

Analysis of Clothing Features Improving Self-Esteem Through Measuring Stress According to Activity Contexts

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ABSTRACT

The increase of mental disorders due to low self-esteem has become a problem recently. This study targets the improvement of self-esteem by changing clothes. The analysis is based primarily on data from activity trackers. The experiment is conducted by collecting data using four questionnaires: multiple affective states generated by dressing, activity context, Rosenberg's self-esteem scale and motivation score. In addition, stress values, heart rate and activity intensity are collected from an activity tracker. We predict stress states according to activity and clothing by a random forest model constructed from real data. The results showed that the variable importance of clothing characteristics belonging to the category 'fulfilled' was high.

Keywords: Clothing, Psychological state, Self-esteem, Machine learning, Activity tracker

INTRODUCTION

In recent years, the decline in self-esteem and the increase of mental disorder have become social problems. Increasing self-esteem is important for people (Kernis, 2006). Various studies have already been carried out on how to improve self-esteem. For example, the interactive technologies to raise young people's self-esteem have been developed (El-Darbi, 2013) and to raise self-esteem through the arts have been attempted (Chevalier-Amy, 2020).

By the way, there is a method of changing human affects with the psychology of cloth or social psychology of dress (Flugel, 1933). This shows that clothing can change human affects. Therefore, this study targets to improve self-esteem by changing clothing.

In addition, the psychology of clothe is a field that researches the cultural and social relationships between clothes and human beings in order to lead a fulfilling life in one's own way. However, there is no way to objectively judge whether people spend a daily life with themselves satisfied. In order to solve this, we propose to use activity trackers in this study. The activity tracker is a wristwatch-type sensor and observes the wearer's stress value as long as well as the heart rate and physical activity level. We analyse sensor data from the wearer's activity tracker and identify the terms where the stress state is suitable for the wearer's current activity. The stress state is an index associating with the self-esteem. Depending on the current activity, our method regards that long-lasting suitable stress state improves self-esteem and the activity

performance. This makes it possible to find clothing features that improve the self-esteem objectively.

Wearing clothes with these characteristics can improve the self-esteem if we can objectively identify the characteristics of clothes that increase the wearer's self-esteem through our method.

The Scales for Clothing and Stress Evaluation

According to the psychology of clothe (Flugel, 1933), people can change their own emotions by changing their appearance. Making one's appearance more agreeable to his/her liking or socially desirable can influence his/her behaviour (Davis and Lennon, 1988) and generally helps to improve his/her self-esteem.

A scale for examining the interrelationship between clothing and affect has been proposed as the scale for the multiple affective states generated by dressing (Saito, Nakagawa and Fujiwara, 1995).

This study uses this scale as a measure of assessment of clothing.

For a measure of the self-esteem, this study does the stress level. It is already known that stress level changes are important and helpful in monitoring the self-esteem (Galanakis *et al.*, 2016). In addition, methods for measuring stress values with activity trackers have already been established to some extent (Siirtola, 2019).

Hypothesis

As we have discussed in above, it is already known that people's emotions can be changed by their clothing.

The following two hypotheses are set out in this study.

- There are common characteristics of clothing that improve people's self-esteem
- With mean μ and standard deviation σ , the appropriate stress value for a particular person in a particular activity context exists in the range of $[\mu - \sigma, \mu + \sigma]$

Based on these two hypotheses, a questionnaire survey and activity tracker sensing were conducted to find clothing features that improve self-esteem.

Figure 1 is a summary diagram of the methods used in this experiment. The method assumes that the subject chooses the clothes of the day and does not change clothes on that day.

On each day, a questionnaire was administered first, after which the subjects wore an activity tracker. At the end of the day's experiment, the activity context is interviewed and revised.

Surveys can be divided into two categories: to get the characteristics of the subjects and to get the characteristics of their clothing.

The surveys to get the characteristics of the subjects are trait self-esteem scale values, motivation scores and activity context. The questionnaire on the trait self-esteem represents the Rosenberg Self-Esteem Scale (Rosenberg, 2011). That on the motivation is based on the Motivation Score (Kobayasi *et al.*, 1998).

