# Stress Response and Personality Traits based on Salivary Amylase Changes in Personality Rating

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**Abstract**

The purpose of this experiment was to measure stress responses from changes in salivary amylase levels during the performance of a personality rating and examine their relevance to specific personality traits. The hypothesis of the experiment was 1) that amylase value would change before and after the act of personality self-rating and 2) that specific personality traits would change the level of amylase. The personality rating was divided into five conditions, and amylase level, which is a stress index, was measured before and after the rating. As a result of performing a hierarchical cluster analysis to examinethe changes in amylase level, the obtained clusters had three centers of gravity, and salivary amylase level, which was an index of the physiological stress response of the experimental participants, was divided into three characteristic clusters. As result of the GLM, each of the three clusters showed a relationship between certain stress response patterns and Extraversion. The personality factors that cause stress during personality rating were found to be related to Extroversion, Openness to experience, and Attitude score. The results of this experiment showed that stress responses differed depending on how individuals perceived tasks and performances that were not evaluated by others.

**Keywords:** Saliva amylase, Stress response, Personality traits, Personality self-rating, Big Five

## 1. Introduction

Certain performances and tasks make some changes in our bodies and minds. Most people will be very stressed by tasks and performances that have correct answers, such as exam questions. Then, does a stress response occur in a task or performance that does not have the correct answer? This experiment examines changes in salivary amylase levels as a degree of stress during personality self-rating and examines specific personality traits that affect amylase levels. Any performance, including completing work or study tasks, increases the physiological or mental arousal known as stress. However, when the level of stress becomes too high, performance decreases. When fatigue peaks, the neural mechanisms of learning and memory do not work smoothly, and under high stress conditions, the brain secretes high levels of hormones like cortisol and noradrenaline. Cortisol in blood is known to be very highly correlated with cortisol in saliva, and salivary alpha-amylase is one of the major enzymes in the oral cavity (Petrakova, L., et al, 2015).

Our first hypothesis is that salivary amylase levels change before and after self-rating personality. Because the brain secretes high levels of cortisol under stress, salivary biomarkers were used as an index to measure the acute stress reaction at the time of personality rating in this experiment. A biomarker is an index that digitizes biological information based on the concentration of chemical substances contained in biological samples such as blood, saliva, and urine (Nida & Nate,2020). Some biomarkers that are directly or indirectly involved in the sympathetic nervous system and the endocrine system show remarkable changes in concentration depending on the strength of the stressor and are also called stress markers. The stress marker can also be analyzed in saliva, and this has the advantages of being non-invasive and being excellent in terms of timeliness and simplicity (Nakano& Yamaguchi, 2011). Salivary amylase levels were measured in this study by placing the tip of the sheet of the saliva collection chip under the tongue and collecting saliva for approximately thirty seconds.

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It is generally assumed that cortisol rises in stressful situations, such as when the subject is under evaluation by others or in an uncontrollable situation. Most people will normally rate their personality test uneventfully. However, there may be physical or psychological changes that may not be easily observed. Human performance shows substantial endogenous variability over time (Perquin& Bompas,2020). This substantial endogenous variability may be the temporal pace, stress, and brain activity within the individual in performance.

The second hypothesis is that specific personality traits would change the level of amylase. This experiment examines the relationship between physiological indicators and personality inventories. By using the inventories, we can examine not only the tendency of specific personality traits, but also the social desirability. Measuring stress responses using physiological responses such as salivary amylase may reveal personality traits that facilitate intentional response and emphasize social desirability. Since Eysenck's research (1967), experimental personality studies have pointed out the relationship between physiological and behavioral indicators and personality traits. In a study on the relationship between personality traits and stress response, there is a study that examined Salivary Alpha-Amylase and Behavior Reaction in Acute Stress and the Impact of Tridimensionality Personality. Salivary α-amylase offers a biomarker for stress and sympathetic nervous system activity; in a study involving acute stress and tridimensionality personality, it was observed that salivary α-amylase levels during the post-stress testing period and the recovery period of the high reward-dependence group, who were high in temperament, were markedly higher than in the low-reward-dependence group, those who were low in temperament, concurrent with high levels for the high novelty-seeking group, who were also high on temperament, compared with the low novelty-seeking group (Wan& Shen,2018).This study shows that individual differences in personality traits are associated with different patterns of stress response.Furthermore, in the BIG5 research, agreeableness can span social behavior and positive affect that both determine positive mental health (Canli, 2009). In study examining cerebral blood flow in the frontal cortex area during personality self-rating tasks, it showed cerebral blood flow varies based on personality rating condition and cerebral blood flow varies based on the personality traits (Sato&Matsuda,2019). In addition to examining the basic personality traits of BIG5, this study also looked at factors conceptually related to Fictional and Attitude. In the Japanese version of the Big 5-J scale, these MMPI's two measurements may be related to shyness scores as follows: items on the Attitude (Att) scale measure the tendency for individuals to express a willingness to present a favorable public impression in employment settings and recruitment examinations. People who do not want to deviate from regular answer patterns will have high Fictional scores; individuals who place importance on creating a favorable public impression will have high Attitude scale scores (Murakami & Murakami, 1997). Thus, the use of physiological indicators may define the truth of the intentional answer to some extent.

