The Stress Relief Effects of Wrist Warming After Mental Workload

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ABSTRACT

To clarify the mental stress relief effects of wrist warming, we conducted an experiment involving 8 healthy participants and evaluated the differences in psychological and physiological responses between using a warm armrest and normal temperature armrest after mental workload from a timed typing test.

Psychological responses were evaluated with a questionnaire: using 21 questionnaire items with 7 mood state categories: “Active”, “Anger”, “Comfort”, “Relaxed”, “Strained”, “Anxiety / Uneasiness”, and “Languor/Boredom”. Furthermore, physiological responses were evaluated with changes in the 3 following parameters: heart rate, skin temperature of the base of the little finger, and galvanic skin temperature. In this experiment, we used NeXus-10 MARKII for measurement and BioTrace+ for analysis.

From our findings, when participants used the warm armrest after mental workload, their questionnaire scores of “Anxiety / Uneasiness” and “Comfort” were improved. In addition, we found that, in many of the participants, the skin temperature of the base of little finger was increased, although it was not in contact with the armrest. These results seem to suggest that wrist warming relieves mental stress.

KEYWORDS

Mental workload, Mental stress relief, Psychological responses, Heart rate, Skin temperature, Galvanic Skin Response, Wrist warming, Time pressure.

1 INTRODUCTION

Work methods have been drastically changed by recent developments in ICT (Information and Communication Technology).

Currently, office workers commonly use diverse technologies; devices such as the desktop PC, Notebook PC, tablet, and smartphone are extensively employed during work hours for emailing, writing documents, and programming, among other activities. These devices are also used outside work for internet surfing, instant messaging, net shopping, and playing games.

ICT provides many opportunities for obtaining necessary information and communication, without the restrictions to time and location. However, it imposes increased mental and physical stress since device displays are looked at for long periods of time.


To reduce office workers’ physical and mental workloads, this guideline recommends shortened continuous VDT operation time per day and constant breaks.

Nevertheless, many workers do not take voluntary breaks and this increases their health risk because of prolonged mental and physical stress.

Many methods have been reported to relieve mental stress and office workers may select suitable methods depending on their situation or condition. Popular methods include exercise, breathing, aromatherapy, healing music, and light therapy. However, the effect of tactile methods and in particular, thermal stimulus has not been well clarified.

Office workers find it difficult to reduce stress during working hours. For example, in case of exercise, a convenient place must be selected, and for methods such as healing music and aromatherapy, the influence of and effect on the surrounding environment must be considered.

Therefore, although many workers are aware of various stress relief methods, these methods are usually infeasible in the workplace. Consequently, we proposed that the use of thermal stimulus might be an effective method that can be utilized regularly without the
surrounding environment constituting any impediment to its use. Incidentally, in the field of nursing science, a popular treatment method using thermal stimulus, called the hot compress, is used for pain care and relaxation. Researchers have investigated the effect of the hot compress, using psychological and physiological parameters [2], [3]. However, many office workers find it difficult to employ this technique because they are not familiar with its use. Therefore, in this study, we focused on the mental stress relief effects of thermal stimulus application to the wrists, a method that may be easily employed during work hours. In this study, we aimed to clarify the mental stress relief effect of wrist warming after mental workload.

2 METHODS

2.1 Experiment Outline

We conducted an experiment to clarify the effect of wrist warming with 8 healthy participants. Figure 1 shows the experiment environment and Table 1 shows the experiment outline.

<table>
<thead>
<tr>
<th>Period</th>
<th>March, 2016 - June, 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Tokyo Metropolitan University Sensibility Evaluation Laboratory</td>
</tr>
<tr>
<td>Participants</td>
<td>8 healthy participants [age, 20s and 30s] *male: 6, female: 2</td>
</tr>
<tr>
<td>Temperature</td>
<td>22 – 25 degrees Celsius</td>
</tr>
<tr>
<td>Number of tests</td>
<td>Two tests using armrests at different temperatures + trial test for each participant</td>
</tr>
<tr>
<td>Mental workload</td>
<td>Timed typing tasks All tasks consisted of about 750 Japanese characters with 46% of the Kanji characters included.</td>
</tr>
<tr>
<td>Wrist warming method</td>
<td>Armrest with gel pad 1st time: normal temperature gel pad 2nd time: warmed by microwave * 52 -54 degrees Celsius</td>
</tr>
<tr>
<td>Typing system</td>
<td>Excel form with checking function</td>
</tr>
<tr>
<td>Psychological responses</td>
<td>21 questionnaire items, with 7 mood s categories</td>
</tr>
<tr>
<td>Physiological responses</td>
<td>Heart rate, skin temperature, and galvanic skin response. (detected by NeXus-10 MARKII)</td>
</tr>
</tbody>
</table>

