Influence of unpleasant feeling toward task performance on the stress response of healthy young male subjects at two sorts of mental tasks was investigated.

A simple calculation task assigned to 10 subjects for 8 hr a day using a new signal indicator was accompanied by increase in serum protein level and decrease in pulse rate, systolic blood pressure, pulse pressure and serum A/G in the morning, but not in the afternoon. Unpleasantness rate during this task performance had converse correlation with the serum level of proteins in the morning but not in the afternoon.

"Addition-subtraction task" of two figures assigned to 20 subjects for 1 hr at the task density of 80% of individual maximum performance using a signal indicator evidently induced the stress response such as increases in pulse rate, diastolic blood pressure and the serum level of proteins, and decrease in the serum water content. In this case, there was no correlation between the physiological stress indices and unpleasantness rate in task performance. Moreover, neither the stress response nor the unpleasant feeling had relation to physical fitness of the subjects.

It was deduced that the stress response during mental tasks was hardly influenced by unpleasant feeling toward task performance or by physical fitness of subjects.

In the previous studies, some positive changes in the physiological indices were found out in the subjects during the arithmetical calculation tasks. Pattern of physiological changes composed of elevation of diastolic blood pressure, decrease in the serum water content and increase in the serum level of proteins was elucidated as the stress response resulting from mental tasks. Moreover, it was shown in the previous papers that the stress response was attributable to the task performance itself and the density of task was a principal factor inducing the stress response. These results suggested that the stress response reflected an intellectual activity of the subjects. It is, however, unknown whether the stress response was influenced or not by any psychological factors in task performance. Under the previous experimental conditions, psychological factors which might affect the stress response commonly were assumed to be feelings toward task performance of the subjects. In order to see effects of feelings toward task per-
performance on the stress response, it is necessary to measure feelings which are composed of various types of expressions. Since the hypothesis of Schlosberg, some useful hypotheses on the basic dimensions constituting human feelings have been proposed. At present, a hypothesis that the greater parts of human feelings can be described with one dimension of “pleasant—unpleasant” is accepted in the field of behavioral psychology. If this hypothesis applies, feelings could be measured with greatness of the basic feeling.

On the other hand, poorer physical fitness may be one of the factors which affect the stress response. Therefore, it seems to be an interesting subject to examine whether there is any correlation between the stress response during mental tasks and physical fitness of subjects.

The present paper deals with the influences of unpleasant feeling toward task performance on the stress response of subjects at a simple calculation task and an “addition-subtraction task” of two figures. Furthermore it refers to the correlation between physical fitness and the stress response to an “addition-subtraction task” of two figures.

**SUBJECTS AND METHODS**

The subjects of the experiments were 24 healthy young men, aged 19-32 years. They were the members of this institute and had graduated from high school or college. They were not always regular subjects in the present experiments. A caution was given to them previously that they should not take any medicine or an excess of irritative drinking (alcoholics, coffee, etc.) on the day and the previous day of experiment.

**A simple calculation task**

A signal indicator for assigning a simple calculation task to subjects was newly devised. It was designed with the intention that task performance might induce an unpleasant feeling owing to a tedious sensation in subjects. The part of numerical indicator resembles in appearance to the indicator devised previously. A noise-counting method and a control system that were developed in the previous study were applied to this signal indicator. Each of 5 subjects who sat in a row facing to the numerical indicator was required to push a press-button in his hand only when the sum of two figures on the indicator is 10 or 0. The number of times that the subjects ought to respond amounts to one tenth of the displays in the final analysis, since each of the two indicator tubes presents numbers from 0 to 9 randomly. When a subject pushes his button correctly, his response is included into a counter belonging to the experimenter. For an incorrect response, one of 5 neon lamps fixed in front of the numerical indicator lights. On the other hand, display time of figures is an important factor that modifies the quality of the task. If display time is too long, the task may lose its essential meaning. If too short, the task may possess the same quality of paced task as the previous ones. In
the present experiment, therefore, display time was set to 2 sec in order to make
the task tedious. Furthermore duration of the task has a great influence upon
the induction of feelings in the subjects. When feelings are concerned with such
a mild negative sensation as tediousness, many hours may be necessary to arouse
a certain stable feeling in the subjects. For experiment's sake, a simple calcula-
tion task was assigned to 10 subjects for 8 hr according to the following schedule.