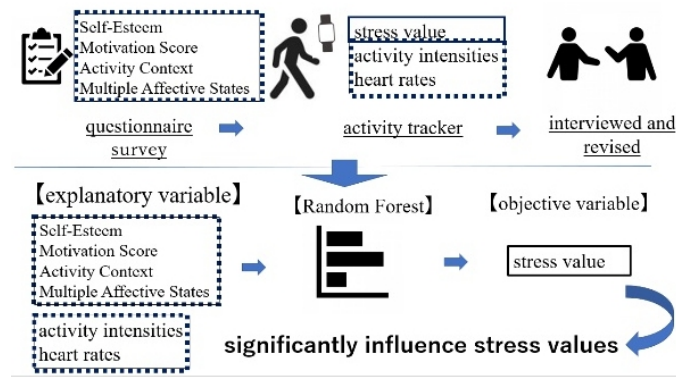


Figure 1: Summary diagram of the methods used in the experiment.

Questionnaire to obtain clothing characteristics is on a multiple states generated affective by dressing scale (Saito, Nakagawa and Fujiwara, 1995). This scale assesses human feelings for clothing in a total of 35 words.

Activity trackers measure physical activity, heart rate and stress levels.

The obtained data for all days are used to predict the results with a Random Forest model. The explanatory variable in the Random Forest model is the questionnaire results and the objective variable is the stress value. From these results, we find explanatory factors that strongly influence the stress level values.

Activity Context and Appropriate Stress Values

Stress values vary depending on the situation. Therefore, stress value means and variances are likely to vary depending on what type of activity is carried out.

In this study, we analyse the acquired stress values on a per-subject and per-activity context basis. First, the average μ and the standard deviation σ of these stress values, divided per subject and per activity context, are determined. In this study, stress values in the range $[\mu - \sigma, \mu + \sigma]$ are referred to as the appropriate stress values for a subject in a given activity context.

The activity context has four stages depending on whether the activity is externally or intrinsically motivated. Externally, subjects are forced by others to perform activities, and intrinsically, they do it because they want to do it themselves.

The division of activities into externally or intrinsically motivated is seen as an important process for motivating subjects to pursue the activity. An activity that is enjoyable for one person may not always be enjoyable for another person, because the same activity may not always be enjoyable for another person. In line with this, it is expected that the level of appropriate stress values in each activity context will vary per person.

In light of the above, clothes with a longer duration of showing an appropriate stress value are considered to be clothes that improve the performance of the subjects and increase their self-esteem.

Experimental Purpose and Method

We carried out an experiment to discover the features of clothing that increase the self-esteem, following Figure 1. Our experiment consisted of a total of four questionnaires on the trait self-esteem, motivation, clothing and activity context, and physical activity data collected by the Garmin. Of the questionnaires, the Rosenberg Self-Esteem Scale and the Motivation Score are used to obtain the characteristics of the subjects. The multiple affective states generated by dressing is for obtaining clothing characteristics, while the Activity Context is to collect the data the subject's behaviour.

The experiments were conducted to six subjects, five females and one male, aged 19–22 years. We focussed on the characteristics of the subjects. We did not focus on gender differences. The six subjects are called as Subject A-F in below.

We carried out 1–4 times of experiments per each subject. Each experiment took 1 hour at least and 5 hours at most. Each experiment was conducted on a different day. The number of the experiments were 2 for Subject A, 4 for Subject B, 3 for Subjects C, D and F, and 1 for Subject E.

The questionnaire on the trait self-esteem was based on Japanese translation of the Rosenberg Self-Esteem Scale proposed in (Uchida, 2010). The answer for each question in the questionnaire was scored in 4 grades. Subjects with higher total scores have higher trait self-esteem.

The motivation questionnaire was based on the Motivation Score (Kobayashi *et al.*, 1998). The Motivation Score questionnaire has originally been applied to the recipients of apoplexies during healing. We referred this questionnaire since it has been more useful for the recipients whose states of health are more closed to healthy. Subjects with higher total scores are more depressed.

Subjects with high total scores on the Rosenberg Self-Esteem Scale and low scores on the Motivation Scale are considered to be the healthiest mentally.

These questionnaires were only asked at the beginning of the first experiment, as they were given to identify the characteristics of the subjects.

At beginning of each experiment, the subject answered the questionnaire on the clothing which he/she is wearing in that day, and that on the activity contexts in the day. The clothing questionnaire consists of 35-word questions shown in Table 1. It shows the multiple affective states generated by dressing (Saito, Nakagawa and Fujiwara, 1995) translated by the author of this paper. The questionnaire at the experiment carried out in Japanese, which is the same language as the references.

