Emotion	A person who is potentially dangerous on psychophysiological tests (Minkin, Tseluyko, 2014)

Defined by the author based on Minkin & Nikolaenko, 2008.

Table2

Binomial logistics regression analysis of subject A

Regression type			Binomial Logistics Regression
Number of measurements			30
Variable selection			Single
Dependent variable		(y1)	Video Type (0: Relax, 1: Stress)
Negative	Aggression	(x1)	–
	Stress	(x2)	–
	Tension	(x3)	35.991 (0.991) .
	Suspect	(x4)	–
<Constant>			14.677(9.144)
AIC			14.748

***p = 0.00, **p < 0.01, *p < 0.05, .p < 0.10
Stress: Watching stressing video and audio
Relax: Watching relaxing video and audio, or watching nothing at all

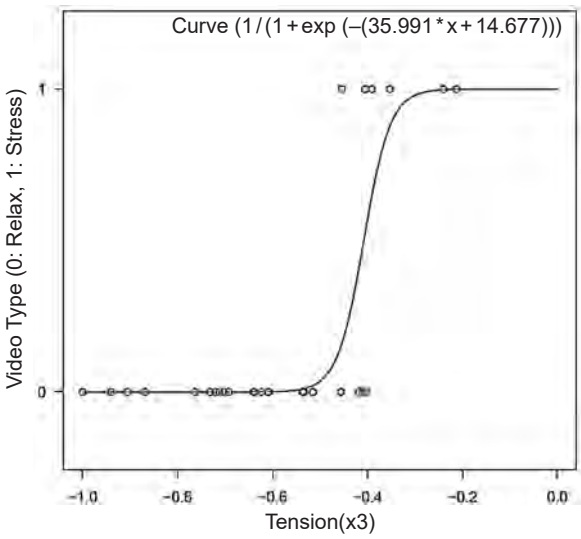

Fig. 3. *Residual plot*

4. Analysis Results and Evaluation

4.1. Measurement data

The measurement data is the result of repeated measurements of one subject, A. Subject A is a male in his 50's. Measurements were taken on December 13, 2020, 8:00–14:00. Each measurement was performed intermittently with a break in between. The test sequence consisted of 5 sub-sequences, so we obtained 30 analysis data for subject A.

4.2. Evaluation by Binomial Logistics Regression Analysis

The measurement results were subjected to binomial logistics regression analysis to verify whether the stress state was detected in the four parameters of negative emotions. The results of the analysis showed that Tension was significant at a significance probability of 10%. Table 3 shows the results of the binomial logistics regression analysis. Table 3 shows the results of the binomial logistics regression analysis. However, the explanatory power was weak because the constant was not significant at 10% significance probability. Figure 2 shows the residual plot of the binomial logistics regression analysis. Figure 3 shows the residual plot of the binomial logistics regression analysis, showing the possibility of misjudgment when Tension (×3) is between –0.6 and –0.2.

Table 3

Factor analysis of subject A

Varimax / Promax			Promax				
Factor names and evaluation items			Factor Load		h2	u2	com
			ML1	ML2			
Negative	Aggression	(x1)	0.640	–0.170	0.320	0.680	1.100
	Stress	(x2)	0.480	–0.200	0.390	0.610	1.300
	Tension	(x3)	–0.130	0.810	0.550	0.450	1.100
	Suspect	(x4)	0.650	0.450	0.940	0.060	1.800
SS loadings			1.180	1.020	With factor correlations of		
Proportion Var			0.300	0.260			
Cumulative Var			0.300	0.550	–	ML1	ML2
Proportion Explained			0.540	0.460	ML1	1.000	0.560
					ML2	0.560	1.000
Cumulative Proportion			0.540	1.000			