In the verification of the first hypothesis, it is possible to obtain objective personality data in a way other than self-rating by measuring the personality rating according to a physiological index. By examining the second hypothesis, it is possible to verify that these objective data are associated with a specific personality trait. Based on the two hypotheses of this experiment, it may be possible to examine personality information based on objective data obtained from physiological indicators for the performance of personality ratings.

## 2. Method

### 2.1 Participants

The participants were 22 Japanese graduate students (13 males, 9 females) aged 19–22 years (One female was excluded due to incomplete data).

### 2.2 Experiment period
The experimental period extended from May 2014 to December 2014.

### 2.3 Ethical Considerations
The researcher fully explained the experimental content to the participants and participants gave written consent before participating in the experiment. These procedures were reviewed by the ethics committee of each author's affiliated institution and were deemed to be appropriate.

### 2.4 Informed Consent
The experimenter fully explained the content of the experiment to the participants and answered their questions. We obtained written consent from the participants before the experiment.

### 2.5 Equipment

The degree of stress during the self-rating task was measured using a salivary amylase monitor (NIPRO; 27B1X00045000073, Osaka, Japan). Salivary amylase levels were measured by placing the tip of the sheet of the saliva collection chip under the tongue and collecting saliva for approximately thirty seconds.

The standard adult value of salivary amylase level was 0–30 KU/L' less stress', 31–45 KU/L was 'slightly stressed', 46–60 KU/L was 'stressed', and 61 KU/L or more was 'quite stressed'.To make sure participant pressed the Yes or No key, we measured reaction time for E-prime 2.0 on the laptop computer (Dell-Vostro 3360) during the three PC sessions.

## 2.6 Experiment Stimulus and Personality inventory

Participants rated themselves on personality inventories using the Japanese version of The Big Five-J scale (Murakami & Murakami, 2008), the BIS/BAS Scale for Japanese version (J-BIS/BAS; Takahashi et al., 2007), the Self-Control Scale (Rotter, 1966) and Lie scale. For personality self-rating on the computer, we selected four terms that would be familiar to university students for each of the five personality traits (Table 1), referring to the manual of the Big Five Inventory for Japanese. These twenty trait terms were set as visual stimuli in computer image files for display on a computer screen. Auditory stimuli of the twenty terms were then recorded on a computer using a male voice (700ms duration).

**Table 1. Stimulus terms of personality trait terms used in experiment**

| Traits Factors | | Stimuli Terms | | |
|---|---|---|---|---|
| | Extroversion | active | sociable | passive | restrained |
| | Agreeableness | kindly | affable | headstrong | tightwad |
| **Big Five** | Conscientiousness | capable | conscientious | sloppy | unreliable |
| | Neuroticism | easygoing | sedate | irascibleness | worrier |
| | Openness to experience | intelligent | clever | conservative | naivete |

## 2.7 Experiment Procedure

The experiment time was approximately 60-70 minutes for each person. The participants' personality rating methods was divided the self-rating into a questionnaire and PC conditions, and before and after that, we measured the amylase level as a stress criterion. As showed in Table2, In the Q1 condition, the participant completed the Big Five using pen and paper. After completing the inventory, the participant's salivary amylase was measured for 30 seconds to determine the degree of stress (Amylase1). As a method of measuring salivary amylase, participants put a measuring tip under the tongue and waited for thirty seconds.