8:10 am—12:00 a simple calculation task (with a 5 min intermission from
9:55 to 10:00)
0:00—0:45 pm lunch time
0:45—4:55 a simple calculation task (with a 5 min intermission from
2:55 to 3:00)

At the end of the morning and afternoon tasks, counting of pulse rate, measure-
ment of blood pressure and sampling of the venous blood were carried out in a
short time. Then unpleasant feeling toward task performance (will be described
later) of the subjects was measured. Pulse rate was obtained by a 30 sec count-
ing of pulse by touch. Blood pressure was estimated by using an automatic
sphygmomanometer model USM-108 (Ueda MFG. Co.). The venous blood was
drawn from the antecubital vein of the subjects using plastic disposable syringes.
Specific gravity of serum was measured by standard cupric sulfate solutions.
Serum water content was assessed by a gravimetry of a glass capillary tube filled
with serum. The serum levels of proteins and albumin were measured by an
A/G-Test (Wako Pure Chemical Co.). Electrophoresis of serum proteins was
practiced by the method described previously.

In such a case as the physiological indices are measured in the subjects after
a long duration of the task, two procedures may be applied for obtaining the
control values of the indices. One is to get the control values prior to the start
of the task and the other is to obtain them on some day else at the same hour
as that of the task day. The former was not applied because it was impossible
to take a 30 min resting time early in the morning and to take no account of the
diurnal variation in the indices. On application of the latter, a preliminary experi-
ment on the daily variation for the physiological indices will be necessary. If the
daily changes in the indices are so large, some correction for subsequent results
must be made.

A blank test was carried out over two successive days in 10 subjects who
were at everyday laboratory work. They were told to go to the examination
room at about 11:30 am and 4:30 pm by stopping their own work, and to take
a 30 min chair rest. Then 6 physiological indices of the subjects were measured.
As described in the results, the blank test hardly indicated any significant daily
changes in the physiological indices. Being based on the result of the blank test,
the control values of the physiological indices were obtained after a 30 min chair
rest from the same subjects at about 5:00 pm of the day before experimental day.
STRESS RESPONSE DURING MENTAL TASK

"Addition-subtraction task" of two figures

A few days before experimental day, the maximum performance which means the maximum amount of task capable of being performed correctly within a limited time was individually estimated by imposing "addition-subtraction task" of two figures to 20 subjects for 10 min using a signal indicator illustrated in the previous paper. A notice was given to the subjects that they should not take any foods and drinks for at least 2 hr prior to entering the examination room. After 30 min chair rest, "addition-subtraction task" of two figures was assigned to the subjects for 1 hr. The density of task was represented with percentage of the maximum performance of each subject in the same manner as described in the previous paper. In the present experiment it was 80%. Measurement of the physiological indices was carried out at the end of the chair rest and of the task. Determination of specific gravity of the whole blood was added to the 6 physiological indices measured in the simple calculation task. After the task, unpleasant feeling toward task performance and physical fitness of the subjects were estimated.

Unpleasant feeling toward task performance

As described in the introduction, "pleasant — unpleasant" has been thought to be the basic human feeling. If both the simple calculation task and "addition-subtraction task" induce the basic feeling in the subjects, unpleasantness may exert more serious effects on the stress response of the subjects than pleasantness. In the present experiments, therefore, the grade of unpleasant feeling toward task performance was estimated by self-rating of the subjects. After the task a sheet of paper, on which 6 phrases were arranged under a straight 15 cm line as illustrated in Fig. 1, was handed to the subjects. They were required to put a dot mark on the line in order to point out the degree of unpleasant feeling toward task performance. The adverbs in these phrases were selected from the data by Yoshikawa and Nishimaru who examined quantitative intensity of many adverbial phrases representing preferences for foods. Six phrases were placed in the positions corresponding to the mean hedonic scales of the adverbial phrases obtained by Yoshikawa and Nishimaru. The whole range of the unpleasantness scales can be expressed with these 6 phrases and their standard deviations. By setting "0—10" for the whole scale range, unpleasantness rate was estimated from a dot point marked on the line by the subjects.

