

Shusaku NOMURA¹, Masateru FUJITA², Takuma SAKAMOTO¹

A PRELIMINARY STUDY OF ESTIMATING A MENTAL WORKLOAD WITH WEB-BROWSING USING STRESS BIOMARKERS

The Recent rapid growth of the information technology aid people to improve the performance in processing their job activities. These changes, in turn, force them to carry out their job activities using computers in the workplace; that results in the increase of somatic and/or mental stresses. In this study, we conducted a preliminary experiment to estimate an impact of web-browsing on human mind and body. Two types of web-browsing tasks, which are a 18-minutes of continuous web-browsing and an intermittent web-browsing (first 45 second of each 1-minutes interval), were given to the subjects (10 healthy male aged from 20-23) with within-subjects experimental design. With regard to physiological measures, two prominent stress biomarkers, salivary immunoglobulin A (IgA) and cortisol, were employed. Comparing among the task conditions, relatively larger and long-lasting increase of IgA and smaller decrease of cortisol was observed with an intermittent web-browsing despite there was no difference in the psychological state. These results illustrate the difficulty of estimating the mental workload caused by web-browsing and the importance of employing physiological indices.

1. INTRODUCTION

Recently, a mental workload by the use of computers in the workplace has been increasing with developing the highly-networked information infrastructures. On the other hand, excessive use of the computer can form a risk factor of a mental diseases. Nowadays, the management of the workload with computer becomes one of the most important issue in terms of the labor hygiene. With this background, researches targeting on the evaluation and the management of the mental workload with computer also increase in number [3], [7].

However, due to the fact that there is huge difference in stress-coping ability among individuals, it is quite difficult to estimate and manage the stress level of a person. In this study, we did a preliminary study to estimate an impact of the mental workload that originates in the web-browsing environment on body and mind, assuming more web-browsing activity would leads more psycho-physiological stress on user.

With regard to physiological measure, the immunoglobulin A (IgA) and cortisol within saliva were introduced. These subjects are considered as a stress biomarker; that means the concentration of the substances within saliva increase under stressful circumstances, such as under a short-time cognitive stressor or a mental workload. Recent development of the biochemical

¹Nagaoka University of Technology, Japan

²Shimane University, Japan

analysis techniques delivers this stress evaluation schema, and now it forms interdisciplinary scientific fields such as psychoneuroendocrinology and psychoneuroimmunology [1], [2], [4], [5], [6].

2. METHOD

2.1. SUBJECTS

Subjects, 10 male university students aged from 20-23, voluntary participated in this study. They were confirmed to be healthy and not to have any medication on the experiment day. This study was conducted in accordance with the ethical principles of the Helsinki Declaration and after obtaining informed consent from each subject.

2.2. EXPERIMENT

Fig. 1 shows the schema of the experiment. The experiment was designed as within-subject study, where subjects were required to perform two types of web browsing task for 18 minutes. Those tasks were 1) conducting web-browsing for 18 minutes continuously without rest (hereafter it is described as Task A) and 2) conducting web-browsing for 18 minutes intermittently with rest: conducting web-browsing the first 45 second of each one-minute interval (denoted as Task B). The subjects were instructed to conduct the web-browsing at any pages they want but limited as news pages with written by their mother language (Japanese). During Task B, the interval of browsing-rest was indicated on the computer screen.

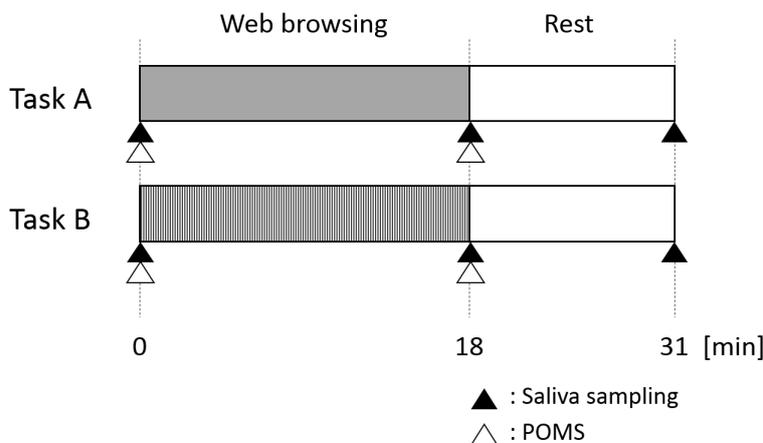


Fig. 1. The schema of the experiment. A continuous and an intermittent web-browsing in Task A and Task B was given to the subjects, respectively, with within-subjects experimental design.

