Title	Prior practice in special breathing technique improves behavior in emergencies
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Citation	Osaka Human Sciences. 5 P.127-P.138
Issue Date	2019-03
Text Version	publisher
URL	https://doi.org/10.18910/71750
DOI	10.18910/71750
rights	
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Osaka Human Sciences, **5**, 127-138
March 2019

PRIOR PRACTICE IN SPECIAL BREATHING TECHNIQUE IMPROVES BEHAVIOR IN EMERGENCIES

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Abstract

We investigated the effects of a special breathing technique, the "Breathing Retraining technique," on performance in emergency situations. Participants were divided into three groups: the breathing method group, the visual task group, and the control group. Participants in the breathing method group performed the Breathing Retraining technique, those in the visual task group performed a simple visual task, and those in the control group performed a random task before performing the main one. The main task was the water-pipe game, whereby participants clicked on a computer mouse in various situations and aimed to complete the game using the minimum number of clicks. Results indicated that the breathing method group accomplished the most difficult main tasks faster and more efficiently than the other groups in simulated emergency situations. These results suggest that people can work comparatively fast and efficiently even in emergency situations by practicing the Breathing Retraining technique beforehand. Additionally, there were no significant differences between the visual task group and the control group. This result indicates that it is not helpful to merely wait for an emergency; practicing the right breathing technique in advance helps individuals perform better in emergency situations.

Key words: Breathing Retraining technique, emergencies, high arousal

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This article is the English translation of the original one "Ueda, M., Wada, K., and Usui, S. (2015). Joint Procrustes analysis: Simultaneous nonsingular transformation of component score and loading matrices. *Japanese Journal of Research on Emotions*, **22(3)**, 103–109 (in Japanese)". The publication of its English translation has been permitted by the Japan Society for Research on Emotions.
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1. Introduction

There is always the risk of being involved in an unimaginable event or encountering a rare emergency while carrying out a task. When in a state of high arousal, as with emergencies, tasks that are normally easy can take longer than necessary or can be done improperly. These kinds of situations happen every day. This can cause a reverse U-shaped relationship between performance and the arousal level and, according to the Yerkes and Dodson rule, performance can drop when arousal is too low as well as too high.

In other words, in emergencies, anxiety or nervousness caused by the unusual environment can make the user's arousal level rise excessively, hindering their ability to perform adequately. In prior research studies, it was observed that people have a tendency toward cursory behavior when in emergencies (Ueda, Wada, & Usui, 2013; Ueda, Wada, Usui, 2011). It has been experimentally demonstrated that these situations increase human error. Thus, this study investigates the kind of actions that should be taken before starting tasks in order to decrease human error caused by emergencies.

In particular, this study incorporates a special coping mechanism called Breathing Retraining and analyzes how it affects work done in various environments after it has been performed beforehand. Various methods and techniques can be used as coping mechanisms. However, Breathing Retraining was selected for this study because special breathing techniques such as this one are beneficial as they can be used anywhere, are free, and save space.

One particular reason for choosing Breathing Retraining and not deep breathing is because breathing deeply during an emergency can cause hyperventilation, since one starts from a state of inhalation and breathes in more air than they need (The Japanese Respiratory Society, 2013). In addition, the general goal of deep breathing is relaxation of healthy individuals when they feel stressed. Using deep breathing in emergencies, however, can cause arousal levels to drop more than necessary, resulting in insufficient actions.

On the other hand, Breathing Retraining is a technique used for patients with panic syndrome or anxiety disorders (Antony & McCabe, 2004; Taylor, 2001). It has two main characteristics: patients are trained to always begin on an exhale, and the ratio of exhalation to inhalation is 1:1. The goal is to regulate arousal and breathing difficulties exacerbated by nervousness and anxiety. In other words, the goal is not to relax but rather to refresh. For this reason, it is thought to be less likely to excessively drop arousal compared to deep breathing.

For the above reasons, Breathing Retraining was chosen as a coping method in situations where swift and precise action is needed. The differences between Breathing Retraining and deep breathing are shown in Table 1.

Table 1.
The Difference between Breathing Retraining and Deep Breathing

	Breathing Retraining Method	Deep Breathing
Subjects	**Panic Syndrome and Anxiety Disorder Patients**	All (the healthy and patients)
Main Goal	**Restore (refresh) irregular respiration caused by nervousness, anxiety, or breathing difficulty**	Stress dissolution/relaxation
Method	**Inhalation and exhalation time is 1:1. Hold breath and start from exhalation**	Inhalation and exhalation time is 1:2

2. Methods

2.1. Participants

The study had, as participants, 45 healthy males aged 22 to 33 (Average age: 27.2 (SD = 3.2). At the end of the experiment, they were paid 10,000 yen for participation.

