The effects of resilience on subjective stress response and salivary secretory immunoglobulin A in university students

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Abstract We examined the effects of resilience on life stress by measuring subjective and physiological responses. Subjects were 32 college students who reported no remarkable subjective burden at the start of the study (initial period: T1), but some level of stressful burden 3 months later (second period: T2). Resilience levels were evaluated using the Bidimensional Resilience Scale (BRS), which measures innate and acquired resilience. The subjective stress level was assessed with the Stress Response Scale-18 (SRS-18). Saliva was also collected to measure the salivary secretory immunoglobulin A (sIgA) level. BRS was performed at T1, and SRS and saliva collection were administered at both T1 and T2. The subjects were divided into high- and low-resilience groups according to their median scores at T1. Additionally, the high-resilience group was classified as either high-innate resilience (HIR) or high-acquired resilience (HAR), and the low-resilience group as low-innate resilience (LIR) or low-acquired resilience (LAR), respectively, to reveal information in more detail. The depression-anxiety score for the SRS-18 in the low-resilience group was significantly higher than that in the high-resilience group at T2. The sIgA level of the high-resilience group was significantly higher than that of low-resilience group at T2. There were significant negative correlations between innate resilience and depression-anxiety, and total SRS-18 score; and negative correlations among acquired resilience and depression-anxiety, helplessness, total SRS-18 score, and sIgA level, respectively. These results suggested that the stress response in low-innate and acquired resilience differs depending on the length of time elapsed with stress, because low-innate and acquired resilience causes higher susceptibility to “depression-anxiety” as a psychological stress response factor. On the other hand, higher acquired resilience improved immune function in the presence of subjective burden.

Keywords: resilience, stress response, sIgA level

Introduction

According to an investigation conducted by the Cabinet Office of Japan1, 60% or more of people aged 20 - 59 experience substantial feelings of insecurity, distress, and stress at school or work. Relaxation methods, such as aromatherapy and mindfulness2,3), and physical activities, such as yoga and sports4), have been shown to ameliorate these conditions. Moreover, a tendency towards affirmative thought reduces anxiety and stress5,6); however, various factors (e.g., subjective state, life events) also affect coping methods, and currently available strategies are not universally applicable7).

Little is known about the individual characteristics that contribute to stress-related problems. Irrespective of whether stress-coping strategies are employed, certain individual characteristics (e.g., seriousness, sense of responsibility) predispose certain individuals to depression, which is a stress-related disease. Conversely, other people are able to maintain their mental and physical health even after exposure to a comparable stressor.

Thus, individuals can vary greatly in their reactions to mental and physical stress. One individual characteristic that has gained attention in recent years is resilience. Resilience refers to “the human capacity to deal with, overcome, learn from, or even be transformed by the inevitable adversities of life”8). However, the components and concepts of resilience are not uniform. For example, many conventional scales that measure resilience also include social support or social stability as external factors.
Recently, Hirano\(^9\) developed a two-dimensional resilience assessment, the Bidimensional Resilience Scale (BRS), that measures both “innate resilience factors”, which are strongly related to temperament, and “acquired resilience factors”, which are formed over the course of one’s lifetime. Hirano\(^9\) reported that innate and acquired resilience factors are each composed of different factors, based on Cloninger’s temperament and character model\(^10\).

Generally, resilience is evaluated by questionnaires and interviews. Questionnaires measuring resilience have been devised worldwide\(^{11-14}\). Previous studies investigating several mental disorders have shown that patients tend to exhibit lower resilience in comparison to the general population\(^15\). Moreover, people with low resilience are more likely to experience depression\(^16\). However, few studies have investigated this topic in individuals with no mental disorder. A clarification of the relationship between resilience and stress may be useful to prevent stress-related disease such as mental disorders. Additionally, previous studies examining the relationship between conventional resilience and stress have mainly used a questionnaire survey method\(^17\). This is problematic because questionnaire scores may be affected by intention, alexithymic/neurotic tendencies, and social desirability, which can confound the results. Therefore, to study the relationship between resilience and stress, a physiological approach may be useful in addition to psychological methods.