h2: Commonality, u2: Uniqueness, com: Complexity

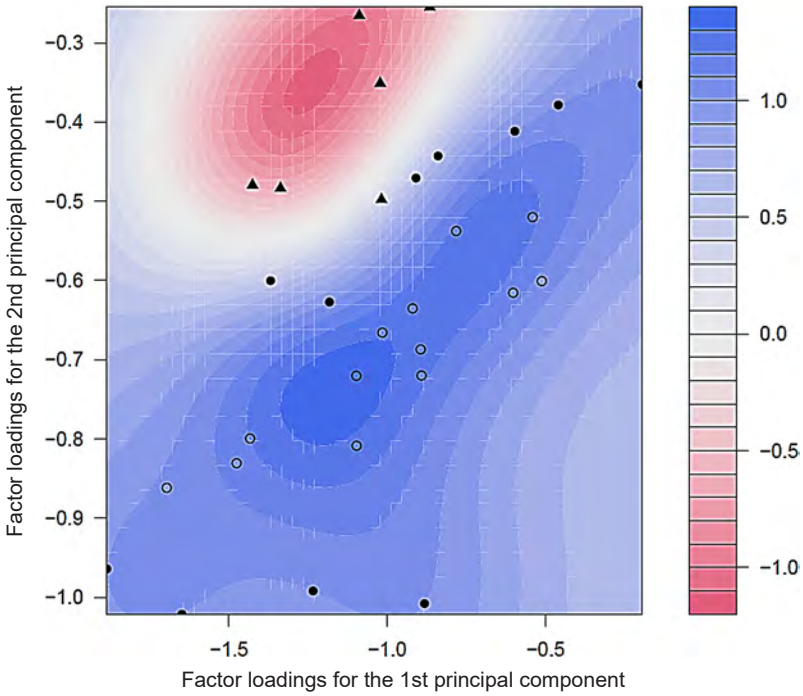

Fig. 4. *Results of SVM analysis.*
Note: Triangle watch stress video and audio

4.3. Factor Analysis and Evaluation with Support Vector Machines (SVM)

Factor analysis and support vector machine (SVM) analysis were applied to the measurement results to verify whether the stress state was detected. First, the four parameters of negative emotions were dimensionally compressed into two factors (two dimensions) by factor analysis. Table 3 shows the results of the factor analysis. In the factor analysis, we analyzed the Promax rotation. The cumulative contribution ratio was 0.550. The "psych" package of the statistical analysis software R was used to calculate the factor analysis.

Next, the results of the Promax rotation were analyzed using a support vector machine. In Figure 4, the vertical axis shows the overall stress level and the horizontal axis shows the overall relaxation state. In Figure 4, the vertical axis shows the overall stress level and the horizontal axis shows the overall relaxed state. The red area (top left) shows the stress state and the blue area (bottom center) shows the relaxed state. The triangles indicate that the subject watched the stress video. The circles indicate that the subject did not watch the stress video (i. e., watched the relaxation video or did not watch anything). The results of the analysis suggest that Vibra-Health was able to detect the stress and relaxation states in subject A. The "kernlab" package of the statistical analysis software R was used for the analysis using support vector machines.

As a result of the verification, the misjudgment rate was $0.033 < -(30 - 29)/30$. Table 4 shows the results of the misjudgment test of the SVM model.

Table 4

Results of misjudgment tests with SVM model

Items		Predicted value		Total
		Stress	Relax	
Real value	Stress	5	1	6
	Relax	0	24	24
Total		5	25	30

Stress: Watching stressing video and audio
Relax: Watching relaxing video and audio, or watching nothing at all

5. Discussion and Summary

In the analysis of this paper, we focused on a non-contact type stress diagnosis system that mainly analyzes videos and examined its effectiveness. In the experiment, 30 measurements were conducted on one subject. The results of the analysis suggest that the non-contact stress diagnosis system is capable of detecting stress conditions from images. However, the analysis in this paper is based on a very small sample of one subject. The limitations of this paper's argument are that it is difficult to generalize and discuss the results of this study. In the future, as further empirical research progresses, it is expected that generalizable verification will become possible.

There are five directions for future research. In this experiment, we were able to capture the tendency for Tension to change mainly in the four parameters of negative emotion. In the future, we may study the experimental method to change the other three parameters. Next, we may increase the number of subjects by controlling for age group, gender, and sleep duration, and proceed with verification of individual differences and differences in physical condition. In addition, the test sequence may be reviewed and improved to prevent subjects from becoming accustomed to repeated measurements and to prevent them from becoming less active, so that accurate measurements can be made repeatedly. Then, the accuracy of each parameter may be individually verified. Finally, we will conduct applied research to expand the possibilities of using the non-contact type stress diagnosis system.

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