2.2 Experimental Procedure

At first, we have explained the experiment contents to each participant. Thereafter, they performed the typing test without any time limit until they became accustomed to the task. After this, we conducted the main experiment twice, on separate days. Throughout the experiments, participants were seated in a chair.

2.2.1 Trial Typing Test

The typing test was performed untimed until the participants become used to the task. The number of characters used were one-third that of the main experiment. The typing system was the same as that in the main experiment.
2.2.2 First Experiment

All participants were tested as follows:

- **Start:** Sensors were placed on the participant

- **Step 1:** The participants kept calm for 5 min at the start. Their eyes were allowed to be open.

- **Step 2:** The questionnaire was filled.

- **Step 3:** Complete typing tasks within a set time.
  - After the participants read the input paper, they started typing on the system.
  - They were required to complete 2 typing tasks within 50 min. We informed the participants of the time at 25 min, 40 min, and 45 min, during the tasks.
  - The experiment was considered completed if they completed tasks before 50 min or if the 50 min elapsed. The latter case was treated as “Time out”.

- **Step 4:** The questionnaire was filled.

- **Step 5:** The participants kept calm for 7 min as the rest condition.
  - The first 2 min was performed as Step 1.
  - In the next 5 min, the armrest with normal temperature was used.

- **Step 6:** The questionnaire was filled.

- **End:** The sensors were removed from the participant.

Notice: The questionnaire used for Step 2, Step 4, and Step 6 was the same.

We continued to detect with using Nexus-10 MARKII during the experiment. The details of these are shown in Section 2.7 (Physiological Responses).

Figure 2 shows the timeline of the experiment.

2.2.3 Second Experiment

The participants were tested in the same way as in the first experiment, except for Step 5.

- **Step 5:**
  - The first 2 min was the same as Step 1.
  - For the next 5 min, the warm armrest was used.

2.3 Mental Workload

We selected the typing test as the mental workload under VDT operations and utilized Japanese newspaper articles for selecting nearly equal numbers of Japanese and Kanji characters. Furthermore, in order to increase the mental workload, two requirements were needed for the typing test to be regarded as completed: All characters were inputted correctly. Typing was completed within the set time.

2.4 Wrist Warming Method

We selected the gel pad for the wrist warming method, which can be warmed by a microwave and keep warm for a period of time. Although it loses heat several hours later, it can warmed up repeatedly.

We used the armrest that comprised the gel pad wrapped in a towel.
2.5 Typing System

We developed the typing form with checking function via Excel VBA programming. Figure 3 shows the typing process.

Figure 3. The typing process

(a) Start to type the characters in the input paper into the Excel form in the desktop PC.

(b) Click the [Check] button on the bottom-right in the Excel form after all characters are input.

(c) The typing form confirms whether all characters are inputted correctly by comparing with the correct output saved beforehand.

(d) If all characters are inputted correctly, a message showing that the task is completed is displayed on the bottom-left.

(e) When a wrong character is entered, the form deletes below the sentences including wrong characters, and a message prompting the participant to re-type the characters is displayed on the bottom-left.

(f) The participant re-types the sentences below the blank line, and continues to type until the task if finished.

2.6 Psychological Responses

At first, we focused on the questionnaire for evaluation of stress caused by phasic task demand [4]. Moreover, we researched other questionnaire items including the Positive and Negative Affect Schedule (PANAS) scales [5] and the Mood Check List-short form 2 (MCL-S.2) for measuring the positive mood state following exercise [6].