2.2. Experiment task

The task of this experiment is shown in Figure 1. A water-pipe task (where the participant moves water from the water tank to a specified point) was shown on a large monitor (Mitsubishi, LCD Display LDT551V). This exercise is a modified version of that used by Kano (1938). The task's content is nearly identical to that used in previous experiments (Ueda et al., 2013; Ueda et al., 2011).

In this task, water flows from the water tank in the upper portion of the screen through pipes (referred to as switches) with various interchangeable channels and squares and finally stops at 7 red or yellow lightbulbs. The switches rotate at 90° when clicked. A left click turns them clockwise and a right click turns them counter-clockwise (the reverse is also possible, counter-balanced between the participants). When the flow of water from the tank to the lightbulbs is blocked by the switches' revolution, the lightbulbs shut off, turning the light grey. At the beginning of each task, red and yellow lightbulbs are always present, but the positions and number of illuminated bulbs are different each time.

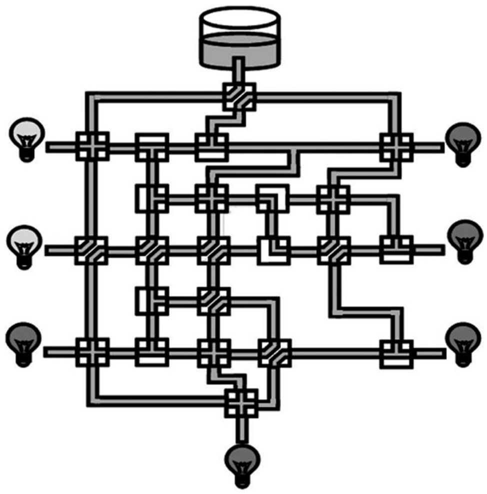

Figure 1. An example of the channel task

The goal of the task is to turn all red bulbs off while keeping the yellow bulbs lit. However, the participants were instructed to complete the task using as few switch changes as possible. There were three difficulty levels: low, medium, and high. This difficulty level was set according to the shortest possible number of revolutions it would take to complete the task. (Low: 3 times, Medium: 9 times, High: 15 times). The order of implemented difficulty was counter-balanced between the participants.

2.3. Arousal condition

The water-pipe task is performed in three conditions: high arousal, time pressure, and the control condition. Each condition is explained below.

2.3.1. High-arousal condition

In addition to displaying a time limit (100 seconds), visual, auditory, and tactile warnings of the time limit are given. However, the task must be completed, even after the allotted time limit ends. A consequence is also established (detailed later). This is based on prior research where emergency situations are defined by time pressure and consequences (Abe, 1988; Hosoda & Inoue, 2000; Ikeda, 1986; Toda, 1992). The stimulus settings are explained below:

1. Time pressure display: A time limit of 100 seconds is displayed on the lower section of the monitor. The numbers count down from 100, decreasing by the second.
2. Visual Stimulus: Illumination of the LED begins in the beginning of the task. The International Organization for Standardization (1996) standard (ISO11428:1996) was referenced for blinking code. Chromatic stimulus follows the International Organization for Standardization (1996) Standard (ISO11429:1996). The 100-second time limit is split into four 25-second stages. As each stage is reached, the LED blinks more frequently, ultimately blinking repeatedly without ceasing. The color of the light changes with each stage: from green, to blue, to yellow, and finally red.
3. Auditory Stimulus: A 2 kHz (approximately 85 dB (A)) pure tone is played based on the Japanese Standard Association (2011) standard (JIS S 0013:2011) and using Mizutani, Matsuoka, and Komatsubara (1997) and Yamauchi, Takada, and Iwamiya (2003) as reference. The repetition and cessation time period is synched with the blinking and cessation of the light.
4. Tactile Stimulus: A factory fan (Trusko, TFZ-45SA) blows a strong wind 25 seconds before the time limit ends. This is based on previous research where the introduction of Strong wind raises arousal levels (Sakamoto, Nozawa, Tanaka, Mizuno, & Ide, 2006).
5. Consequence setting: Participants are told that depending on the average of their 3 scores in the high arousal setting, their reward would gradually drop from 10,000 yen to 5,000 yen. This concept was based on preceding research which states that an unstable reward structure contributes to panic (Minz, 1951). As the investigation goal is later revealed in debriefing, however, they receive 10,000 yen regardless of their performance results.

2.3.2. Time pressure condition

Time pressure is imposed on condition only. There are neither visual, auditory, or tactile stimuli, nor consequence configuration. However, as with the high arousal condition, the task must be completed even after the end of the allotted time limit. The time pressure display is identical to that of the high-arousal condition.