After that, when it was put on a measuring machine, the amylase level was presented in thirty seconds. Participant performed the PC conditions; P1, P2, P3. In the session of the PC conditions, we measured the RT during personality self-rating to make sure that the participants pressed the Yes/No reaction key each time. In the simple-response session(P1), we measured individual differences in the RT during stimulation and reaction. After displaying a gaze point (+) on the computer screen for 500ms, we displayed a black dot for 700ms. Upon seeing the black dot, the participant heard an audio stimulus via headphones. If the audio and visual stimuli matched, the participant pressed "Yes." If the terms did not match, the participant pressed "No". After the participant pressed a key, that trial was finished (masking). each participant randomly performed 200 trials in the simple-response session (20 terms * each 10 times). In the self-rating by-term session(P2), participants rated their own personality using only personality trait terms. After displaying a gaze point (+) for 500ms and a black dot for 500ms, we randomly displayed a trait term (Table1) on the next screen. The experimenter instructed the participants to press 'Yes' if they thought the personality trait term presented on the PC screen would match their personality, and to press 'No' if they thought the personality trait term did not match them. The trial was then finished (masking). Participants randomly performed 100 trials (20 terms*each 5 times). In the self-rating by-sentences session(P3), we created a rating by adding "Are you…" at the beginning of the sentences used in the previous term session. After silently displaying a gaze point (+) for 500ms and a black dot for 500ms, we randomly displayed an "Are you…" sentence using a trait term on the next screen. Each participant randomly performed 60 trials (20 terms*3 times). In the Q2 condition, the participant completed the BIS/BAS Scale, Self-Control Scale and Lie Scale. After

another thirty seconds of saliva amylase measurement (Amylase2), the researcher removed the participant's experimental equipment, and the experiment was completed.

**Table 2 Experimental Procedures and Measurement conditions of amylase and self-rating.**

| Analysis Conditions | Amylase conditions and personality self-rating conditions |
|---|---|
| **Questioner 1 (Q1)** | A condition for completing for Big Five with pen and paper. |
| **Amylase 1** | Amylase measurement before PC session. |
| **PC-conditions** | **P1** A session to match the visual and auditory stimuli of personality terms. |
| | **P2** A session to self-rating only with personality trait term. |
| | **P3** A session to self-rating sentence by adding "Are you-" to personality term. |
| **Questioner 2 (Q2)** | A condition for completing for BIS/BAS, Self-Control and Lie Scale inventory with pen and paper |
| **Amylase 2** | Amylase measurement after all sessions. |

**2.8 Data Analysis**

We performed non-hierarchical cluster analysis by the k-means method with the values of salivary amylase 1 and amylase 2. The number of clusters was determined on the basis of minimizing the sum of squares of error in clusters with a smaller number of classes. Then, we calculated the standard score for the Big Five for analysis using BIS/BAS, Self-Control Scale and Lie Scale. Moreover, the BIS/BAS, Self-Control Scale and Lie Scale (MMPI) used raw scale scores for analysis. To perform analysis of variance (*ANOVA*) in these clusters and these questionnaires, we used the General Linear Model (GLM) from the Statistical Analysis System (SAS) statistics software package (Takeuchi et al., 1999).

**3. Results**

We calculated the Mean amylase levels before (Amylase 1) and after (Amylase 2) self-rating (Fig.1). As a result, it was found that the amylase level was different by 20 ku/l or more before and after self-rating and that the amylase level changed depending on the performance of the personality rating.