Stress is associated with changes in subjective responses such as resilience. In addition, stress affects the immune, autonomic nervous, and endocrine systems. For example, stress induces an endocrine response along the hypothalamic-pituitary-adrenal (HPA) axis and an autonomic nervous response along the hypothalamic-pontine-medullar-oblongata-spinal-adrenal medullar pathway. The HPA axis governs the secretion of cortisol and adrenocorticotropic hormone (ACTH), and the autonomic (sympathetic and parasympathetic) nerves modulate levels of adrenaline, noradrenaline, and secretory immunoglobulin A (sIgA). Therefore, stress-induced physiological alterations have been evaluated through the measurement of cortisol levels in blood, urine, saliva and other markers\(^{18-20}\).

It is feasible and economically efficient to measure levels of markers in saliva, which can be collected non-invasively. Further, research has demonstrated the effect of certain conditions on levels of different markers. For instance, cortisol levels in saliva are elevated in individuals who have experienced general chronic stress\(^{21,22}\). As sIgA decreases with chronic stress, it can be used as an index to objectively evaluate chronic stress\(^{23,24}\). Thus, conventional studies on stress have used indirect evidence from sIgA levels to demonstrate subjective changes, in addition to questionnaires.

The psychobiological mechanisms of resilience were reviewed by Charney\(^25\). This review indicated that resilience was associated with eleven factors, i.e., cortisol, dehydroepiandrosterone (DHEA), corticotropin-releasing hormone (CRH), etc. However, collecting these factors involves invasive measures and expensive analysis procedures. Although the sIgA level is thought to be an index of immune function, elucidating the level of change may illuminate the relationships among stress, resilience, and immune function. Therefore, the clarification of these relationships may contribute to the prevention of psychosomatic and cardiac diseases. However, the relationship between sIgA level and resilience has not been clarified by previous studies.

The purpose of the present study was to examine the effects of resilience on life stress through the evaluation of psychological and physiological parameters. The subjective stress responses of subjects were assessed and saliva was collected at the beginning of the experiment and 3 months later. Then, the relationships between the BRS scores and other indices were determined.

Methods

Subjects. All of the subjects were selected from a college class in which they participated voluntarily. The syllabus explained the outline of the class. To evaluate the effects of resilience on life stress responses, the intent of this study was to select subjects who had individually experienced stressful and non-stressful events, as described in the procedures. Ultimately, the data provided by 32 students were analyzed.

The present study was conducted according to the regulations of the Rikkyo University Committee for Life Science Research Ethics and Safety, Japan. Subjects were informed of the purpose of the study and assured that there would be no negative consequences if they chose not to participate. Additionally, subjects were informed that the data would not be used for purposes other than those of the study. Finally, voluntary consent was obtained from all subjects.

Psychological Responses. The following self-report questionnaires were used to measure psychological responses. Subjective stress level was evaluated by the Stress Response Scale-18 (SRS)\(^26\). The SRS consists of 18 items corresponding to three subscales: “depression-anxiety”, “irritability-anger”, and “helplessness”. The items were rated on a 4-point Likert-type scale ranging from 1 (no stress at all) to 4 (high stress).

The BRS, which was developed by Hirano\(^9\), is a 21-item scale composed of seven factors that reflect both innate (four factors) and acquired (three factors) resiliencies. Innate resilience factors include optimism, control, sociability, and vitality, while acquired resilience factors include attempting to solve a problem, self-understanding, and understanding others. The items were rated on a 5-point Likert-type scale ranging from 1 (disagree) to 5 (agree).
**Saliva Collection.** Saliva was collected based on methods used in a previous study [27]. Oral swabs (Salimetrics) were used to collect the saliva samples. The subjects rinsed their mouths three times with water before saliva was collected. Afterwards, sterilized cotton was placed in their mouths, and the subjects bit the cotton piece 60 times at a rate of approximately 1 bite/s. The saliva samples were kept frozen at -20°C prior to analysis.