Finally, we selected the following 21 items, which comprised 7 moods, from among the questionnaires. Thereafter, we used the following items for evaluation in this experiment (Table 2).

2.7 Physiological responses

To confirm the effects of mental workload and thermal stimulus, we selected the following three parameters as physiological parameters (Table 3). We continued measurements using Nexus-10 MARK II. All Physiological parameters were measured at 32 samples per second (SPS). Figure 4 shows the sensor placement position.
Table 2. Questionnaire items for psychological parameters

<table>
<thead>
<tr>
<th>Active</th>
<th>Active, Exited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anger</td>
<td>Provoked, Anger, Offended, Irritated</td>
</tr>
<tr>
<td>Comfort</td>
<td>Relieved, Pleasant, Comfort, Refreshed</td>
</tr>
<tr>
<td>Relaxed</td>
<td>Calm, Settled</td>
</tr>
<tr>
<td>Strained</td>
<td>Strained, Thumping</td>
</tr>
<tr>
<td>Anxiety /Uneasiness</td>
<td>Timid, Confused, Worried, Depressed</td>
</tr>
<tr>
<td>Languor /Boredom</td>
<td>Tired, Ineffective, Gloomy</td>
</tr>
</tbody>
</table>

*All the questionnaires were applied by 7 scales of SD (Semantic Differential) method.

Table 3. Physiological parameters

<table>
<thead>
<tr>
<th>Index</th>
<th>Measurement Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin Temperature (TEMP)</td>
<td>Detected by TEMP Sensors on the base of the little finger of the left hand</td>
</tr>
<tr>
<td>Galvanic Skin Response (GSR)</td>
<td>Detected by GSR sensors attached to the middle and ring fingers of the left hand</td>
</tr>
<tr>
<td>Heart Rate (HR)</td>
<td>Detected by ECG sensors attached to both arms</td>
</tr>
</tbody>
</table>

3 RESULTS AND DISCUSSION

In this experiment, the participants were classified as follows:

- Completed all typing tasks: 4 Participants
- Timed out at first attempt: 2 Participants
- Timed out throughout: 2 Participants

We analyzed the psychological responses from the questionnaire data of all participants, and the physiological responses. The details are as follows:

3.1 Psychological Responses to Wrist Warming

First, for the evaluation of each questionnaire data, we confirmed the differences between after the typing test and after rest. Next, we calculated the mean score for each of the 7 mood states, and compared the differences between after the typing test and after rest. Moreover, we compared the differences between the results of the first and second experiments and the results suggested that wrist warming could have positive effects on mental workload. Table 4 shows the positive effects of wrist warming on the 7 moods.

Table 4. Effects of wrist warming on psychological responses

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Anger</td>
<td>++</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Comfort</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Relaxed</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>Strained</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Anxiety /Uneasiness</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Languor /Boredom</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

[++] : Clearly improved by warming
[+]  : Slightly improved by warming
[ 0 ] : Not changed by warming
[-]  : Worsened by warming
As shown, the scores of many participants were clearly improved in the items of “Anxiety/Uneasiness” and “Comfort”. Six participants had clearly positive psychological effects of “Anxiety / Uneasiness” as shown in Figure 5. Moreover, four participants had clearly positive “Comfort” effects as Figure 6 shows.

In addition, three participants had clearly positive “Relaxed” effects distinctly positive effects and all of them were classified as “Completed all typing tasks”.

From these results, all participants clearly obtained psychological positive effects in at least one mood item via wrist warming. However, the positive effect varied. The main factors were assumed the case of the effect of timeout or the case where the number of input errors in the second experiment was greater than the number of input errors in the first experiment.

### 3.2 Physiological responses to Wrist Warming

To confirm change of TEMP, GSR, and HR, the following data were extracted from BioTrace+:

- **PRE-EX**: Last 30 seconds before the first calm period elapsed.
- **EX-FIN**: Last 30 seconds before the typing test ended.
- **REST-FIN**: Last 30 seconds before the armrest use ended.

We then calculated the average of each data and compared both of them. To analyze the statistical data, we used IBM SPSS Statistics.

