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Affective Modelling of Eustress and Distress using Psychological Scales

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Abstract— This article is a case study that illustrates how a linear regression model can be implemented in eustress and distress analysis based on the correlation between emotion and stress and uses it to develop prediction equations of stress. This study proposes the use of five questionnaires; Perceived Stress Scale 10, Academic Eustress scale, Academic Distress scale, Bosse's Distress Eustress scale and Adolescent Distress Eustress scale to determine perceived stress, eustress or distress. A sixth questionnaire, the Self-Assessment Manikin was used to determine emotional state in terms of valence and arousal, which are represented on 2-dimensional axis, where the x axis represents valence, and the y axis represents arousal. An analysis of the relationship between the results of the stress questionnaires and results of SAM based valence and arousal is carried out. Significant correlations are then used to derive regression equations used to predict eustress, distress or perceived stress. The findings showed that neither valence nor arousal was correlated with perceived stress, hence no regression equation was derived for it. However, valence and/or arousal were correlated with the remaining five questionnaires. Finally, this article analyses the predictions comparing actual vs predicted values. Error analysis showed that the ADES questionnaire had the lowest average error, making it the most suitable in predicting eustress and distress from emotion.

Keywords— Eustress, Distress, Transactional model, Circumplex model, Linear regression, Loss function.

I. Introduction

Stress has generally been considered an amalgamation of psychological, physiological and behavioural responses triggered when a significant imbalance exists between demands placed on a person and their perceived capacity to deal with those demands – also known as stressors ([1], [2]). A more holistic definition of stress was introduced by Hans Seyle, where he described it as "any non-specific response of the body to the demands made upon it" [3]. His findings also identified a distinction between positive stress and negative stress that relied on a person's contextualization of their experience [4]. Positive stress is called eustress and leads to feelings of fulfilment, joy and motivation, while negative stress is called distress and is characterized by depression; anxiety reduced productivity and if experienced over a prolonged period may lead to chronic diseases [5], [6]. Several studies have also proposed that eustress leads to savouring i.e., appreciating and intensifying positive experiences which then leads to a flow state (i.e., reaching a level of peak performance where an individual is completely absorbed in a task) [7], [8]. The flow state is considered the ultimate eustress experience [9], [10]. This proposed research can help students and faculty members to identify stress level so that stress can be handled in an optimum manner. Figure 1 shows a partial-consensus illustration of the stress process. This framework shows that:

- Stressors are an ever-present part of life.
- Stress is a precursor to emotional/affective state.
- Individual appraisal and coping are key in processing stressors
- Eustress and distress are essentially preceded by affective response [11].

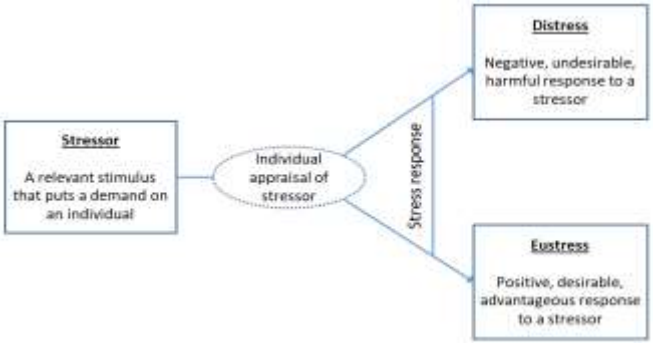

Fig. 1 Illustration of the stress process [12]