**Measurements of Salivary sIgA.** Salivary sIgA concentrations were determined by sandwich ELISA [27]. Each well of a microtiter plate (MaxiSorp, Nunc, Wohlen) was coated for 1 h with goat anti-human IgA-affinity purified antibody (BETHYL: A80-102A) in a buffered solution. The wells were washed four times with phosphate-buffered saline (PBS) that contained 0.05% Tween-20 (Bio-Rad Laboratories, Glattbrugg). Nonspecific binding was blocked by incubating wells with Tween-20/PBS containing caseinate 1% bovine serum albumin (BSA) (SIGMA: A7030-10G) at room temperature (20 - 25°C) for 1 h. Then, standard or saliva samples were added to the wells and incubated at room temperature (20 - 25°C) for 1 h. Unbound IgA was removed by washing four times, and then goat anti-human IgA- horseradish peroxidase conjugate (BETHYL: A80-102P) was added and incubated at room temperature (20 - 25°C) for 1 h. After washing, TMB Microwell Peroxidase Substrate (Kirksgaard and Perry Laboratories, Inc.: 53-00-01) was added into each well at room temperature (20 - 25°C). After 20 minutes, the absorbance of the plate was measured via an enzyme-linked immunosorbent assay plate reader (ELISA; Microplate Reader iMarK, BIO-RAD) with an absorption wavelength of 655 nm.

To measure total protein concentration (mg/mL), a Pierce 660 nm protein assay reagent (Thermo: 22660) was added to each well for 5 min; wells were then read using an ELISA plate reader with the absorption wavelength set at 655 nm. The sIgA levels were determined by calculating the ratio of sIgA concentration to total protein concentration [28].

**Procedure.** First, 84 students were asked to respond to a simple questionnaire indicating whether they had experienced a subjective burden (Q1) and to what degree they experienced this burden (Q2) (Table 1). From these students, we chose 70 subjects who rated their degree of subjective burden as less than “3” (ordinary), and who had not experienced any stressful life event at the start of the experiment (initial period: T1). Additionally, other relevant factors were assessed (i.e., how they felt about their physical condition (Q3), how they traveled to the laboratory (Q4), and hours of sleep the previous night (Q5) (Table 1)).

Second, we selected 32 subjects (25 males and 7 females aged 18 - 21 years; mean age: 19.2 ± 1.3 years) from the above 70 subjects who rated their degree of subjective burden as “5” (strong) 3 months later (second period: T2). Only the data of these 32 subjects who had experienced a subjective burden at T2, despite a lesser burden level at T1, were used for analyses in the present study.

All subjects were informed that they would be assigned code numbers and that 1) answers would be confidential, 2) participation in the study was voluntary, 3) refusal to participate would not confer any disadvantage, 4) the results would not be used except to fulfill the purposes of the present study, and 5) consent would be required prior to psychological scale administration and saliva collection.

The above procedure was performed at T1, and the questionnaire (except for the BRS) and saliva collection were administered again at T2. At both T1 and T2, all subjects arrived in the study room at 9:00 a.m., completed the SRS, and then underwent saliva collection after resting for 15 min.