Subjects were asked to select all the words that match their own feelings about their own clothes on that day from the list of 35 words based on the multiple affective state scale generated by dressing. The 35 words are grouped into the main categories shown in the top part of Table 1. The names of the main categories were not indicated to the subjects.

Table 1. The words in multiple affective states generated by dressing.

1.cheerfulness and refreshingness	2.fullfilment	3.firstclass feeling	4.relaxation of positive
Energetic	Intelligent	Proud	At case
Light	New	Steady	Relaxed
Uplifting	Calm	Superior	Comfortable
Refreshing	Classy	Aroused	Relieved
Sleeker	more drawn	Richer	Gentler
5. depression and unsettled	6.shame	7.pressure and strain	
Sullen	Ashamed	Strict	
Frustrated	Awkward	Sickening	
Upset	Embarrassed	Nervous	
Depressed	Restless	Breathless	
Miserable	Unbearable	Oppressive	

To obtain the subjects' activity contexts, we first asked them to respond in writing to one or more of their main activities for the schedule of the day at the start of each day's experiment. Then, for each activity, they were asked to answer the activity context on four levels: hobby, somewhat hobby, somewhat obligatory and obligatory. The intrinsic activity contexts discussed in this section are corresponding to hobbyist. The extrinsic activity contexts correspond to obligatory.

Furthermore, after the end of each day's experiment, we interviewed the subjects to determine what activities they have actually carried out and at what time of the day. If the actual context of the interviewed activity has been different from the pre-responded activity context, the actual activity context was recorded as the activity context.

The Garmin sensor, a wristwatch-type activity tracker, was worn on the subject's wrist to acquire physical activity data. The data acquired by the device can be collected by an application on the smartphone and can be downloaded in a certain format called .fit from the official website. We converted it to an Excel file format with FitFileTool.

In the data, the stress values and heart rates are time series data recorded in every minute. For the activity intensity, the intensity s and time t of the exercise are recorded after a certain activity is detected by the device.

Experimental Result of Questionnaire

The characteristic data of the subjects are shown in Table 2.

Table 2. Characteristic data of the subjects.

Subjects	Motivation	Self-esteem
A	16	23
B	17	14
C	20	21
D	19	21
E	15	26
F	25	16

In the references (Okada *et al.*, 1998), a motivation score of 16 or more points was considered to be low motivation and a score of 30 or more points was considered high.

For the Self-Esteem Scale, they are recommended that a score of 20 or more should be considered low and a score of 30 or more should be considered high (Uchida, 2010).

However, as it is only a recommendation and we referred the inter-subject averages, in this study a motivation score of 20 or more is considered to be low motivation. the Self-Esteem Scale score of less than 18 points is considered to be low and that of 25 points or more is considered to be high.

The time distribution over the whole period for each activity context obtained during the experiment is shown in Table 3. The codes 1–4 at the top of the table are codes for the activity context, where 1 represents duty, 2 does somewhat duty, 3 does somewhat hobby and 4 does hobby. The numbers in the table are represented by minutes.

Table 3. Activity context per experiment.

\		1	2	3	4
A	1st		84	83	
	2nd			403	
Total			84	486	
B	1st	752		533	
	2nd		270		
	3rd				
	4th		279		
Total		752	549	533	
C	1st			145	
	2nd			126	
	3rd		89		
	4th		248		
Total			337	271	
D	1st				249
	2nd				272
	3rd	343			
Total		343			521
E	1st		523		
Total			523		
F	1st			261	
	2nd	399			101
	3rd		413		101
Total		399	413	261	101
Overall Total		1495	1903	1551	622

Table 4 shows the multiple affective state generated by each clothing per experiment session. This shows the words which each subject selected in the questionnaire on clothing in each experiment. The words are classified according to the main categories.

Table 4. Multiple affective states.