**Fig1. Means of salivary amylaseby before and after personality self-rating.**
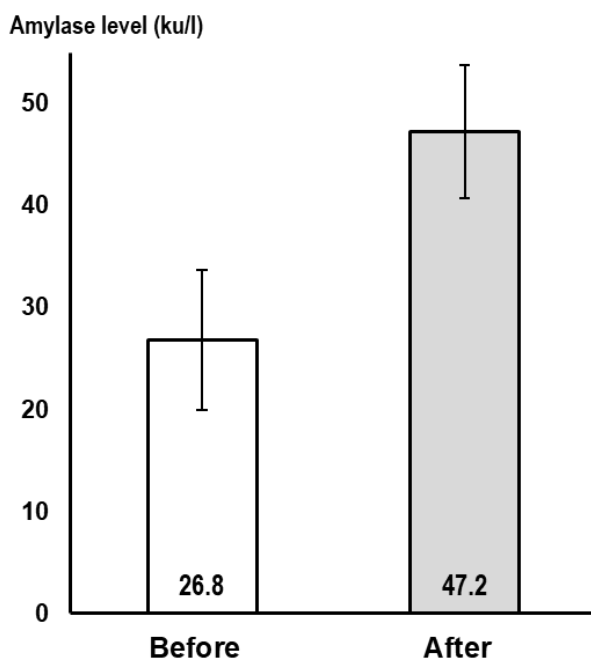


*Note: N=21 (13 Males, 8 Females).*Whisker line showed 95% critical limits of mean. The Lead lines indicated the results of paired t-test.

**3.1 Cluster analysis of amylase levels and Analysis of variance in personality inventories**

To examine the tendency of change in amylase level in personality rating, we performed non-hierarchical cluster analysis by the k-means method with the values of Amylase 1 and Amylase 2(Fig.2).

The number of clusters was determined on the basis of minimizing the sum of squares of error in clusters with a smaller number of classes. The cluster obtained had three centers of gravity, salivary amylase (ku/l), which is an index of the physiological stress response of the experimental participants, showed three pronounced changes. Fig 3 showed changes in amylase levels before and after personality rating in the three clusters, each of which had a unique amylase change.

**Fig2. Means of salivary Amylase before and after rating by three clusters mapping**
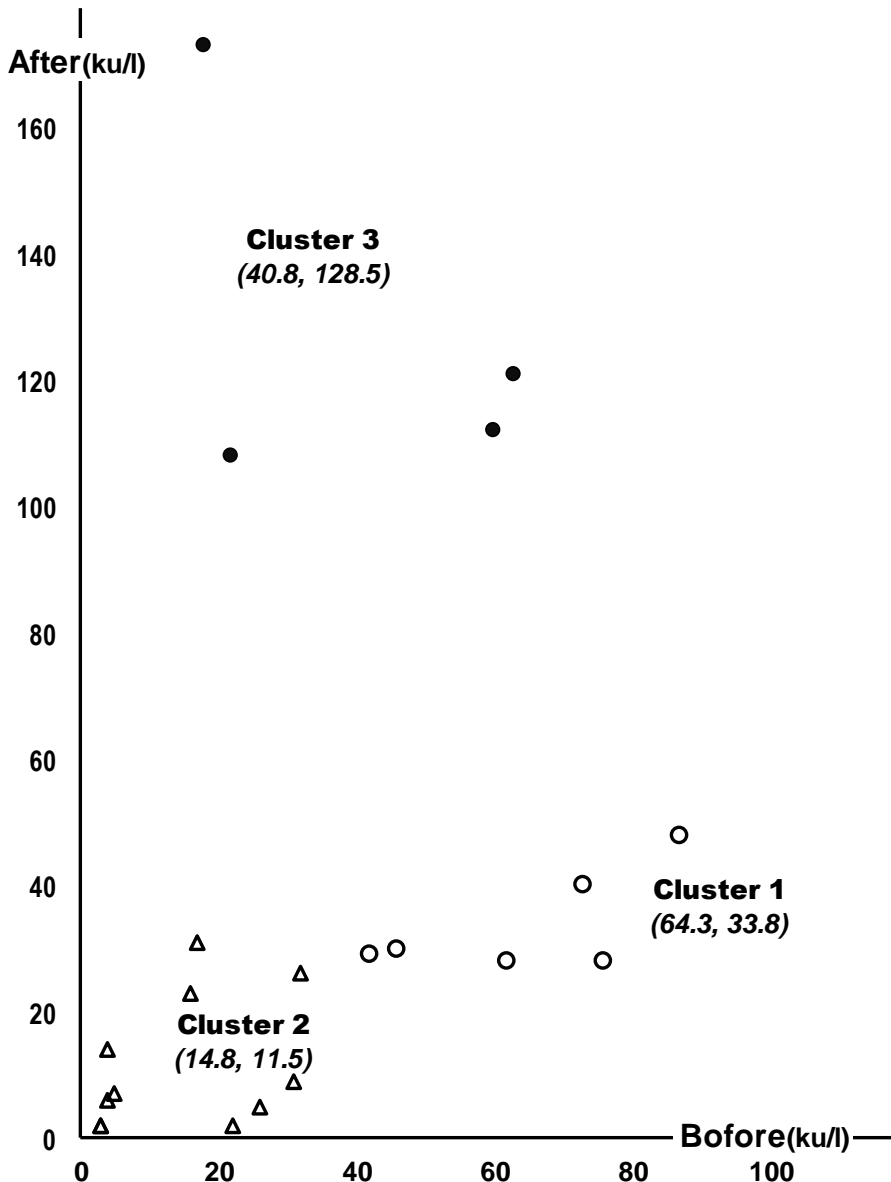