**Statistical Analysis.** The 32 subjects were divided into two groups, each group with two classifications, by referring to the study of Hirano [29]. Specifically, the high-resilience group (high-innate resilience: HIR, high-acquired resilience: HAR) and low-resilience group (low-innate resilience: LIR) were established.
resilience: LIR, low-acquired resilience: LAR) were established by dividing subjects according to their median scores (Table 2) at T1. Results of a Mann-Whitney U test indicated that the innate resilience score of the high-resilience group (HIR, 10 males and 6 females) was significantly higher than that of the low-resilience group (LIR, 15 males and 1 female) [HIR: Median = 42.50 (2.00), Mean = 44.75 ± 3.96, LIR: Median = 33.50 (2.00), Mean = 33.81 ± 3.10, Z = 4.83, p < .001]. A similar tendency was obtained for the acquired resilience scores [HAR: Median = 34.00 (3.00), Mean = 34.50 ± 2.92, LAR: Median = 28.00 (1.63), Mean = 26.31 ± 3.72, Z = 4.84, p < .001]. Additionally, 22 subjects out of 32 were classified into the high-innate and acquired resilience group (HH, n = 11), and the low-innate and acquired resilience group (LL, n = 11), respectively, to reveal information in more detail. Results of the Mann-Whitney U test indicated that the total BRS score of the HH group was significantly higher than that of the LL group [HH Group: Median = 78.00 (3.00), Mean = 80.00 ± 6.99, LL Group: Median = 60.00 (2.50), Mean = 60.45 ± 3.53, Z = 3.98, p < .001]. A similar tendency was obtained for the innate [HH Group: Median = 43.00 (2.00), Mean = 44.45 ± 4.95, LL Group: Median = 33.00 (1.75), Mean = 55.00 ± 4.95, Z = 3.98, p < .001] and acquired resilience scores [HH Group: Median = 35.00 (2.75), Mean = 35.55 ± 3.36, LL Group: Median = 28.00 (1.50), Mean = 27.27 ± 2.57, Z = 3.99, p < .001].

The relationship between resilience (innate and acquired) and SRS (three subscales) was evaluated using a two-way mixed (repeated-measures and between-groups) ANOVA (Group [e.g., HIR, LIR] × Time [T1, T2] and, correlations between resilience (innate and acquired) and SRS (three subscales) were tested using Spearman’s rank order correlation test. The same type of statistical analysis was performed to assess the association between resilience and sIgA level.

Results

Subjects’ conditions and psychological burden. All subjects stated that their physical condition was good and that they had traveled slowly by foot to the laboratory at both T1 and T2. Additionally, subjects reported sleeping between 5 and 9 h (mean ± SD: 6.2 ± 0.9) the previous night.

Table 2. Type of quartile by BRS

|                | N  | Min | 25%  | Median | 75%  | Max  |
|----------------|----|-----|------|--------|------|------|
| Innate Resilience | 32 | 27.0| 33.8 | 39.0   | 44.3 | 56.0 |
| Acquired Resilience | 32 | 18.0| 27.8 | 30.5   | 33.3 | 40.0 |
| Total RSS       | 32 | 49.0| 61.8 | 70.5   | 78.0 | 94.0 |

Table 3. Type and frequency of psychological burdens among subjects

| Types of psychological burden                                      | n (%) |
|-------------------------------------------------------------------|-------|
| Academics (e.g., preparing for classes, examinations)             | 10 (31.3) |
| Interpersonal relations (e.g., loneliness, unable to communicate with other people) | 6 (18.8) |
| Group or club activities (e.g., hard practice, fatigue)           | 4 (12.5) |
| Physical conditions (e.g., physical problems, slumps)             | 4 (12.5) |
| Uncertainty of future (e.g., job hunting)                         | 2 (6.2) |
| Part-time or full-time jobs (e.g., deadline for job, job training) | 2 (6.2) |
| Other (e.g., long commute, friend's traffic accident)             | 4 (12.5) |
| Total                                                             | 32 (100) |
Table 3 describes the subjective burdens experienced by subjects at T2. Academic burdens (31.3%; n = 10) were most prevalent (e.g., presentation for class, examinations). Uncertainty of the future (6.3%; n = 2; e.g., job hunting) and part-time or full-time jobs (e.g., job deadline, job training) were least commonly cited.

