Original Article

Effect of perceived happiness level on cardiac response to mental stress testing: A pilot study

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Abstract

Increasing evidence suggests that perceived happiness influences stress responses to mental stress testing. We examined the effects of perceived happiness on heart rate (HR) and subjective responses induced by mental stress tests such as speech and mental arithmetic among 235 participants screened according to levels of perceived happiness. After a 10 minutes pre-task period, 8 high and 8 low happiness participants completed the task period which included 2 minutes preparation for speech, 3 minutes speech and 5 minutes mental arithmetic in front of an observer followed by a 30 minutes post task period. Subjective stress responses were assessed by NASA-TLX. HR was higher in the lower happiness group compared to the higher happiness group during the pre-task and mental arithmetic. Both groups did not differ in subjective stress responses.

Key word: perceived happiness, heart rate, mental stress testing, subjective stress responses

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メンタルストレステストに対する心拍反応に与える
主観的幸福感水準の影響：探索的検討

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抄 録

主観的幸福感がメンタルストレステストに対するストレス反応に影響するという証拠が増えている。235名の対象者から選抜された主観的幸福感が高いグループと低いグループ（各8名）に対して、スピーチと暗算課題からなるメンタルストレステストを負荷した時の心拍（HR）及び主観的ストレス反応を比較した。メンタルストレステストは、10分間の前課題期、2分間のスピーチ準備期、3分間のスピーチ期、5分間の暗算課題期、そして30分間の後課題期からなっていた。主観的ストレス反応は、NASA-TLX により測定された。幸福感が高いグループの HR は、前課題期及び暗算時において、幸福観感が高いグループよりも高かった。主観的ストレス反応は、両グループで差異がなかった。

キーワード：主観的幸福感、心拍数、メンタルストレステスト、主観的ストレス反応

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Introduction

Happiness is generally defined in terms of frequently experienced positive affect, high life satisfaction, and infrequent negative affect [1]. There is growing evidence that perceived happiness or positive affect influences stress responses to acute mental stress. Mental stress testing is a standardized procedure to measure psychophysiological parameters during a stress state elicited by imposed mental load task [2]. This methodology permits sophisticated measurements of subjective and physiological parameters, while strictly controlling effects of confounding factors such as smoking or ongoing exercise on the parameters [2].

Previous studies have mainly focused on the level of happiness at a particular moment [3, 4] or over specific time periods such as a week or month [5, 6]. In a previous study, college students with higher levels of positive affect, which was measured prior to the experiment based on emotions felt at that moment, showed faster cardiovascular recovery after the challenging tasks [3]. In addition, a higher level of happiness over a prolonged period (two days) correlated with rapid cardiovascular recovery after mental stress testing [6].

In contrast, very few studies have examined the effects of happiness as one's trait or characteristic level of positive affect on stress responses to mental stress testing [7]. Such examinations have not been carried out in Japan. Such tests would improve understanding of the relationship between happiness as a trait level of positive affect and stress responses under stressful situations.

These previous studies have measured psychophysiological as well as subjective parameters. It is reported that psychophysiological parameters such as blood pressure or heart rate are useful as objective indicators of stress responses [8]. Thus, it is advantageous to measure psychophysiological parameters. Therefore, the purpose of the present study was to examine the effects of perceived happiness as a trait level of positive affect on cardiac and subjective responses induced by mental stress.

Method

Screening higher and lower happiness

To screen individuals with higher or lower level of perceived happiness, we asked 235 college students who received lectures on health or welfare psychology to take the Japanese Version of Subjective Happiness Scale (JSHS) test [9]. The JSHS is a 4-item scale and measures perceived happiness that is relatively stable. Internal consistency, test-retest reliability, convergent validity, and discriminant validity of the JSHS were confirmed [9]. They also answered questions on sex and age. We instructed each respondent to write his or her respective e-mail address and/or telephone number if he or she wished to volunteer for the study. Of the 235 respondents, 55 (10 males and 45 females) were teenagers, 169 (74 males and 95 females) were in their twenties, 5 (1 male and 4 females) were in their thirties, 2 females were in their forties, 3 females were in their fifties, and 1 male was in his sixties. Results of this screening investigation indicated that the mean score of the JSHS in a sample of 235 undergraduate and graduate students was 4.5 with a standard deviation (SD) of 1.0, which were similar to those reported by Shimai et al. [9]. We selected respondents with a score above 5.5 as higher happiness respondents (N=8) and below 3.5 as lower happiness respondents (N=8). Sixteen of 74 respondents whose score was above 5.5 or below 3.5 agreed to volunteer for the experiment when offered. The others did not write their telephone number and/or e-mail address, or could not participate in the experiment because of their schedule unavailability. The 16 participants consisted of 8 higher-happiness (3 males and 5 females) and 8 lower-happiness respondents (5 males and 3 females). The mean ages of participants in the higher-happiness and the lower happiness group were 24.4 and 19.8 with an SD of 10.3 and 1.5 years, respectively. The SD was greater in the higher-happiness group, because it included two female participants whose ages were 28 and 50.