Physical fitness of subjects

Although many measuring methods have been proposed to estimate the physical fitness of human subjects, any valid method has not yet been established. This may be due to the fact that the physical fitness concerns with the harmonized
many functions of the human being that are hard to be appreciated by a few means. Two methods applied in the present experiment are relatively popular and simple. One was Vervaeck's index which adopted the nutritive physical examination, the other was a step method by which the circulatory function is examined. Vervaeck's index can be obtained from the formula $100(W+Cg)/L$, by measuring stature (L cm), body weight (W kg) and girth of chest (Cg cm) of subjects. The step method was practiced in the manner of Harvard step test\textsuperscript{8}) using a step of 40 cm height. Physical fitness index (FI) was calculated according to the original method or its simplified method.

Fig. 1. A scale diagram for self-rating of unpleasantness. Subjects were required to point out the degree of unpleasantness by putting a dot mark on the line. The diagram was composed in reference to the data by Yoshikawa and Nishimaru. The mean hedonic intensity and the standard deviation of each phrase are equivalent to the following values when the whole scale was limited to the range of 0—100.

<table>
<thead>
<tr>
<th>Phrase</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>kai demo fukai demonai</td>
<td>0 ± 2.5</td>
</tr>
<tr>
<td>(neither pleasant nor unpleasant)</td>
<td></td>
</tr>
<tr>
<td>wazukani fukai</td>
<td>10.2±7.7</td>
</tr>
<tr>
<td>(slightly unpleasant)</td>
<td></td>
</tr>
<tr>
<td>sukoshi fukai</td>
<td>22.0±12.9</td>
</tr>
<tr>
<td>(somewhat unpleasant)</td>
<td></td>
</tr>
<tr>
<td>hikakuteki fukai</td>
<td>45.2±17.2</td>
</tr>
<tr>
<td>(comparatively unpleasant)</td>
<td></td>
</tr>
<tr>
<td>sótō fukai</td>
<td>72.5±18.9</td>
</tr>
<tr>
<td>(considerably unpleasant)</td>
<td></td>
</tr>
<tr>
<td>kiwamete fukai</td>
<td>92.0±13.5</td>
</tr>
<tr>
<td>(extremely unpleasant)</td>
<td></td>
</tr>
</tbody>
</table>

The above adverbs in English may not strictly correspond to the Japanese words.
RESULTS AND DISCUSSION

A simple calculation task

a) blank test. The results of a blank test carried out in 10 subjects were tabulated in Table 1. The values marked with a dagger were statistically different from the other values ($p < 0.05$). The physiological indices scarcely changed through four times of the measurement except a few indices. Systolic blood pressure and the serum level of albumin decreased in the morning of the second day. Diastolic blood pressure also decreased in the afternoon of the second day. The decrease in these indices was an opposite change to the stress response that had been observed in the subjects at the mental tasks. Consequently, no physiological indices exerted any positive variation concerned with the stress response. These results gave a suggestion that, when these physiological indices are measured in the morning or afternoon in a certain experiment on the stress response, the control values of these indices can be obtained at the same hour of the preceding or next day. In the present experiment on the simple calculation task, the control values of these physiological indices of the subjects were taken in the afternoon of the preceding day.

Table 1. Changes in physiological indices taken in the morning (11:30) and afternoon (4:30) over two consecutive days.
Values are means ± S.D. of 10 subjects. The values marked with a dagger are statistically different from the other values ($p < 0.05$).