**Resilience and SRS.** Table 4 shows the mean SRS scores at both T1 and T2 for the high- and low-resilience groups. The two-way mixed-methods ANOVA revealed significant main effects of group on depression-anxiety \( F(1,30) = 4.61, p < .05 \) and total SRS scores \( F(1,30) = 4.75, p < .05 \) for innate resilience (Table 4). Both scores for the LIR group were significantly higher than those for the HH group (\( p < .05 \)). Conversely, no significant main effects of group and time were observed for the acquired resilience groups (Table 5). Additionally, there were no significant Group × Time interactions for any of the groups.

Moreover, the two-way mixed-methods ANOVA revealed significant main effects of group on depression-anxiety \( F(1,20) = 7.19, p < .05 \), helplessness \( F(1,20) = 10.51, p < .01 \) and total SRS scores \( F(1,20) = 6.82, p < .05 \) for the HH and LL resilience groups. Their LL scores were significantly higher than the HH scores (depression-anxiety and total SRS scores: \( p < .05 \), helplessness: \( p < .01 \)) (Table 6). Simple main effect analyses indicated that total SRS score \( p < .05 \) at T2 and helplessness scores at T1 \( p < .05 \) and T2 \( p < .01 \) for the LL group were significantly higher than those for the HH group.

A significant Group × Time interaction was obtained only for depression-anxiety \( F(1,20) = 8.08, p < .01 \). Simple main effect analyses indicated that the depression-anxiety score for the LL group was significantly higher than that for the HH group (\( p < .01 \)).

There were significant negative correlations between

### Table 4. Means of SRS by innate resilience group

| Factors of SRS | Group   | N     | Mean (SE) | T1     | T2     | Main Effect of Group | Main Effect of Time | Group × Time interaction |
|---------------|---------|-------|-----------|--------|--------|-----------------------|----------------------|-------------------------|
|               |         | Men   | Women     | Age    |        |                       |                      |                         |
| Depression-Anxiety | HIR Group | 10    | 6        | 19.4 (0.3) | 4.69 (0.91) | 4.02 (1.62) | \[F(1,30) = 4.61, p < .05\] | \[F(1,30) = 0.38, n.s\] | \[F(1,30) = 4.20, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Irritability-Anger | HIR Group | 10    | 6        | 19.4 (0.3) | 3.13 (0.65) | 2.50 (1.43) | \[F(1,30) = 0.98, n.s\] | \[F(1,30) = 0.05, n.s\] | \[F(1,30) = 0.97, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Helplessness | HIR Group | 10    | 6        | 19.4 (0.3) | 5.5 (1.04) | 4.69 (1.67) | \[F(1,30) = 4.02, n.s\] | \[F(1,30) = 0.38, n.s\] | \[F(1,30) = 0.38, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Total SRS | HIR Group | 10    | 6        | 19.4 (0.3) | 13.31 (2.39) | 13.46 (3.22) | \[F(1,30) = 4.75, p < .05\] | \[F(1,30) = 0.30, n.s\] | \[F(1,30) = 0.70, n.s\] |

* \( p < .05 \): HIR Group vs LIR Group

### Table 5. Means of SRS by acquired resilience group

| Factors of SRS | Group   | N     | Mean (SE) | T1     | T2     | Main Effect of Group | Main Effect of Time | Group × Time interaction |
|---------------|---------|-------|-----------|--------|--------|-----------------------|----------------------|-------------------------|
|               |         | Men   | Women     | Age    |        |                       |                      |                         |
| Depression-Anxiety | HAR Group | 10    | 6        | 19.4 (0.3) | 5.35 (1.06) | 4.47 (1.52) | \[F(1,30) = 0.37, n.s\] | \[F(1,30) = 0.58, n.s\] | \[F(1,30) = 4.55, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Irritability-Anger | LAR Group | 15    | 1        | 19.1 (0.4) | 4.67 (0.74) | 6.53 (1.65) | \[F(1,30) = 3.12, n.s\] | \[F(1,30) = 0.73, n.s\] | \[F(1,30) = 3.12, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Helplessness | LIR Group | 15    | 1        | 19.1 (0.4) | 4.13 (1.29) | 2.93 (1.15) | \[F(1,30) = 2.50, n.s\] | \[F(1,30) = 0.76, n.s\] | \[F(1,30) = 0.93, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Total SRS | LIR Group | 15    | 1        | 19.1 (0.4) | 14.94 (2.55) | 14.88 (3.23) | \[F(1,30) = 0.84, n.s\] | \[F(1,30) = 0.22, n.s\] | \[F(1,30) = 0.25, n.s\] |