*Note: N=21 (13 Males, 8 Females).* The horizontal axis was amylase before session. The vertical axis was amylase after session. The numeric value below the cluster number was the coordinates of the cluster centroid. The parentheses in the Figure showed the Means of each cluster.

**Table 3.  k-means cluster by Amylase level (ku/l)**

| Cluser Number | n | Amylase Before session | | Amylase After session | | RMS SD | Distance |
|---|---|---|---|---|---|---|---|
| | | mean | SD | mean | SD | | |
| 1 | 6 | 64.3 | 17.7 | 33.8 | 8.3 | 13.8 | 54.3 |
| 2 | 11 | 14.8 | 11.6 | 11.5 | 10.5 | 11.1 | 54.3 |
| 3 | 4 | 40.8 | 24.0 | 128.5 | 30.2 | 27.3 | 97.6 |

Note: RMS SD was root mean squarestandard deviations. Distance was distance between each clustercentroids

Then, we calculated the standard score for each personality inventories.To examine the factor by which the cluster was divided by amylase, we performed *ANOVA* in these clusters and these inventories, and used the General Linear Model (GLM). As result of BIG5 (Fig.3), *ANOVA* results for these three clusters and the Big Five questionnaire standard scores showed a significant difference in Extraversion ($F(2, 20) = 6.41, p < .01$).

As seen in BIG5 (Fig.3), *ANOVA* results for these three clusters and the Big Five inventory standard scores showed a significant difference in Extraversion ($F(2, 20) = 6.41, p < .01$). There was a difference between clusters 1 and 3, clusters 2 and 3 in the t-test. Significant differences were also found in Openness to experience ($F(2, 20) = 2. 65, p < .10$). There was a difference between clusters 1 and 3. Significant differences were also found in Attitude scale ($F(2, 20) = 2. 65, p < .10$). There was a difference between clusters 2 and 3. As a result of the BIS/BAS, significant differences were also found in the BAS Drive ($F(2, 20) = 2.47, p < .10$). There was a difference between clusters 1 and 3. There was no significant difference between the Self-Control Scale ($F(2, 20) = 0.00, n.s.$) and the Lie Scale ($F(2, 20) = 0.31, n.s.$).