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According to the Transactional Stress model, stress is neither inherently good nor bad; and that the stress state and subsequent stress reaction can be either beneficial or detrimental depending upon a person's appraisal and coping mechanism. The model states that an individual's experience of stress is a 'transaction' between their self and their environment, and is dependent on their ability to cope with the stressful stimuli [13] – [15]. Hence, environmental stimuli are appraised in two steps, namely; the primary appraisal where individuals assess the motivational relevance of the stimuli and consider the importance of the situation or event for their individual wellbeing; and the secondary appraisal, where the individual assesses their ability to cope with a given stimuli, or 'stressor'. When their coping skills are perceived as inadequate, they are said to experience 'negative stress', or *distress*. However, if their coping skills are perceived as adequate, then they experience 'positive stress', or *eustress*. A person filters their experiences by appraising the extent to which they believe they can reduce loss, minimize harm, or address challenge and engage in behaviours that specifically affect outcomes [16], [17]. Figure 2 depicts the stages in the Transactional model of stress and coping. The *antecedents* define the stressors derived from the relationship between an individual and their environment. The *processes* comprise of applying a coping mechanism, after completing a primary and secondary appraisal of stressors [18]. The final outcome depends on whether the individual is able to cope or not and can be classified as an emotion or affective state that can motivate, challenge or demoralise an individual [3], [4].

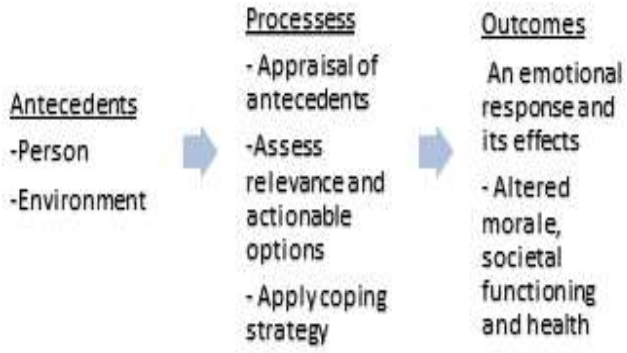

Fig. 2 Transactional model of stress and coping [19]

Emotional states usually correspond to specific physiological states which affects a person's perception of stress. A positive perception of stressful stimuli might fire certain brain signals associated with joy and calmness. For a different subject, the same stimuli might ignite brain signals associated with sadness or fear [2], [20]

Emotion models have been used for systematic analyses of human emotion and have been utilized in assessing the neurophysiological mechanisms activated by different emotional states. The most significant models used to categorize emotions are the basic emotion model, the dimensional emotion model and, the appraisal-based model [21]. At present, there are two main theories of emotion. One kind is Ekman's basic emotion theory, which includes the positive emotions (interest, pleasure and other basic), as well as the basic negative emotions (sadness, anger, tension, etc.) The other theory is known as Russel's dimensional representation of emotion which is composed of two dimensions: pleasure and arousal. In this paper, we adopt the dimensional interpretation [22].

Figure 3 illustrates the dimensions of Russel's circumplex model of affect, which proposes that emotional states arise from two neurophysiological components that can be represented as 2-dimensional scale. The horizontal axis (x) component is called valence, and describes how pleasant an emotion might be; it may be positively perceived as joy and amusement, or negatively perceived as sadness and fear. The vertical axis (y) component is arousal and describes the activation due to an emotional state. This can range from low arousal, when an individual is bored or sleepy to high arousal during excitement or anger [23], [24].