### Table 6. Means of SRS by high-innate and acquired resilience group and the low-innate and acquired resilience group

| Factors of SRS | Group   | N     | Mean (SE) | T1     | T2     | Main effect of group | Main effect of Time | Group × Time interaction |
|---------------|---------|-------|-----------|--------|--------|-----------------------|----------------------|-------------------------|
|               |         | Men   | Women     | Age    |        |                       |                      |                         |
| Depression-Anxiety | HH Group | 6     | 5        | 19.6 (0.4) | 5.64 (0.85) | 2.73 (1.97) | \[F(1,20) = 7.19, p < .05\] | \[F(1,20) = 2.40, n.s\] | \[F(1,20) = 8.08, p < .01\] |
|               |         |       |          |        |        |                       |                      |                         |
| Irritability-Anger | LL Group | 10    | 1        | 19.0 (0.4) | 4.55 (0.70) | 7.64 (2.03) | \[F(1,20) = 0.99, n.s\] | \[F(1,20) = 0.01, n.s\] | \[F(1,20) = 0.61, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Helplessness | HH Group | 6     | 5        | 19.6 (0.4) | 3.82 (0.85) | 3.46 (1.65) | \[F(1,20) = 10.51, p < .01\] | \[F(1,20) = 0.43, n.s\] | \[F(1,20) = 0.01, n.s\] |
|               |         |       |          |        |        |                       |                      |                         |
| Total SRS | LL Group | 10    | 1        | 19.0 (0.4) | 7.82 (1.56) | 8.27 (1.96) | \[F(1,20) = 6.62, p < .05\] | \[F(1,20) = 0.93, n.s\] | \[F(1,20) = 0.57, n.s\] |

* \( p < .05 \): HH Group vs LL Group, ** \( p < .01 \): HH Group vs LL Group

† \( p < .05 \): HH Group vs LL Group at T2, †† \( p < .01 \): HH Group vs LL Group at T2
with stress; and low-innate and acquired resilience to “depression-anxiety” is one of the psychological stress responses factors. On the other hand, higher acquired resilience improved immune function in the presence of subjective burden. This phenomenon is described in the discussion below.

Subject conditions prior to sIgA measurement. In the present study, we endeavored to control for several factors thought to affect sIgA levels. At both measurements, T1 and T2, all subjects stated that their physical condition was good and that they traveled slowly by foot to the laboratory. Additionally, subjects reported sleeping between 5 to 9 h the previous night. However, several limitations and problems remained (e.g., gender ratio of sample, timing of meals, oral disease), as described below.

Resilience and sIgA levels. Table 8 presents the mean sIgA levels measured at T1 and T2 for each of the high- and low-resilience groups. The two-way mixed-methods ANOVA showed a significant main effect of time for acquired resilience \( F(1,30) = 6.29, p < .05 \). The mean sIgA levels at T2 were significantly higher than those at T1 for the acquired resilience groups \( p < .05 \). Additionally, a significant Group × Time interaction was obtained only for acquired resilience \( F(1,30) = 6.85, p < .05 \). Simple main effect analyses indicated that the sIgA levels in the HAR group were significantly higher than those of the LAR group at T2 \( p < .05 \). Moreover, no significant main effect, time effect, or Group × Time interaction was observed for HH and LL resilience. There was a significant positive correlation between acquired resilience and sIgA level (Table 9).