**Fig3. Means of there Clusters according to Amylase value and BIG5 inventory**
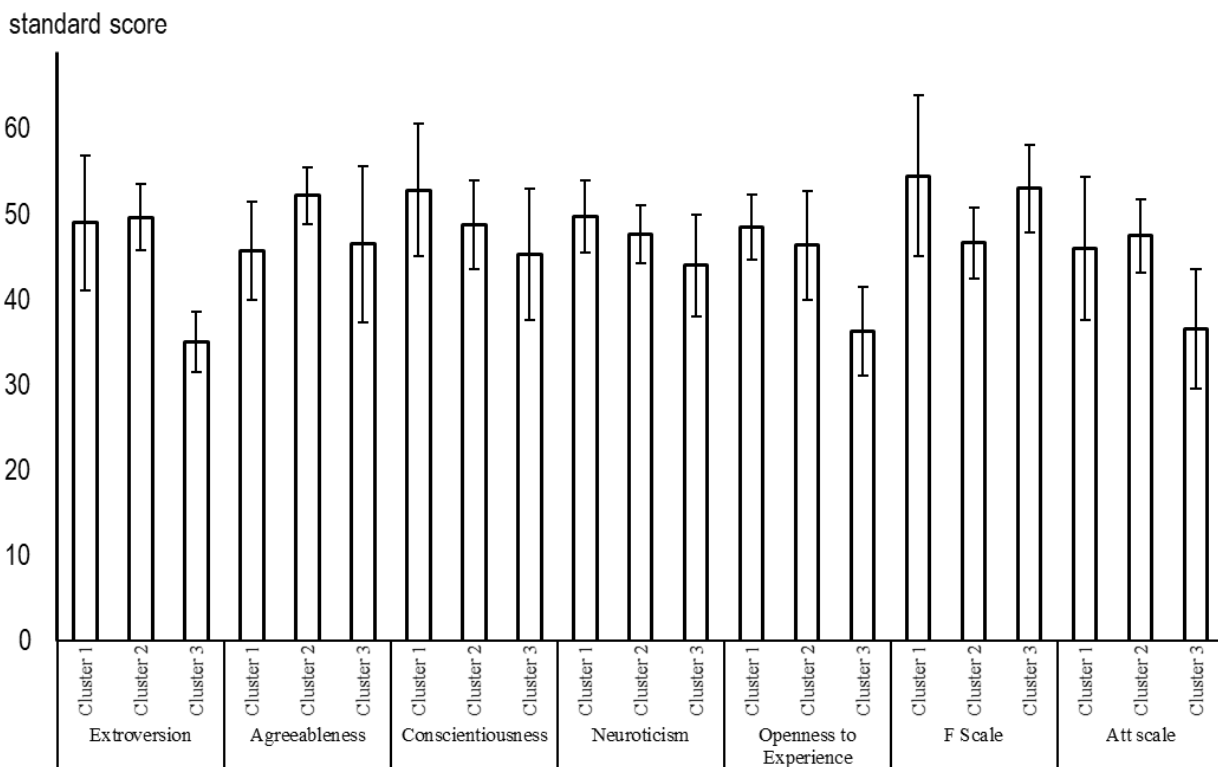


*Note: N=21 (13 Males, 8 Females).*Whisker line showed 95% critical limits of mean. The Lead lines indicated the results of paired t-test.

The first cluster included six participants (male=5, female=1). This cluster included those with a pre-rating amylase mean of 64.33 ku/l and a post-rating of 33.83 ku/l, which was quite stressful but decreased post-rating, indicating that the personality rating was not as stressful. Although people in this cluster were tense before the performance, it was found that they did not find self-rating to be stressful and tended to gradually become accustomed to the performance. In BIG5, the Means of Neuroticism, Conscientiousness and Openness to experience were higher than other clusters, and BAS-drive was slightly higher than other clusters at 13.16ku/l. This cluster suggested that they are the type of people who were nervous at first and do not move steadily in daily life, but their stress decreases as they get used to the situation and tasks.

The second cluster included eleven participants (male=8, female=3), the mean pre-rating amylase was 14.82 ku/l, and the mean post-rating amylase was 11.54 ku/l. The second cluster showed very low amylase levels before and after self-rating and little change. It was found that people in this cluster experienced little stress in their personality rating performance. In BIG5, the means for Agreeableness were slightly higher than those for other clusters.

The third cluster included four participants (male=4 female=0), all of them men. The mean pre-rating was 40.75 ku/l, and the mean post-rating increased to 128.5 ku/l. This cluster showed extremely high amylase levels of 173.0 ku/l after self-rating. Although it was initially thought that one outlier had inflated the value, the other three participants also had post-ratings greater than 100 ku/l. In BIG5, this cluster had a significant difference in extraversion in the t-test. In addition, there was a slight difference in Openness to experience. Although there was no significant difference in the t-test, the Conscientiousness and Neuroticism scores were also relatively low. Compared to clusters 1 and 2, these people were extremely introverted and had a low Openness, which suggested that they were very stressed during performances such as personality rating and repeating the rating many times.

### 3.2 Correlation coefficient between salivary amylase levels and personality inventories

To examine the relationship between the Amylase levels and personality inventories, we performed correlation coefficient (Table4). As a result, the correlation coefficient between Amylase 2 and the Extroversion score was $r = -.602$, and between Amylase 2 and the Attitude score was $r = -.420$. This showed that those with highly extroverted scores and those with a high attitudinal scale had decreased amylase levels after the experiment. No correlation was found between scores from BIS ($r=-.363$), BAS ($r=.076$), the Self-Control Scale ($r=-.006$), the Lie Scale ($r=.016$) and Amylase 1. No correlation was found between scores from BIS($r=-.145$), BAS($r=.168$), the Self-Control Scale($r=-.099$), the Lie Scale($r=.045$) and Amylase 2.