2.3.3. Control condition

No visual, auditory, or tactile stimuli are given and there is no time pressure. Participants are instructed to take as long as they need to complete the task with minimal effort (switch changing). Counterbalancing is applied for the high arousal, time pressure, and control conditions. The three types of procedural orders are counterbalanced between subjects. Additionally, in all conditions, the participants are instructed to complete the task regardless of the presence or absence of a time limit. However, if the participant is unable to complete the task within 15 minutes, then the exercise is terminated and deemed a failure[1)].

2.4. Each group's activity

Participants were split into three groups in order to assess the effects of performing Breathing Retraining beforehand. Below is an explanation of the activity for each group.

2.4.1. The breathing method group

Before the water pipe task, this group practiced Breathing Retraining for two minutes (15 subjects, average age: 26.7 (SD = 3.2)). This method of Breathing Retraining is based on that of Taylor (2001) Antony and McCabe (2004), and Kobayashi and Shimizu (2008). The participants performed the Breathing Retraining technique and started the actual experiment after training.

The training and actual experiment procedures are shown below:

1. Training: Before the experiment, researchers explained Breathing Retraining using the following procedures:
   First, the researchers explained the difference between abdominal breathing and thoracic breathing through illustrations. Afterwards, they made participants rehearse Breathing Retraining via abdominal respiration. Takahashi and Miyagawa (2008) served as a reference for abdominal breathing. Breathing Retraining always started from exhalation in both training and the actual experiment. Additionally, participants were instructed to inhale through the nose and exhale through the mouth. Orders were given to end exhalation and inhalation in four seconds. Participants practiced abdominal breathing as researchers counted to four. For a better sense of abdominal breathing, researchers made participants place one hand on their stomach and feel that while the abdomen moves up and down, their chest does not.
   Additionally, researchers would occasionally place their hand on the participant's hand to ensure that their abdominal breathing was in proper rhythm. Confirmation of electric discharge from the muscles via abdominal electrocardiograph was used as an objective indicator of proper abdominal respiration (Tanaka, Nagaita, Kobayashi, and Sakakibara, 2008). Further, participants were told to relax and focus more on inhalation than exhalation. They were advised to calmly recite, "Relax-2-3-4" mentally when exhaling to aid in focus.
   In the actual experiment, participants were supposed to breathe in time with a display on a

[1)] There were 4 terminations in the breathing group, 11 in the inserted task group and 14 in the control group.

monitor in front of them (not the oral count of the researcher) while in a dark room. Thus, the time spent practicing breathing in accordance with the onscreen instructions was three minutes, to the extent that after they have learned Breathing Retraining. During this practice, the researcher stood next to the participant to make sure that they were breathing abdominally, to go over how to perform The Breathing Retraining technique, and to facilitate their attention. Finally, the participants rehearsed in an environment identical to that of the actual experiment. The researcher did not stand next to the participants as they executed Breathing Retraining by themselves. The above Breathing Retraining practice required approximately 30 minutes.

2. Actual Experiment: Before the water-pipe task. Breathing Retraining was done then followed by the onscreen directions for two minutes. After the command for each type of arousal level (High arousal, time pressure, and control) was given, the screen changed and displayed the Breathing Retraining screen. The Breathing Retraining screen was ordered as follows. First, a five-second countdown along with a "Please get ready for Breathing Retraining" advisory was shown. Next, the following advisories were displayed consecutively: "Please hold your breath" was shown for five seconds, "Exhale through your mouth" was shown for four seconds, and "Please inhale through your mouth" was shown for four seconds. Then, "Exhale through your mouth" and "Inhale through your nose" were repeated alternatively 15 times every four seconds (for approximately two minutes). After the alternation of these phrases, "Please breathe regularly" was displayed.

2.4.2. Visual task group

This group (15 subjects, average age: 28.1 (SD = 2.9) performed a simple visual task for two minutes. The visual task group was established to assess how a different activity, other than that performed by the breathing group, before the main task affects performance on the water-pipe task. To that end, the task was set to take the same amount of time as that of the breathing method group to ensure they spent the same amount of time looking at a monitor as the breathing group did, and to ensure that their activity was not excessively difficult.

Researchers offered training for the visual task and conducted the actual experiment after training. Training and the experiment were carried out in a dark room. Below are the training and experiment procedures:

1. Training: The same visual task was used for training and the experiment. A black cross shape appeared on the upper portion of the monitor in front of the participant, moving clockwise. The participant was instructed to follow the cross with their eyes. The cross icon occasionally changed to a red X. The participant was instructed to press 0 on a number pad on the left as fast as they could when they saw the red X. Training and the real experiment both took two minutes.
2. Experiment: Before the water-pipe task, participants performed the visual task for two minutes. The task was similar to the training.

2.4.3. Control group

This group (15 subjects, Average age: 26.7 (SD = 3.2)) completed the water-pipe task without conducting any task beforehand. No instructions were given on the monitor. The control group was established to measure the intrinsic performance of the water-pipe task by not placing a 2 second interval beforehand as in the breathing method and visual task groups.