Discussion

The present study examined the effects of resilience on life stress by measuring psychological and physiological responses. Consistent with conventional research on the associations between resilience and subjective stress response, our results indicated that low-innate and acquired resilience differs depending on the length of time elapsed with stress; and low-innate and acquired resilience to “depression-anxiety” is one of the psychological stress responses factors. On the other hand, higher acquired resilience improved immune function in the presence of subjective burden. This phenomenon is described in the discussion below.

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Resilience and SRS. Mean SRS scores among Japanese college students have been reported to range from 14.75 to 15.70. In the present study, the mean total SRS scores of 32 subjects were 15.39 ± 2.35 at T1 and 16.25 ± 2.20 at T2. Although the score at T1 was within the previously reported range, the score at T2 was slightly higher. However, no significant difference was obtained between these scores in the present study. A simple questionnaire (Table 1: Q1 and Q2) showed that the subjects experienced a strong subjective burden at T2, despite having a lesser burden at T1. Therefore, it was suggested that the subjective stress response was not directly affected, regardless of whether the daily subjective burden was strong. Additionally, Hirano suggested that resilience factors do not change over the course of 3 months. Therefore, resilience factors might not have affected the change in subjective stress responses between T1 and T2. To clarify the effects of resilience factors, future studies should employ a longer interim period.

Haga and Ishizu reported that the higher innate and acquired resilience group presented lower scores for...
depression-anxiety, irritability-anger, and total stress responses compared to the lower resilience group two weeks after the start of their experiment. In the present study, however, only the depression-anxiety scores three months after start were significantly higher for the low-resilience group in comparison to the high-resilience group, partially supporting the report of Haga and Ishizu3). These results suggest that the factor of stress response on low-innate and acquired resilience differs depending on the length of time elapsed with stress, because low-innate and acquired resilience to “depression-anxiety” is one of the psychological stress responses factors in the presence of subjective burden.

Moreover, it indicated that innate resilience acted more effectively on mental health than did acquired resilience, and acquired resilience might support the function of innate resilience. However, regarding the relationship to resilience, the depression-anxiety scores from the SRS in the present study (i.e., subjective stress response) differed significantly between T1 and T2. As for innate resilience, it is possible that the total SRS scores did not increase significantly at T2 because they were sufficiently high even at T1, when subjects did not experience a stronger burden. Conversely, subjects who possessed higher innate resilience might be resistant to enhanced subjective stress responses (e.g., depression, anger, helplessness), even if they experience stronger burdens in daily life. In fact, innate resilience demonstrated significant negative correlations with depression-anxiety and total SRS scores, and acquired resilience showed negative correlations with depression-anxiety, helplessness, and total SRS, respectively (Table 7). These results suggest that innate resilience fulfilled the function of reducing subjective stress responses, even under greater burdens in daily life, at least within a certain restricted period. Conventional studies on resilience have generally indicated that low resilience, which is related to inborn temperament, is associated with poor mental health4). Because innate resilience in the present study may be considered related to inborn temperament, our results offer support for previous studies.

Considering resilience level, the mean total SRS score for the LIR subgroup was significantly higher than that for the HIR subgroup (Table 4). This result suggests that high-innate resilience could attenuate subjective stress responses. In contrast, for acquired resilience, there was no significant difference between mean total SRS scores for the LAR and HAR subgroups at either T1 or T2 (Table 5). Therefore, the relationship between acquired resilience and subjective stress responses was not clear, and no positive evidence was obtained that indicated acquired resilience influenced subjective stress responses. These results suggest that subjective stress responses are related to trait resilience, as between-group differences in subjective stress responses were not significant in terms of acquired resilience.