Experimental procedure

Participants gave written informed consent when they came to the experimental room. They were seated in a sound-attenuated small chamber (2m×3m), and the session started with a 10-minute pre-task period during which we instructed them to relax.

After the pre-task period, they completed a 10-minute task, which consisted of a 3-minute speech task with 2-minute preparation and a 5-minute
mental arithmetic task in front of an observer. The speech task required the participants to speak about “recent pleasurable experience” facing a video camera and the experimenter. The mental arithmetic task required them to subtract 7 from 2007 and answer aloud to the experimenter as promptly and accurately as possible. Previous studies showed that evaluative observers or evaluative threat enhanced cardiac response to mental arithmetic [10] and delivering speech [11]. Therefore, the experimenter stayed in the experiment room during the task period to be an evaluative observer to make both tasks more effective for mental stress testing.

After the task period, the Japanese version of NASA-TLX [12] was administered to measure subjective stress responses. NASA-TLX, developed by Hart and Staveland [13], is a multidimensional workload scale, which measures mental and cognitive demands required for a given task. This scale consists of 6 items related to mental demand, physical demand, temporal demand, performance, effort, and frustration. Each item is rated on a 10-point scale.

The task period was followed by a 30-minute post-task period. We also instructed each participant to relax during this period. Although the post-task period was for 30 minutes, there was no significant difference between the heart rate (HR) during the first and the last 3 minutes. Therefore, we analyzed HR during the first 3 minutes. An electrocardiogram (ECG) was recorded throughout the session to measure HR. The ECG signal was A/D converted at a sampling rate of 1000 Hz to obtain inter-beat interval (IBI) data, and stored on a computer. HR was calculated from the IBI data.

Statistics

Average HR during each period was calculated for analysis. With regard to the task period, we calculated means of HR during the 2-minute preparation for speech, the 3-minute speech task, and the 5-minute mental arithmetic task. A mixed design two-way analysis of variance (ANOVA) was used to test the significant difference in HR between the two groups. An unpaired t-test was used to test the significant differences between the NASA-TLX scores of the two groups. The significant level was set at less than 5%.

Result

Age, body mass index, and happiness

There were no systematic differences between the two groups regarding body mass index and age. Scores on chronic happiness measured by the JSHS were significantly higher in the higher-happiness group than in the lower-happiness group \( (t(14)=11.49, p<0.01) \).

HR response

Figure 1 shows HR responses in the two groups. ANOVA revealed a significant main effect of period \( [F(4, 56)=4.89, p<0.01] \) and group \( [F(1, 14)=6.29, p<0.05] \). ANOVA also revealed a significant effect of interaction \( [F(4, 56)=2.93, p<0.05] \). Analysis of the interaction showed significant effects of group during the pre-task period \( [F(1, 14)=17.14, p<0.01] \) and mental arithmetic \( [F(1, 14)=7.87, p<0.05] \), suggesting that HR was significantly higher in the lower-happiness group than in the higher-happiness group at these points. The analysis also revealed that significant effects of period in the lower-happiness group \( [F(4, 56)=4.86, P<0.01] \) and the higher-happiness group \( [F(4, 56)=3.61, P<0.05] \). Multiple comparisons by Turkey’s HSD test revealed that in the higher-happiness group, HR was higher during the preparation for speech and the speech task than during the pre-task period. No other comparisons were significant. These results suggested that HR increased significantly from the pre-task period to the preparation for speech and the speech task, and

![Figure 1. Mean levels of HR in beat per minute (bpm) at the pre-task, preparation for speech, mental arithmetic (MA), and the post-task period in the higher- (white bars) and lower-happiness group (black bars).]
then decreased toward near the HR level of the pre-task period from the speech task to mental arithmetic task.

Multiple comparisons by Turkey’s HSD test also revealed that in the lower-happiness group, HR was significantly lower during the post-task period than during the speech task and mental arithmetic task (all, p < 0.05). No other comparisons were significant.