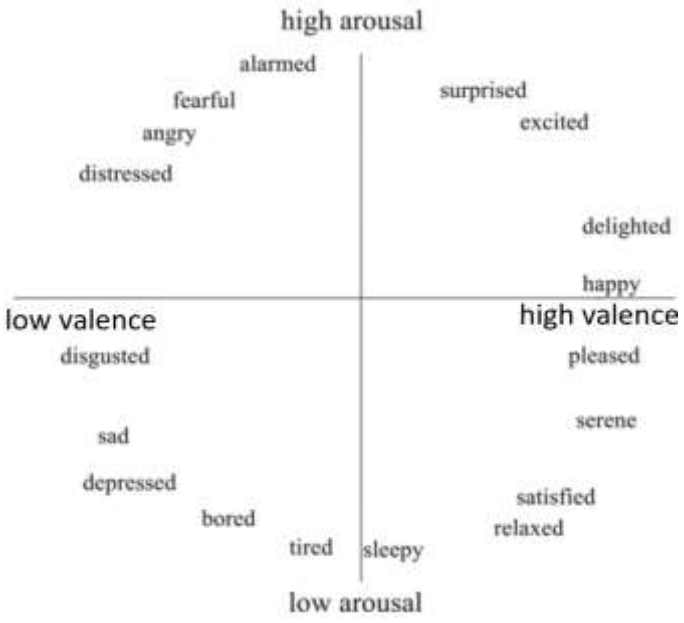

Fig. 3 Circumplex model of affect [25]

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The research on stress is a near-exclusively negatively biased, hence there is a lack of research on positive eustress. To counteract this negative emphasis, a more balanced approach is required, to fully take into account both the negative and positive aspects of the stress [26], [17]. The principal goal of the study was therefore to account for both eustress and distress, as well as their relationship to emotion. The remainder of this paper is organized as follows: Section 2 describes the entire process, dataset, and the algorithm for stress prediction. Linear regression is used to predict stress a comparison is done between measured and predicted values of stress. Section 3 validates the performance of regression algorithms by deriving the cost function and using optimization. Finally, Section 4 concludes this paper.

II. Methodology

This study presents a direct approach to investigate the relationship between emotion, positive stress and negative stress from a sample of 109 university students. An online Google forms survey was administered to the participants where they were asked to fill their demographic details and respond to the following psychological instruments – the Perceived Stress Scale (PSS–10), Academic Eustress Scale, Academic Distress Scale, Bosse's Eustress and Distress Scale, the Adolescent Distress Eustress Scale (ADES), and the Self-Assessment Manikin (SAM). The first six scales measured either for eustress, distress or perceived stress, while the SAM scale is used to determine the participants' valence and arousal. Table 1 shows demographics of the experiment participants.

TABLE I
PARTICIPANTS' DEMOGRAPHICS

Variable	Total Number	Percentage %
Male	62	56.8
Female	47	43.2
Undergraduate	80	73.4
Postgraduate	29	26.8
Malaysian	56	51.3
International	53	48.6
Below 21	23	21.1
Between 22 and 28	72	66.1
Between 29 and 36	14	12.8
Total respondents	109	100

The sample size of 109 subjects was selected in accordance to requirements of simple regression analysis that needs at least 50 samples and generally 100 samples for most research situations [27].

Table 2 shows the internal consistency of each psychological instrument and the scoring method to calculate the stress from them. All 109 subjects were required to respond to all the questionnaires.

TABLE III
PSYCHOMETRIC PROPERTIES OF PSYCHOLOGICAL SCALES

Psychological Instrument	Reliability (α)	Scoring
Academic Eustress Scale	0.80	Uses 6-point Likert Scale. -Higher scores from 4 to 6. -Medium scores are from 3 to 4. -Lower scores are from 1 to 3.
Academic Distress Scale	0.91	Uses 6-point Likert Scale. -Higher scores from 4 to 6. -Medium scores are from 3 to 4. -Lower scores are from 1 to 3.
Bosse's Eustress and Distress Scale	Eustress subscale = .87 Distress subscale = .93	Uses 6-point Likert Scale. -Higher scores from 4 to 6. -Medium scores are from 3 to 4. -Lower scores are from 1 to 3.
Adolescent Distress Eustress Scale	Eustress subscale = .83 Distress subscale = .87	Uses a 5-point Likert-type scale. -Higher scores are from 2.5 to 4. -Medium scores are from 1.5 to 2.5. -Lower Scores are from 0 to 1.5

Figure 4 shows the SAM scale, which is a 9-point scale rated between -4 to 4 and used to measure the valence and arousal of each participant. Participant circle the number closest to the figure that represents his or her affective state best.