<table>
<thead>
<tr>
<th>Physiological indices</th>
<th>The first day</th>
<th>The second day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Morning</td>
<td>Afternoon</td>
</tr>
<tr>
<td>Pulse rate (b/min)</td>
<td>60.4±8.2</td>
<td>57.8±6.3</td>
</tr>
<tr>
<td>Systolic pressure (mmHg)</td>
<td>108.3±9.9</td>
<td>107.6±9.7</td>
</tr>
<tr>
<td>Diastolic pressure (mmHg)</td>
<td>67.0±10.8</td>
<td>66.3±9.5</td>
</tr>
<tr>
<td>Pulse pressure (mmHg)</td>
<td>41.3±12.6</td>
<td>41.3±10.6</td>
</tr>
<tr>
<td>Specific gravity of blood</td>
<td>1.067±0.013</td>
<td>1.068±0.010</td>
</tr>
<tr>
<td>Serum water (% by w/w)</td>
<td>91.68±0.46</td>
<td>91.62±0.36</td>
</tr>
<tr>
<td>Serum proteins (g/dl)</td>
<td>6.95±0.49</td>
<td>7.10±0.49</td>
</tr>
<tr>
<td>Serum albumin (g/dl)</td>
<td>4.54±0.21</td>
<td>4.67±0.37</td>
</tr>
<tr>
<td>Serum globulin (g/dl)</td>
<td>2.42±0.41</td>
<td>2.43±0.35</td>
</tr>
<tr>
<td>A/G (weight)</td>
<td>1.93±0.30</td>
<td>1.97±0.33</td>
</tr>
<tr>
<td>Albumin (%)</td>
<td>69.0±4.5</td>
<td>68.2±4.5</td>
</tr>
<tr>
<td>$\alpha_1$-Globulin (%)</td>
<td>2.9±0.9</td>
<td>3.1±0.7</td>
</tr>
<tr>
<td>$\alpha_2$-Globulin (%)</td>
<td>6.7±1.2</td>
<td>6.8±1.1</td>
</tr>
<tr>
<td>$\beta$-Globulin (%)</td>
<td>8.2±1.3</td>
<td>8.4±1.2</td>
</tr>
<tr>
<td>$\gamma$-Globulin (%)</td>
<td>13.2±3.4</td>
<td>13.5±3.2</td>
</tr>
<tr>
<td>A/G (fraction)</td>
<td>2.29±0.48</td>
<td>2.20±0.41</td>
</tr>
</tbody>
</table>
b) simple calculation task. Mean values±S.D. of the physiological indices of 10 subjects at rest (C) and at the simple calculation task were shown in Fig. 2. Single and double asterisk were placed under the values which were significantly different from control values (C) or values taken in the morning (M). Pulse rate and pulse pressure were reduced in the morning, though systolic and diastolic blood pressure decreased in the same way as the blank test. Specific gravity of the serum gained both in the morning and afternoon. The serum levels of proteins and globulin increased in the morning, with a decline in A/G. Any appreciable change was not observed in the serum water content and fractional percentage of serum proteins.

Fig. 2. Changes in physiological indices and unpleasantness rate measured in the morning (M) and afternoon (A) at the end of simple mental task.

Control values (C) were taken in the afternoon (5:00) of the preceding day. Lines represent means±S.D. of 10 subjects. The values changed significantly versus control values (C) or values taken in the morning (M) are marked with asterisks (*p<0.05, **p<0.01).
In spite of the reduction in pulse rate and systolic blood pressure in the morning, the increase in the serum protein level and the decrease in pulse pressure were observed. This may suggest that the task in the morning was somewhat stressful to the subjects. However, the stress response was not induced in the afternoon. Tension that could affect the stress response of the subjects might relax in the afternoon. Moreover, it is noticed that the error in task performance was very little in the morning and afternoon.

The simple calculation task induced a fairly unpleasant feeling in the subjects both in the morning and afternoon. There was no statistic difference between the unpleasantness rates reported by the subjects in the morning and in the afternoon, though differences were observed between the two rates of some individual subjects. The unpleasantness rate had a statistically significant correlation (correlation coefficient: $-0.68$, $p < 0.05$) only with the serum level of proteins in the morning, but not in the afternoon (correlation coefficient: $-0.30$, $p > 0.05$). The negative coefficient means that unpleasantness rate inversely correlates with the rise in the serum protein level. Thus it may be inferred that in the morning unpleasant feeling tended to lessen the stress response during the mental task or undeveloped stress response induced unpleasant feeling.

"Addition-subtraction task" of two figures

"Addition-subtraction task" of two figures was adopted as one of relatively complex mental tasks against the previous simple calculation task. The mean amounts ($\pm$ S.D.) of the task assigned to and performed correctly by the subjects were 562.7 ($\pm$ 95.8) and 526.3 ($\pm$ 93.9) in 1 hr respectively. The results of the physiological measurement carried out in 20 subjects before and after the task were shown in Table 2. Significant differences between the two values were indicated with daggers. The task was not accompanied by any change in fractional percentage of proteins assessed by an electrophoresis of the serum. The physiological indices which showed significant changes were those confirmed already as the useful stress indices for mental tasks. From these results it is known that "addition-subtraction task" of two figures was certainly stressful for the subjects.