\		1. cheerfulness and refreshingness	2. fullfilment	3. firstclass feeling	4. relaxation of positive
A	1st	Energetic Sleeker	More drawn		
	2nd	Energetic Sleeker			
B	1st				Relaxed Comfortable
	2nd		Clam		
	3rd	Light			At ease Relaxed Comfortable
	4th		New Calm Classy		
C	1st	Uplifting		Proud	At ease Relaxed Comfortable
	2nd	Light			At ease Relaxed Comfortable
	3rd	Sleeker	Calm		At ease Relaxed Comfortable
	4th	Refreshing	Intelligent		Gentler
		Sleeker	Calm Classy		
D	1st	Sleeker	Calm		At ease Comfortable
	2nd	Sleeker	more drawn		At ease Relaxed
	3rd	Sleeker	Calm	16	At ease Relaxed Comfortable
E	1st	Sleeker	Calm		Reliever Gentler
F	1st	Light Sleeker			Relaxed
	2nd	Light Sleeker	Calm		At ease
	3rd	Uplifting	Calm Classy Classy		

All the subjects selected the words belonging to the main categories “1. cheerfulness and refreshens” or “2. fulfilment” during the experiments. None of those belonging to “5. Depression and unsettled”, “6. shame”, or “7. Pressure and strain” were selected.

From these results and the testimonies of the subjects, it can be concluded that the subjects were successful in selecting clothes that they themselves believed would improve their performance to some extent.

Experimental Results and Pre-Processing of Sensor Data

The three kinds of sensor data acquired are stress values, heart rates and physical activities. Each of the data was modified into a time series data with a 1-minute period. The method of filling in each missing value is as follows.

First, for stress values, values below zero can be regarded as missing values, or zero values due to cancellation with the activity intensity. In this study, all values below 0 were removed without completion as missing values, because there were few values below 0 originally and because only a very small number of subjects performed hard exercises during the experiments.

For heart rates, the missing values were replaced by the mean of the values immediately before and after the missing values.

An activity intensity is recorded after a certain amount of activity, with the amount of movement s and time t . Therefore, for each momentum data (s, t) , the activity intensity during the term from the previous momentum data time t' to time t was complemented with the momentum s .

Table 5 shows the results of the mean and standard deviation of the stress values for each activity context. The codes 1–4 in the top row of the table are codes for the activity context, where 1 represents duty, 2 somewhat duty, 3 somewhat hobby and 4 hobby. As predicted before the experiment, there was a significant variation in stress values from each activity context and from each subject.

Table 5. Stress values for each activity context.

\	1		2		3		4	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
A			12.621	6.086	25.763	17.152		
B	84.349	5.140	69.048	15.455	52.256	19.051		
C			27.808	25.299	37.553	19.497		
D	16.572	10.809					44.009	35.713
E			51.005	14.117				
F	37.503	22.754	34.599	19.411	46.391	21.970	25.087	15.546

Table 6 shows a summarisation of the mean and standard deviation of the heart rates. Values in the range 80–90 are the most frequent. The average heart-rates are similar (89.016 and 89.729, about 89) in both of the activity context 2 of Subject B and the activity context 3 of Subject C. However, the corresponding average stress values that are calculated with

reference to the heart rates are 69.048 and 37.553, showing a considerable difference.

Table 6. Heart rates for each activity context.

\	1		2		3		4	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
A			66.742	8.077	80.457	20.912		
B	93.403	16.556	89.016	28.912	86.262	15.341		
C			83.496	21.438	89.729	17.138		
D	70.297	19.681					76.722	30.141
E			84.977	20.033				
F	90.779	17.269	85.322	13.017	84.925	13.780	84.401	9.330

Table 7 shows a summrisation of the means and standard deviations of the activity intensities. When compared to the other activity contexts, it was found that the momentum averages for activity context 2. somewhat obligatory were a little more similar among the subjects. The standard deviations are mostly between 30 and 40.

Table 7. Activity intensities.

\	1		2		3		4	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
A			120.900	30.162	138.432	32.386		
B	118.480	33.503	134.974	36.247	96.284	34.310		
C			130.493	38.303	159.616	37.175		
D	95.000	30.322					111.429	32.759
E			147.866	33.673				
F	141.404	47.401	122.828	28.899	103.264	32.722	95.129	22.681

Specific Clothing Features That Improve Performance

Based on the acquired data, we predicted the data for each subject using the Random Forest model. The purpose of the prediction is to find the important factors, especially associating with the clothing, to affect the stress. The stress is regarded to be related to the self-esteem, then activity performance. The explanatory variables are the features on the heart rates, those on the physical activities and the clothing characteristics given by the 35 words. The objective variable is the stress value.