Resilience and sIgA level. It has been proposed that acquired resilience can be learned in everyday life5). Moreover, the American Psychological Association32) reported that resilience is not a trait, but consists of behaviors and thoughts that can be learned and developed. Although there is no unanimous agreement on the definition of resilience, “resilience has been defined as a dynamic process that can correct falling into maladaptive mental or social symptoms and problem behaviors and realize positive adaptation”33), and as “adaptability when adverse circumstances are faced”3). Therefore, it is possible that this adaptation would be reflected in increased sIgA levels. However, the relationship between sIgA level and resilience has not been clarified.

The sIgA level was used as an index of physiological stress responses in the present study, based on previous studies. Usually, an increase in sIgA level is accompanied with increases of cortisol during an acute stress response. As cortisol is maintained at a high level during prolonged stress, the sIgA level has also been used as an index of chronic stress responses30). Additionally, sIgA levels are affected by the HPA system and the autonomic nervous system (i.e., sympathetic and parasympathetic nervous systems). Deinzer et al.34) reported that sIgA levels continued to decrease until 2 weeks after the start of school examinations. In the present study, the change in sIgA level was characteristic for the HAR group. The sIgA level in the HAR group was significantly higher than that of the LAR group, but only at T2; and there was a significant positive correlation between acquired resilience and sIgA level. The increased sIgA levels observed in the acquired resilience group might indicate that these subjects exhibited somewhat lower physiological stress responses, and their immune function was maintained at a higher level. The HAR group may possess relatively advanced mental traits for problem solving, self-understanding, and understanding others, and their recovery from a subjective burden may be more rapid. These results suggest that high levels of acquired resilience attenuated physiological stress responses and improved immune function, even if a subjective burden was experienced.

However, the influence of innate resilience on sIgA levels was unclear. Additionally, the experimental conditions of the subjects’ stress points were uncontrolled in the present study. Accordingly, further investigation may be needed.

Enhancing resilience. As previously described, Hirano9) reported that, based on the Temperament and Character Model10), innate resilience factors comprise optimism, control, sociability, and vitality. In contrast, acquired resilience factors include problem solving, self-understanding, and understanding others. Therefore, the latter factors may be important for enhancing resilience.

Additionally, the APA32) has suggested 10 ways to increase resilience (e.g., make connections, avoid seeing
crises as insurmountable problems). It appears that the subjects experienced numerous stressors after the start of the present study. The subjects with low psychological stress responses and high immune function may have possessed psychological characteristics consistent with the suggestions of the APA. In contrast, subjects who experienced high psychological stress responses and low immune function may benefit from adherence to one or more of the APA recommendations. The gradual acquisition of at least one of the 10 items recommended by the APA may help to prevent stress-associated diseases, thus supporting the premise that increased acquired resilience is necessary.

**Limitations.** Several limitations may be identified in the present study. First, the gender ratio was not controlled for in any of the resilience categories (HIR, LIR, HAR, and LAR) because of the restriction on the number of subjects. Second, the specific life events and everyday irritations experienced by subjects during the study period were not examined. Therefore, the degree of stressors experienced by each subject was not measured sufficiently, in addition to not accounting for the potential influences of gender differences. Third, as the subjects were restricted to healthy university students, it is not certain whether our results can be generalized to other populations (e.g., persons of advanced age, sick persons). Moreover, because the present study was conducted in a college class, we could not control several factors thought to affect sIgA levels, such as timing of meals, oral disease, medications, smoking, menstrual cycle, and so forth. Finally, strictly speaking, the results of the present study did not always indicate similarities between psychological and physiological responses, which may be due to our experimental procedures. Since the sIgA level is usually influenced by several factors, e.g., circadian rhythms, acute stress events, etc., we controlled for these factors as well as possible. However, we could not control all of the potential factors in the subjects’ daily lives, particularly the occurrence of stressful events, before the collection of saliva. To clarify the relationship between resilience and mental health, more controlled and precise studies are needed.

**Conflict of Interests**

The authors declare that there is no conflict of interests regarding the publication of this article.

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