2.3. MEASUREMENTS

For the purpose of behavioral analysis, we developed a proprietary web browser (Fig. 2), by which the number of character on the web page at which the user is watching and the duration of the page at which the user is staying; so the speed of browsing (Fig. 2A) and total number of the character on the pages the subjects go through (Fig. 2B), can be measured.

With regard to psychological measure, the Profile of Mood State (POMS) in Japanese version, was asked to complete before and after the browsing tasks (Fig. 1). POMS is a standardized



Fig. 2. The hard-copy of our developed web browser by which a browsing speed (depicted as the area A) and total number of characters browsed (depicted as the area B) are monitored.

psychological mood scale which consists of 64 items and assess six mood factors: which are anger-anxiety, tension, depression, fatigue, vigor, and confusion.

With regard to physiological measures, the immunoglobulin A (IgA) and cortisol in saliva were employed. IgA, an immune substance, and cortisol, a steroid hormone, has been frequently introduced as a stress biomarker which represents two types of physiological stress reaction in the body: these are the sympathetic-adrenal medulla (SAM) system and hippocampus-pituitary-adrenal (HPA) system [1], [5], [6], respectively. Both substances within saliva elevates rapidly when the subject is exposed to a short-time cognitive stressor or a mental workload. However, because of the nature of HPA system, cortisol response can be solely induced with relatively stronger stressor, such as oral defense for the final examination at university [1], [2], [4], [6], [5]. Saliva samples were taken at the beginning of the task, at the end of the task, and at end of the rest (13 minutes rest after web-browsing). Then the samples were stored at bio-freezer by the day of biochemical determination. IgA and cortisol were determined by enzyme-linked immunosorbent assay (ELISA) with commercial reagents kit (Salivary assay kit for IgA and cortisol, Salimetrics, Inc., USA).

Each subjects went through the two condition (Task A and Task B) on a separate day in an air-controlled laboratory room with the counter-balanced sequence.

3. RESULT AND DISCUSSION

With regard to the number of characters on pages where subjects has browsed, the number in Task A is significantly larger than that in Task B as shown in Table 1 ($p < 0.01$). Although taking the actual web browsing time in Task B, which is the three fourths of that in Task A, into account, the total number of the characters that the subjects looked through in Task A is still higher than that in Task A. This simply means that the subjects browsed faster in Task A than in Task B.

Table 1. Total number of the characters on pages where subjects went through during Task A and Task B, respectively.

	Task A	Task B
Mean	17402	10048
S.D.	(7706)	(3137)

With regard to the psychological measure (POMS), the factor fatigue in POMS were significantly increased in both Task A and Task B. However, no marked difference was found among

the other factors and between the tasks as well. This indicated the web-browsing employed in this study functioned as a simple and weak mental workload to some extent, but there was psychologically no difference in the mood between Task A and Task B.

With regard to physiological measures, IgA concentration increased before and after the task ($p < 0.05$) for both tasks as shown in Fig. 3. In Task B, IgA increased even in the rest period after the Task B ($p < 0.05$). As mentioned above, IgA is the physiological stress bio-marker responding against a short-term cognitive stressor [1]. So the result of that the increase of IgA in both tasks is consistent with previous and relevant studies. However, comparing among the conditions, it is intriguing that IgA kept increase during the rest period in Task B resulting relatively higher IgA in the rest period than that in Task A: it implies Task B gave more impact on the subjects despite it has an intermittent break during web-browsing. One possible explanation for this result may be of that the subject could not focused on the web browsing by the intermittent break during the task B and such a frantic effort, in turn, impaired their physiological states. Thus it is possible that too often forced breaks can be more stressful than a continuous given task.