Transvascular shift of serum constituents under different conditions has commonly been represented merely by differences in serum concentrations of each constituent. However, the transvascular shift can be evaluated only on the basis of concomitant changes in serum volume. If total content of a serum constituent remains unchanged in the vascular bed under different conditions, the per cent change in concentration of the serum constituent should match with per cent change in serum volume. On the other hand, the per cent change in serum volume can enough be substituted by net change of serum water per deciliter of serum, since the serum water content counts normally for about 97.6% (v/v) of serum volume. The net change of serum water per deciliter of serum under different conditions can be calculated using the following equation,
where $W$ (\%) : net change of serum water per deciliter of serum i.e. per cent change in serum volume, $SW$ (\% by w/w): serum water content, $SG$ : specific gravity of serum, $BW$ (g): water combined with proteins. The amount of water combined with proteins is estimated to be 11.8\% of proteins.\(^{10,11}\) Using the above equation, the net change of serum water per deciliter of serum calculated from Table 2 was $-2.64\%$. This exactly coincides with the per cent change in the serum protein concentration ($+2.63\%$). Therefore it is understood that the rise in the serum protein level during the mental task was attributable to the decline in the serum water content. Recently dynamic transvascular shift of serum proteins has been noticed even under physical stresses.\(^{9,12,13}\) And some investigators\(^{9,14}\) who measured plasma volume and plasma protein concentration during exercise found larger changes in plasma volume than the change in serum water content during the present mental task. Under these conditions, it may be a reasonable assumption that intravascular fluids shift primarily out of the vascular bed in consequence of the elevation in inner pressure of the peripheral capillary blood vessels,\(^{15,16}\) then protein influx from extravascular protein pool into the blood stream takes place in order to compensate the hypovolemia. During the present mental task, it is presumed that fluid loss was not so large as to induce protein influx.
STRESS RESPONSE DURING MENTAL TASK (5)

The “addition-subtraction task” did not arouse so intense unpleasant feeling toward task performance as that induced by the simple calculation task. The mean unpleasantness rate was 3.1 (±1.4 S.D.) in 20 subjects. There was only one subject who gave an answer “kai demo fukai demonai (neither pleasant nor unpleasant)”. The unpleasant feeling toward task performance appears not to be largely involved in the difficulty or the complexity of task in question.

Vervaeck’s index of the subjects was 86.4 (±5.7 S.D.) on the average. The mean fitness index (FI) of the subjects estimated by the step method was 80.9 (±16.2 S.D.). The 20 subjects were able to be distributed among 3 classes of the physical fitness according to the standard settled in the original step method; 8 middle 7 (lower 4, higher 3), good 7, and superior 6. Nobody was counted into the inferior class. The correlation between these two physical fitness indices was not significant statistically, though both indices reflected the physical fitness of the subjects. This may be due to the fact that Vervaeck’s index indicates the nutritive physical condition, while FI the circulatory function of the subjects. Moreover there was no significant relation between the values of physical fitness, task performance and unpleasant feeling. This may suggest that physical fitness of the subjects would have no connection with task performance and unpleasant feeling toward task performance. Furthermore relation between the above three parameters and the physiological indices could not reveal any statistically significant correlations between them. This lack of correlation may indicate that the stress response would not be influenced by physical fitness and unpleasant feeling toward task performance.

On the other hand, when the subjects were divided into two groups based on the grade of Vervaeck’s index, the change in the scrum protein level was statistically larger in the upper group (13 subjects) than the lower group (7 subjects). When the subjects were divided into two groups based on the standard of FI, the decline in the serum water content was also larger in the upper group (13 subjects) than the lower group (7 subjects). The classification as above based on the unpleasantness rate was, however, unable to bring about any remarkable findings. These results may suggest that the subjects who are better in physical fitness generally hold higher metabolic activity and respond readily to stressors.

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REFERENCES

T. KAKIZAKI