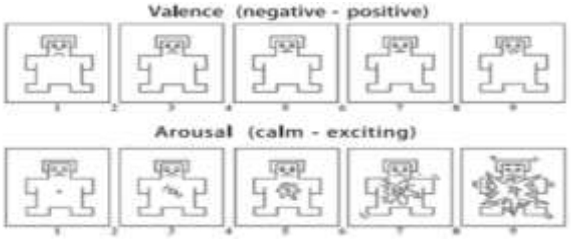

Fig. 4 SAM scale [28]

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A. Exploratory Analysis

This study utilizes the existing literature on stress analysis using psychological instruments and machine learning to develop and test practical strategy model. The data frame has 109 observations with 9 variables. Table 3 shows the final variables used to create the linear regression model. Some are numerical while others are categorical. Therefore, the categorical variables need to be converted

TABLE IIIIVV
VARIABLES FOR MODEL DESIGN

Variable	Data type
Valence	Numerical
Arousal	Numerical
Gender	Categorical
Age	Categorical
Nationality	Categorical
Degree Type	Categorical
Perceived Stress	Numerical
Academic eustress	Numerical
Academic distress	Numerical
Bosse eustress	Numerical
Bosse distress	Numerical
Adolescent eustress	Numerical
Adolescent distress	Numerical

Table 4 depicts part of the dataframe used in designing the prediction model. The categorical variables were converted to numerical values in the following manner; Gender is either 1 and 0 for male and female, respectively. Participants' ages which are grouped as either below 21, 21 - 29 or 29 - 36 are represented by 0, 1 and 2 respectively. Nationality is represented by 0 and 1 for either Malaysian or international students, respectively. Degree type is represented by 0 and 1 for postgraduate and undergraduate students, respectively. Variables derived from the questionnaires are all numerical.

Table VIV
DATAFRAME CONSISTING OF PARTICIPANT DEMOGRAPHICS AND QUESTIONNAIRE SCORES

Valence	Arousal	Gender…	PSS-10	Acad. Eustress Scale …
-3	-1		22	1.6
4	2	0	14	5.2
4	0	0	22	3.7
4	1	1	15	4.6
4	2	1	28	4.8
-1	-1	1	13	2.7
4	1	0	21	4
0	1	1	12	3.8
…	…	…	…	…

Figure 5 shows the scatter plot matrix used to assess whether an obvious correlation exists between each pair of variables for Valence, Arousal, Gender, Age, Degree Type, Nationality, Perceived stress, Academic eustress, Academic distress, Bosse eustress, Bosse distress, Adolescent eustress, Adolescent distress. Only valence and arousal showed clear correlation with several of the stress questionnaire scores.