**Subjective stress responses**

Table 1 shows subjective stress responses in the two groups measured using the NASA-TLX. A series of unpaired t-tests revealed that there were no significant differences in the scores of all subscales.

Table 1. Comparisons of mean values (SD) of subjective stress responses between the higher- and lower-happiness groups

<table>
<thead>
<tr>
<th></th>
<th>Higher happiness group</th>
<th>Lower happiness group</th>
<th>n.s.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental demand</td>
<td>7.5 (2.0)</td>
<td>6.6 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Physical demand</td>
<td>3.0 (2.5)</td>
<td>2.6 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Temporal demand</td>
<td>7.3 (2.1)</td>
<td>6.8 (2.1)</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>4.9 (3.0)</td>
<td>5.5 (2.4)</td>
<td></td>
</tr>
<tr>
<td>Effort</td>
<td>6.6 (2.3)</td>
<td>5.8 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Frustration</td>
<td>3.9 (2.0)</td>
<td>5.5 (2.3)</td>
<td></td>
</tr>
</tbody>
</table>

N. number of participants; n.s., non significant.

**Discussion**

The purpose of this study was to examine the effects of perceived happiness on HR and subjective responses to mental stress testing. We compared these responses between the lower- and higher-happiness groups. Participants with higher level of happiness showed similar subjective stress responses to those with lower level. This result was consistent with those of previous studies, which did not find significant effects of perceived happiness or positive affect on subjective responses to mental stress testing [5-7].

It is of interest, however, that the cardiac response patterns of the two groups were different. HR responses differed at the two time points: before the task period and during mental arithmetic task. HR during the pre-task period was significantly higher in the lower-happiness group than in the higher-happiness group even when HR did not differ during the post-task period, which was inconsistent with results of previous studies [3-6].

This discrepancy between the present study and previous ones may be explained by the differences in measured constructs. With regard to the mechanism, one might expect that the difference in HR during the pre-task period may be explained by the difference in resting HR. Both speech and mental arithmetic cause an increase in HR [14], and it is expected that subjective stress responses increase with HR.

Therefore, it seems unreasonable that subjective response was similar between the two groups, while the increase in HR induced by mental stress testing was more prominent in the higher-happiness group. Thus, the interpretation of the difference during the pre-task period based on resting HR level does not seem reasonable. One possible explanation might be that individuals with lower level of perceived happiness tended to show heightened cardiac response to an experimental stress setting before actual exposure to mental stress.

In addition, cardiac responses to speech task and mental arithmetic differed between individuals with higher and lower levels of perceived happiness. HR response to mental arithmetic was greater in the lower-happiness group, while HR responses to speech and its preparation were similar. This result was inconsistent with those of previous studies showing that HR responses were not related to the level of perceived happiness during one week or one day [5, 6].

The mechanism through which differential responses to the two tasks occurred between the two groups remains unknown. However, it is suggested that higher level of perceived happiness buffers cardiac response during mental arithmetic task. It seems unreasonable that subjective response was similar between the two groups while HR levels during the two tasks were higher in the lower-happiness group. We measured subjective stress responses only once and it is expected that responses to the two tasks were added, resulting in this discrepancy.

First limitation of this study was that, with lack of data on subjective stress responses to the two tasks, we could not clarify the mechanism through which differential HR responses occurred during speech and mental arithmetic between the two groups in detail. Further studies should measure subjective responses to the tasks separately.
The second was that we could not examine the effects of perceived happiness on the recovery process. Previous studies have reported that the level of perceived happiness is related to cardiovascular recovery [3, 5]. Recovery is defined as returning from a stressed to a resting state, and information about a resting state is necessary. The difference in HR between the pre-task period and the post-task period was about 7 beats per minute in the lower-happiness group, making it extremely difficult to estimate resting HR in the lower-happiness group. Therefore, in this study, it was impossible to define cardiovascular recovery in the lower-happiness group. Further studies should be planned to measure resting HR properly, for example, by varying instructions.

The third was that the number of the participants was quite limited. The effects of cardiovascular responses to acute mental stress should be examined with a higher number of participants. Despite these limitations, it was implied that the level of perceived happiness influences cardiovascular responses to acute mental stress. Further studies are necessary to examine the effects of perceived happiness on acute stress responses to facilitate understanding of the relationship between happiness as a trait level of positive affect and subjective stress responses under stressful situations.

Reference