**Table4. Correlations between Amylase level and Big Five questioner scales**

| | Big Five scale | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fictional scale | Attitude scale | Extraversion | Agreeableness | Conscientiousness | Neuroticism | Openness to Experience |
| **Amylase1** | .204 | -.018 | -.082 | -.255 | .204 | .192 | .144 |
| **Amylase2** | .249 | **-.420** * | **-.602** * | -.283 | -.177 | -.296 | -.329 |

| | BIS/BAS scale | | | | | | |
|---|---|---|---|---|---|---|---|
| | BIS | BAS | BAS-D | BAS-RR | BAS-FS | Self-control scale | Lie Scale |
| **Amylase1** | -.363 | .076 | .137 | .020 | .012 | -.006 | .016 |
| **Amylase2** | .145 | -.168 | -.240 | -.155 | .056 | -.099 | .045 |

*Note. N=21 (13 Males, 8 Females) *p<.05*

## 4. Discussion

This experiment examined changes in salivary amylase levels as a degree of stress during personality self-rating and examined specific personality traits that affect amylase levels. We compared the Mean before and after self-rating, and the first hypothesis showed that the amylase levels differed by more than 20 ku / l before and after the personality rating, as shown in Fig.1.

The second hypothesis was examined that specific personality traits would change the level of amylase. As shown in Fig.2 and 3, through the result of non-hierarchical cluster analysis, each of the three clusters had unique amylase level characteristics. The first cluster feels nervous at first, but getting used to the work or performance shouldn't be too much of a problem in daily life. Most people are probably in the second cluster, so even performances that don't have the right answer probably don't feel stressful because of the Openness to experience. The third cluster was very stressed during the repeated self-rating performances. This cluster was extremely introverted compared to clusters 1 and 2, this personality factor was a significant difference in Extroversion and Openness to experience. This result suggested that they were very stressed during the performance and by repeating the self-rating many times without finding the significance of the task.This experiment'sresult was suggested that stress responses occurred in people with high Extraversion, Openness to experience, and Attitude scale scores, even if there is no correct answer in tasks and performance. We often have to do a lot of work and performance in our daily lives, even if we don't have the right answer or evaluation, for example housework, work, and workouts.This experiment suggested that people with certain personality traits might be stressed in simple and problem-free daily life tasks; some people are nervous at first but feel less stressed by getting used to work, some are almost stress-free, and some are very introverted and have multiple stresses.

Then, the result of the correlation coefficient showed that people with higher extroversion and attitude scale scores had lower levels of stress when personality rating continued multiple times. In pre-experimental amylase 1, no stress was felt in all personality traits. However, since the extraversion and Attitude scale had a negative correlation in amylase2, it was possible that there was some stress during the experiment because the stress value decreased after the experiment. The stress common to these two scores might be social desirability. Those with high extroversion might have considered social desirability when rating personality trait terms. As individuals who place importance on creating a favourable public impression will have high Attitude scale scores (Murakami & Murakami, 1997), people with high Attitude scale might have responded to the task of personality rating.

The results of this experiment on stress during personality rating showed that stress responses differed depending on how individuals perceived tasks and performances that were not evaluated by others.The personality factors that cause stress during personality rating were found to be related to Extroversion, Openness to experience, and Attitude score. It was suggested that Extroversion and Attitude score included social desirability due to fear that they might actually be evaluated by others. In addition, it was suggested that people with high Openness to experience score could do not feel stress in tasks and performances because they could find fun on their own even if there were no others.The significance of the measurement of personality by the physiological index of this experiment was that not only the qualitative results, as in the conventional personality test, but also the personality traits that change depending on the situation were obtained from the objective data.

## 5. Conclusion

This experiment measured stress responses from changes in salivary amylase levels during the performance of a personality rating and examined their relevance to specific personality traits. Non-hierarchical cluster analysis with the value of salivary amylase indicated by k-means was obtained three clusters. As a result of the GLM on three clusters and inventories scores, each of the three clusters showed personality traits and stress response. Results of correlation coefficient between amylase level and inventories changed after the act of personality self-rating, and that Significantly changed the amylase level in Extraversion. The personality factors that cause stress during personality rating were found to be related to Extroversion, Openness to experience, and Attitude score. The results of this experiment showed that stress responses differed depending on how individuals perceived tasks and performances that were not evaluated by others.

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