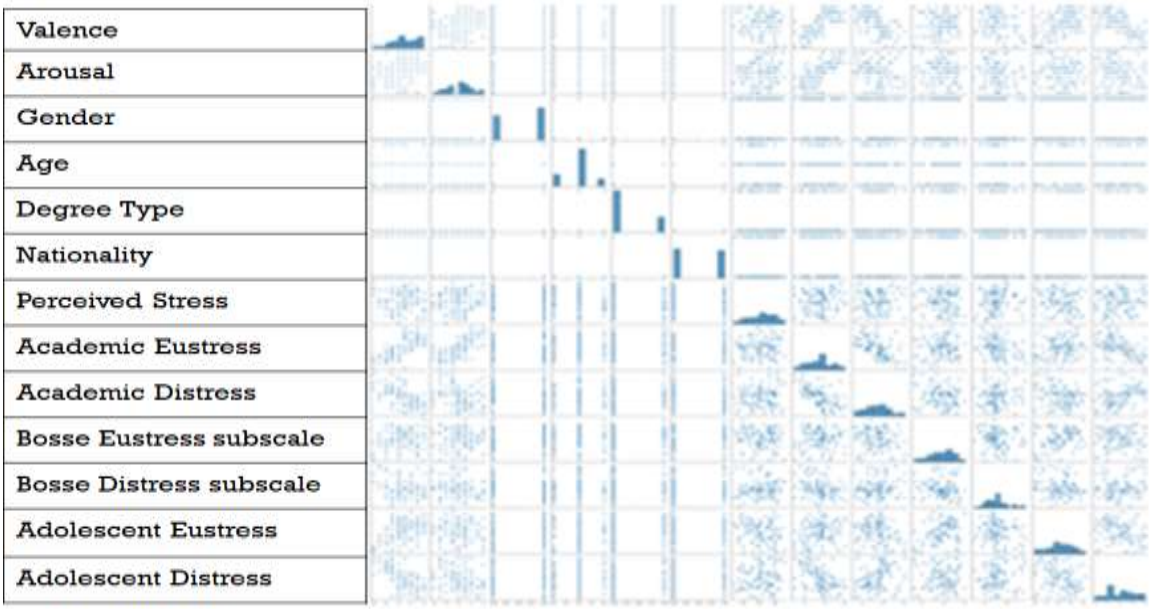

Fig. 5 Scatter matrix plot

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B. Model Design

A linear regression model is derived for each of the 6 stress questionnaires. The input into each model comprises of data derived from a stress questionnaire to represent the features, while data from the SAM scale represents the target. Figure 6 shows the overall components of the machine learning model.

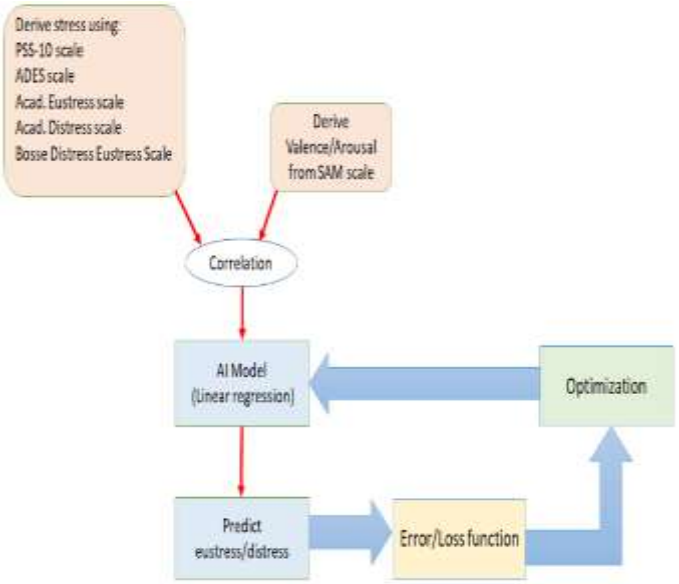

Fig. 6 Components of model for stress prediction

III. Prediction Analysis

Next, an analysis of the relationships between the variables is carried out by deriving the Pearson's correlations as shown in Equation 1.

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \quad (1)$$

where,

- 'r' is the correlation coefficient,
- 'x_i' represents values of the x-variable in the sample,
- $\bar{x}$ represents the mean of the values of the x-variable and,
- 'y_i' represents values of the y-variable in the sample and
- $\bar{y}$ represents the mean of the values of the y-variable.

Table 5 shows the resulting correlations between demographic data and scores from the psychological instruments.