#### 3.2.1 Influence on TEMP

No significant difference was observed between the warm and normal temperature armrest. However, we discovered that in many participants, the skin temperature of the base of little finger was increased, although we did not directly warm this region.

Figure 7 shows the amount of change from PRE-EX, and Table 5 shows the effect obtained from the difference between EX-FIN and REST-FIN.
Table 5. Effects of TEMP (Skin Temperature)

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>○</td>
<td>○</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>○○</td>
<td>○○</td>
<td>○○</td>
</tr>
<tr>
<td>Warm</td>
<td>Δ</td>
<td>○○</td>
<td>○</td>
<td>○</td>
<td>×</td>
<td>○○</td>
<td>○○</td>
<td>○○</td>
</tr>
</tbody>
</table>

[○○] : Significantly increased (>1 )
[○] : Increased (>0.5)
[△] : Increased slightly (>0)
[×] : Not Increased

From the result, the finger skin temperature (TEMP) increased for many participants via wrist warming. Therefore, it is possible that they experienced stress relief by wrist warming. Moreover, there is a high possibility that they obtained these stress relieving effects by the warming of their fingers whose temperatures had decreased because of the mental workload.

3.2.2 Influence on GSR

Wrist warming decreased GSR for some participants. However, many of them had the result of their GSR decreased in normal temperature armrest than in wrist warming. Figure 8 shows amount of change from PRE-EX, and Table 6 shows the effect obtained from the difference between EX-FIN and REST-FIN.

![Figure 8. Changes of GSR](image1)

Table 6. Effects of GSR

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>○</td>
<td>○</td>
<td>○○</td>
<td>○○</td>
<td>○○</td>
<td>△</td>
<td>○○</td>
<td>○○</td>
</tr>
<tr>
<td>Warm</td>
<td>○</td>
<td>○○</td>
<td>○</td>
<td>×</td>
<td>×</td>
<td>△</td>
<td>○○</td>
<td>○○</td>
</tr>
</tbody>
</table>

[○○] : Significantly decreased (>1 )
[○] : Decreased (>0.5)
[△] : Decreased slightly (>0)
[×] : Not Decreased

From the result, it seems possible that increased finger skin temperature by wrist warming increases GSR. Therefore, it seems possible that the sensors could not accurately detect the stress relieving effects of wrist warming.

3.2.3 Influence on HR

Figure 9 shows EX-FIN and REST-FIN for HR, and Table 7 shows the effect obtained from the reduction rate between EX-FIN and REST-FIN. In this result, no significant difference was detected between the warm and normal armrests.

![Figure 9. Changes in HR](image2)

Table 7. Effects of HR

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>○</td>
<td>○</td>
<td>○○</td>
<td>*</td>
<td>○○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Warm</td>
<td>○</td>
<td>○○</td>
<td>○</td>
<td>*</td>
<td>△</td>
<td>○○</td>
<td>○○</td>
<td>○○</td>
</tr>
</tbody>
</table>

*1 participant data was excluded cause by sensor measurement error

[○○] : Significantly decreased (>10%)
[○] : Decreased (>5%)
[△] : Slightly decreased (>0%)
[×] : Not Decreased
In this experiment, we had measured ECG data from both arms of each participant. 1 participant could not detect normal heart rate because of interference by muscular motion. Moreover, it seemed possible that other participants HR data had some influence due to same reason.

4 CONCLUSION

In this study, we researched the psychological and physiological responses to wrists warming after mental workload from a timed typing test. Psychological responses were evaluated with a 21 questionnaire items with 7 mood state categories. Physiological responses were evaluated with changes in the heart rate, skin temperature and galvanic skin temperature. We conducted an experiment involving 8 healthy participants.

Considering the results, wrist warming after mental workload may result in mental stress relief. This is because participants had clearly improved moods of “Anxiety/Uneasiness” and “Comfort” due to the temperature rise of their fingers. On the other hand, it is possible that wrist warming could bring a few positive effects for people under intense stress.

In the future, to clarify the mental stress relief effects of wrists warming, the impact of differences in personality should be elucidated. We will research it by using additionally physiological responses such as heart rate variation. Moreover, we will research the impact of wrist warming as a new relief method in the office after implementing mental workload.

REFERENCES