Important Explanatory Variables

Tables 8–12 shows the variable importance of the Random Forest model for each subject. The respective prediction accuracies were 0.864 for Subject A, 0.669 for B, 0.938 for C, 0.871 for D, and 0.850 for F.

Table 8. Subject A.

Explanatory Variables	Variable Importance
HeartRate	0.522719541615503
2.fulfilment	0.32030412328238645
CurrentActivityTypeIntensity	0.14797633510211047
Rosen	0.0
fight	0.0
Oppressive	0.0
1.cheerfulnessandrefreshingness	0.0
3.firstclassfeeling	0.0
4.relaxation	0.0
5. depressionandagitation	0.0

Table 9. Subject B.

Explanatory Variables	Variable Importance
1.cheerfulnessandrefreshingness	0.45244583144092465
2.fulfilment	0.21981797673739273
4.relaxation	0.2140119257738869
HeartRate	0.05920790748043063
CurrentActivityTypeIntensity	0.054516358567365045
Rosen	0.0
fight	0.0
3.firstclassfeeling	0.0
5. depressionandagitation	0.0
6.shame	0.0

Table 10. Subject C.

Explanatory Variables	Variable Importance
2.fulfilment	0.7401367578384876
3. firstclassfeeling	0.11959923056284943
HeartRate	0.09135584841867374
CurrentActivityTypeIntensity	0.0489081631799892
Rosen	0.0
fight	0.0
1.cheerfulnessandrefreshingness	0.0
4.relaxation	0.0
5. depressionandagitation	0.0
6.shame	0.0

“HertRate” represents heart rate, “CurrentActivityIntensity” represents activity intensity, “fight” represents motivation score and “Rosen” represents self-esteem scale. The reason why the importance of the heart rate as an important variable is high is that the heart rate is based on the calculation of stress values in Garmin. We could not obtain the important variables for Subject E because only one experiment (only one clothing and activity context) was conducted for E. For this reason, the table of Subject E is not available.

Table 11. Subject *D*.

Explanatory Variables	Variable Importance
HeartRate	0.619411
CurrentActivityTypeIntensity	0.380589
Rosen	0
fight	0
1.cheerfulnessandrefreshingness	0
2.fullfilment	0
3.firstclassfeeling	0
4.relaxation	0
5. depressionandagitation	0
6.shame	0

Table 12. Subject *F*.

Explanatory Variables	Variable Importance
4.relaxation	0.4334203242310192
2.fullfilment	0.34701519123747737
HeartRate	0.1240022269515484
CurrentActivityTypeIntensity	0.09556225757995493
Rosen	0.0
fight	0.0
1.cheerfulnessandrefreshingness	0.0
3.firstclassfeeling	0.0
5. depressionandagitation	0.0
6.shame	0.0

In summary, it was found that whether or not the clothing features belonging to “2. Fulfilled” were included (except Subject *E*) was an important variable in determining the prediction results for all subjects.

On the basis of these results, it was found that the appropriate stress values were shown when wearing “2. Fulfilled” clothing, as shown in Table 13. It shows the percentage of appropriate stress values. Percentages are calculated per subject and per activity context. The codes 1–4 in the top row of the table are codes for activity contexts, where 1 indicates duty, 2 somewhat duty, 3 somewhat hobby and 4 hobby. The table shows that the percentages of appropriate stress values are over 60% in all subjects and in all activity contexts.

Table 13. Percentage of appropriate stress values (wearing ‘fulfillment’).

Subjects	1	2	3	4
A		0.667	0.699	
B		0.667		
c	0.733	0.646		
D	0.773			
E		0.667		
F	0.604	0.642		0.842

The results show that people are more likely to be in appropriate stress when wearing clothes that they describe themselves as being in the ‘fulfillment’ category.

DISCUSSION

Table 14 shows the results of applying the RandomForest model with sensor data and questionnaire data for all respondents.

It shows the objective variables as stress values and the explanatory variables as heart rate (HertRate), motivation score (fight), self-esteem (Rozen) and self-esteem scale for clothing. It can be inferred that the motivation score and wearing “2. fulfillment” clothing are important in predicting the stress level values.

Table 14. RandomForest model with all.