TABLE V
RESULTING CORRELATIONS BETWEEN PSYCHOLOGICAL SCALES AND EMOTION

Scales	Statistical tools	Valence	Arousal
Perceived Stress score	Pearson correlation	-0.03	0.1
	Significance	0.7	0.30
Academic Eustress score	Pearson correlation	0.21	0.31
	Significance	0.03	0.0011
Academic Distress score	Pearson correlation	-0.35	-0.19
	Significance	0.00017	0.04
ADES (eustress subscale score)	Pearson correlation	0.228	-0.025
	Significance	0.016	0.79
ADES (distress subscale score)	Pearson correlation	-0.23	-0.21
	Significance	0.015	0.024
Bosse's Scale (eustress subscale score)	Pearson correlation	0.138	0.020
	Significance	0.149	0.829
Bosse's Scale (distress subscale score)	Pearson correlation	-0.218	-0.167
	Significance	0.022	0.08

* $p < .05$, ** $p < .01$, *** $p \leq .001$

A. Academic Stress Analysis

The analysis of academic eustress is carried out using two independent instruments; the Academic eustress scale and the Academic distress scale. The output of these scales is shown below.

1) Academic eustress scale

The study focuses on relationship with emotion, hence and the two predictors; valence (*V*) and arousal (*A*) are modeled. There is a significant positive correlation between academic eustress and valence as well as arousal as shown in Table 5.

Regression analysis is conducted for the significant correlations to derive prediction equations. Table 6

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shows the weight, loss and intercept parameters derived for the regression equation. After optimization using Stochastic Gradient Descent (SGD), the loss of the model is reduced from to as shown in the table.

TABLE VVII
PARAMETERS OF ACADEMIC EUSTRESS LINEAR REGRESSION MODEL

Input features	Weights	Loss	SGD optimizer Loss	Intercept
V	0.302	0.35	0.59	3.31
A	0.297			

Therefore, the final regression equation for academic eustress is:

$$Academic\ eusterss = 3.31 + 0.302V + 0.29 \quad (2)$$

2) Academic Distress as Target Variable

There is no significant negative correlation between academic distress and valence (*V*), while a significant correlation exists with arousal (*A*) as shown in Table 5.

Regression analysis is conducted for the significant correlations to derive prediction equations. Table 7 shows the weight, loss and intercept parameters derived for the regression equation. After optimization using Stochastic Gradient Descent (SGD), the loss of the model is reduced from to as shown in the table.

TABLE VVIIIIX
PARAMETERS OF ACADEMIC DISTRESS LINEAR REGRESSION MODEL

Input features	Weights	Loss	SGD optimizer Loss	Intercept
A	-0.164	1.07	1.04	3.41

Hence the final regression equation for academic distress is:

$$Academic\ distress = 3.41 - 0.16A \quad (3)$$

B. Bosse Distress Eustress scale Analysis

Bosse Distress Eustress scale comprises of two subscales used to analyse both eustress and distress, respectively. Results from each subscale are shown below.

1) Bosse Eustress as Target Variable

The two predictors used to design the regression model were valence (*V*) and arousal (*A*). The table shows there is a significant positive correlation between Bosse's eustress subscale and valence, while no significant correlation exists with arousal as shown in Table 5.

Next, regression analysis is conducted for the significant correlations to derive prediction equations. Table 8 shows the weight, loss and intercept parameters derived for the regression equation. After optimization using Stochastic Gradient Descent (SGD), the loss of the model is reduced from to as shown in the table.

TABLE VIIX
PARAMETERS OF BOSSE'S EUSTRESS LINEAR REGRESSION MODEL

Input features	Weights	Loss	Loss after using SGD optimizer	Intercept
V	0.07	1.11	1.05	3.80

Hence the final regression equation for Bosse's eustress is:

$$Bosse's\ eusterss = 3.80 + 0.07V \quad (4)$$

2) Bosse Distress as Target Variable

The two predictors used to design the regression model were valence (*V*) and arousal (*A*). The table shows there is a significant positive correlation between Bosse's distress subscale and valence, while no significant correlation exists with arousal as shown in Table 5.

Regression analysis is conducted for the significant correlations to derive prediction equations. Table 9 shows the weight, loss and intercept parameters derived for the regression equation. After optimization using Stochastic Gradient Descent (SGD), the loss of the model is reduced from to as shown in the table.