On the other hand, cortisol has a trend of decrease in Task A ($p < 0.10$), but not in Task B. Because cortisol is a biomarker representing the HPA system which enhances its activity against a strong, like a life-threatening, stressor, it is natural that cortisol has decreased against a mental cognitive stressor employed in this study. Nevertheless, it is relatively smaller decrease of the cortisol in Task B than that in Task A was observed. Collectively with the result of IgA, it indicated that Task B may give a relatively greater impact on the physiological state of subjects comparing with Task A.

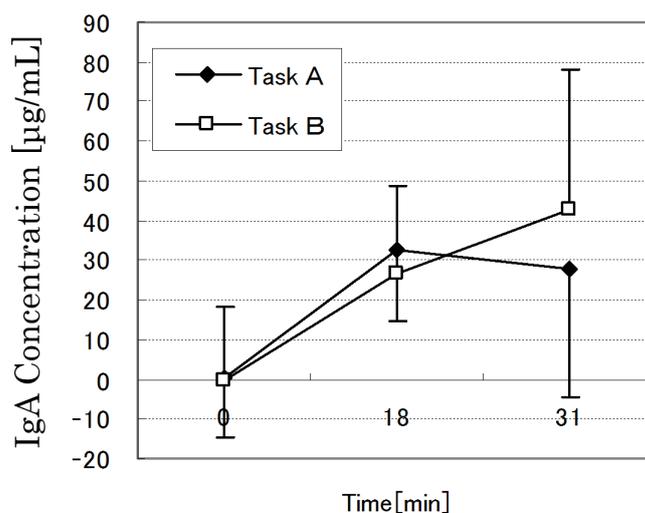


Fig. 3. Change in the salivary immunoglobulin A (IgA) during the tasks and the rest afterward.

Contrary to our expectations, the result of our psycho-physiological experimental shows the simple fact that the human mental and somatic stress caused by web browsing would not be presumable by merely the amount of reading pages. However at the same time, the result of our experiment also implies the difficulty of self-management of physical stress induced by web browsing. Because IgA and cortisol showed the difference in stress reaction between the tasks while no difference was observed in the psychological measures.

The biochemical determination technique are drastically developing day by day, as real time monitoring are promising in near future. Therefore, as for the future works, it is necessary to introduce physiological measures to precisely estimate the workload of a person.

The homogeneous subject (male university student), small number of subjects, no variation in the duration of the web-browsing, no variation of the web page (limited as news pages)

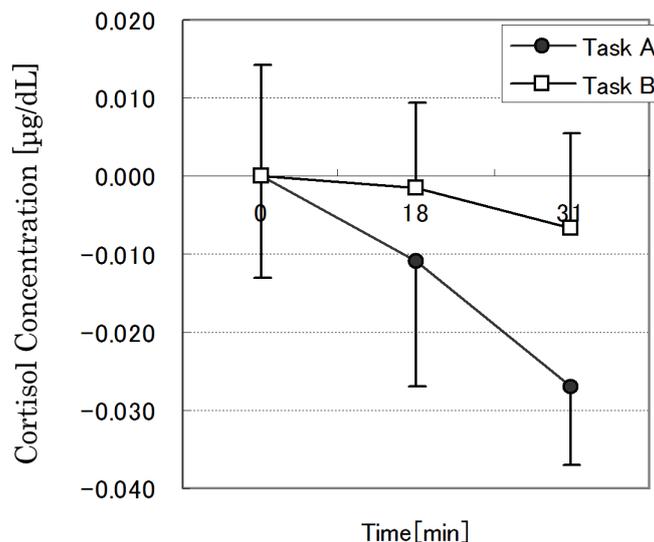


Fig. 4. Change in the salivary cortisol during the tasks and the rest afterward.

can form the limitations of this preliminary study. Especially, the psycho-physiological stress reaction under a longer period and repeated web-browsing task should be addressed in the future research as the mental workload in the work place would normally continue several hours without rest. More studies needs for the better understanding of the nature of a mental workload caused by web-browsing.

4. CONCLUSION

In this study, we conducted a preliminary experiment to estimate an impact of web-browsing on human mind and body. Considering the result of stress biomarkers on SAM and HPA system collectively, it was indicated that an intermittent web-browsing gave more impact on the subject's physiological state than a continuous web-browsing, despite there was no difference in the psychological state and the subject put more effort to conduct the continuous web-browsing. These results illustrate the difficulty of estimating the mental workload caused by web-browsing and the importance of employing physiological indices.

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