Explanatory Variables	Variable Importance
2.fullfilment	0.21750090166687297
fight	0.20242566845608273
Rosen	0.1519055034862937
4.relaxation	0.12897415631553708
HeartRate	0.12405119689450947
1.cheerfulnessandrefreshingness	0.10073044047447664
CurrentActivityTypeIntensity	0.06450295774159492
3.firstclassfeeling	0.00990917496463255
5. depressionandagitation	0.0
6.shame	0.0
7.pressureandstrain	0.0

CONCLUSION

This study attempted to identify clothing features that improve the self-esteem by analysing sensor data obtained by activity trackers. To find clothing features that improve the self-esteem, a RandomForest model was constructed to predict changes in stress levels, which are said to be closely related to the self-esteem.

In this model, the stress values, heart rates, activity intensities, affect words and their categories for multiple affective states generated by dressing characteristics, subjects’ trait self-esteem scale values and motivation scores were used as explanatory variables.

The results show that people are more likely to be appropriately stressed when wearing clothes that they perceive to be in the ‘fulfilment’ category in the multiple affective scale for clothing. In the present experiment, the range of appropriate stress values was set to $[\mu - \sigma, \mu + \sigma]$ based on the mean μ and standard deviation σ .

However, there is still room for further study on this range, which should be addressed in the future.

REFERENCES

- Chevalier-Amy, N. (2020) 'Becoming: How Expressive Arts Nurture Self-Esteem, Identity and Empowerment, Development of a Method', in. Available at: <https://www.semanticscholar.org/paper/Becoming%3A-How-Expressive-Arts-Nurture-Self-Esteem%2C-Chevalier-Amy/6e023fa783e8ff890f5a9537768d754641017bdd> (Accessed: 21 April 2023).
- Davis, L. L. and Lennon, S. J. (1988) 'Social Cognition and the Study of Clothing and Human Behavior', *Social Behavior and Personality: an international journal*, 16(2), pp. 175–186. Available at: <https://doi.org/10.2224/sbp.1988.16.2.175>.
- El-Darbi, A. (2013) 'How to Improve Self-Esteem Workshop', in. Available at: <https://www.semanticscholar.org/paper/How-to-Improve-Self-Esteem-Works-hop-El-Darbi/622ed7d7fc9e15346e3ed9f15c26dcef4e9fee44> (Accessed: 21 April 2023).
- Flugel, J. C. (1933) 'The Psychology of Clothes', *The Sociological Review*, a25(3), pp. 301–304. Available at: <https://doi.org/10.1111/j.1467-954X.1933.tb01889.x>.
- Galanakis, M. J. et al. (2016) 'A Literature Review on the Connection between Stress and Self-Esteem', *Psychology*, 07(05), pp. 687–694. Available at: <https://doi.org/10.4236/psych.2016.75071>.
- Kernis, M. H. (ed.) (2006) *Self-Esteem Issues and Answers: A Sourcebook of Current Perspectives*. New York: Psychology Press. Available at: <https://doi.org/10.4324/9780203759745>.
- Kobayashi, S, et al. (1998) 'Assessment of post-stroke motivational decline using a motivation score', *Stroke*, 20(3), pp. 318–323. Available at: <https://doi.org/10.3995/jstroke.20.318> (in Japanese).
- Okada, K. et al. (1998) 'Assessment of reduced motivation after stroke using motivation scores', *Stroke*, 20(3), pp. 318–323. Available at: <https://doi.org/10.3995/jstroke.20.318>.
- Rosenberg, M. (2011) 'Rosenberg Self-Esteem Scale'. Available at: <https://doi.org/10.1037/t01038-000>.
- Saito, E., Nakagawa, S. and Fujiwara, Y. (1995) 'Construction of the Scale for Measurement of Multiple Affective States Generated by Dressing', *Sen'i Kikai Gakkaishi (Journal of the Textile Machinery Society of Japan)*, 48(4), pp. T105–T112. Available at: https://doi.org/10.4188/transjtsmj.48.4_T105.
- Siirtola, P. (2019) 'Continuous stress detection using the sensors of commercial smartwatch', *Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers*, pp. 1198–1201. Available at: <https://doi.org/10.1145/3341162.3344831>.
- Uchida, Tomohiro (2010) 'An examination of the reliability and validity of the Rosenberg Self-Esteem Scale: Using the Japanese version translated by Mimura & Griffiths', *Annual Review of Graduate School of Education, Tohoku University*, 58(2), pp. 257–266. (In Japanese).