TABLE XIX
PARAMETERS OF BOSSE'S DISTRESS LINEAR REGRESSION MODEL

Input features	Weights	Loss	Loss after using SGD optimizer	Intercept
V	-0.10	0.94	0.97	3.18

Hence the final regression equation for Bosse's distress is:

$$Bosse's\ distress = 3.18 - 0.1V \quad (5)$$

C. Adolescent Distress Eustress Analysis

The Adolescent Distress Eustress scale comprises of two subscales used to analyse both eustress and distress, respectively. Results from each subscale are shown below.

1) Adolescent Eustress as Target Variable

The two predictors used to design the regression model were valence (*V*) and arousal (*A*). There is a significant

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positive correlation between ADES eustress subscale and valence, while no significant correlation exists with arousal as shown in Table 5. Regression analysis is conducted for the significant correlations to derive prediction equations. Table 13 shows the weight, loss and intercept parameters derived for the regression equation. After optimization using Stochastic Gradient Descent (SGD), the loss of the model is reduced from to as shown in the table.

TABLE X
PARAMETERS OF ADES EUSTRESS SUBSCALE LINEAR REGRESSION MODEL

Input features	Weights	Loss	Loss after using SGD optimizer	Intercept
V	0.22	0.86	0.93	2.01

Hence the final regression equation for ADES eustress is:

$$ADES\ eusterss = 2.0 + 0.22V \quad (6)$$

2. Adolescent Distress as Target Variable

There is a significant positive correlation between ADES distress and both valence as well as arousal as shown in Table 5.

Next, regression analysis is conducted for the significant correlations to derive prediction equations. Table 11 shows the weight, loss and intercept parameters derived for the regression equation. After optimization using Stochastic Gradient Descent (SGD), the loss of the model is reduced from to as shown in the table.

TABLEXXII
PARAMETERS OF ADES DISTRESS LINEAR REGRESSION MODEL

Input features	Weights	Loss	Loss after using SGD optimizer	Intercept
V	-0.30	0.67	0.82	2.17
A	-0.06			

Hence the final regression equation for ADES distress is:

$$ADES\ distress = 2.17 - 0.3V - 0.06A \quad (7)$$

VI. Discussion

The analyses conducted in Section 5 shows the feasibility of using correlation analysis to assess relationships between emotion and stress, followed by derivation of regression models whenever a correlation is significant.

The percentage error of each prediction model is calculated using Equation 8.

$$Percentage\ error = \left|\frac{Actual\ value - Predicted\ value}{Actual\ value}\right| \times 100) \quad (8)$$

Academic eustress, calculated using equation (2) yielded an average percentage error of 14.26%, while the academic distress score that was calculated using equation (3) yielded an average percentage error of 18.40%.

Bosse's eustress subscale, calculated using equation (4) yielded an average percentage error of 22.62%, while Bosse's distress subscale that was calculated using equation (5) yielded an average percentage error of 24.82%.

ADES eustress subscale, calculated using equation (6) yielded an average percentage error of 12.36%, while ADES distress subscale that was calculated using equation (7) yielded an average percentage error of 15.91%.

IV. Conclusions

Results of the study show the feasibility of using emotion data based on valence and arousal, to predict eustress and distress scores. The Self-Assessment Manikin was shown to be an adequate tool as it was used to derive the participants' valence and arousal. Six equations that predict eustress and distress based on valence and arousal were determined. Error analysis was conducted to compare calculated results of stress with the actual scores from the questionnaires. The ADES questionnaire had the lowest error scores, in the prediction of both eustress and distress; making it the most suitable in determining positive and negative stress based on emotion.

Further work can be conducted in and expand the defined methodology. As the psychological findings in the study relate emotion to eustress and distress, future research can focus on the correlation between emotion from neurophysiological data and scores of eustress and distress from the above-mentioned questionnaires. It is also possible to explore increasing the number of samples available in the dataset as well as refine the quality of selected samples in terms of variables such as gender, age, nationality, etc.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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