3. Results

The three independent variables are the types of pre-activity (between subject factors: breathing method, visual task, and nothing (control)): arousal condition (within subject factors: high Arousal, time pressure, and control) and level of difficulty (within subject factors: high, medium, and low). Taking these three independent variables as factors, a three-way mixed design analysis of variance was conducted as shown below. The dependent variables of this investigation are the time needed to complete the objective (required time) and the number of clicks made until the objective was completed (total number of clicks)

3.1. Required time

An analysis of variance was conducted for the required time. As a result, the main effect of difficulty was found to be significant (See Figure 2) ($F(2, 84) = 184.85$, $p < .001$).

In addition, the first-order interaction between the types of preliminary preparation was significant ($F(4, 84) = 2.51$, $p < .05$). After performing post-hoc tests, the simple main effect of

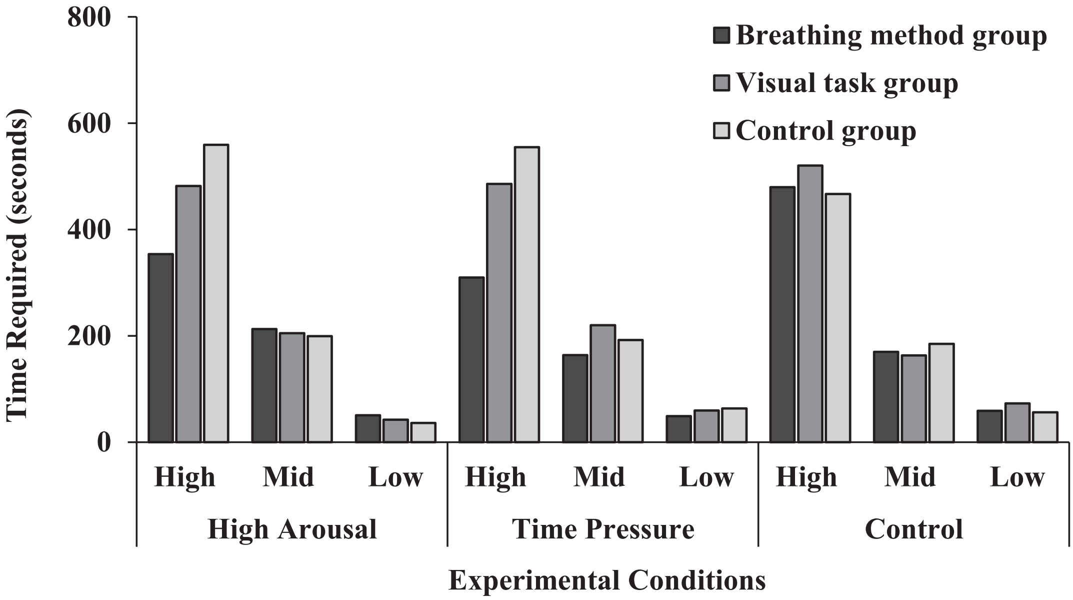

FIGURE 2. Time Required (seconds)

difficulty was found to be significant in every group (Breathing Method Group: $F(2, 84) = 37.86$, $p < .001$, Visual Task Group: $F(2, 84) = 69.39$, $p < .001$, Control Group: $F(2, 84) = 82.62$, $p < .001$). After conducting a Ryan multiple comparison test in every group, a significant difference was observed between all of the difficulty levels of each group (all $p < .01$). The simple main effect of the type of preliminary preparation in the "high" difficulty level condition was also significant ($F(2, 126) = 7.20$, $p < .005$). After conducting a multiple comparison, it was observed that the breathing method group completed the water-pipe task significantly faster than the visual task and control groups (all $p < .01$).

3.2. Total number of clicks

Conducting an analysis identical to that of Required Time, the main effects of the type of preliminary preparation, arousal condition, and difficulty were all found to be significant (See Figure 3) (type of preliminary preparation: $F(2, 42) = 7.01$, $p < .005$, arousal condition: $F(2, 84) = 9.50$, $p < .001$, difficulty: $F(2, 84) = 67.92$, $p < .001$).

A difference was observed in the first-order interaction between arousal condition and difficulty, and the first-order interaction between the type preliminary preparation and difficulty was found to be significant (arousal condition and difficulty: $F(4, 168) = 2.28$, $p < .10$, type of preliminary preparation and difficulty: $F(4, 84) = 2.49$, $p < .05$). When conducting a post-hoc test for the first-order interaction between the arousal condition and difficulty, the simple main effect for the arousal condition in the high and medium difficulty levels was significant (high difficulty: $F(2, 252) = 9.63$, $p < .001$, medium difficulty: $F(2, 252) = 3.15$, $p < .05$). After

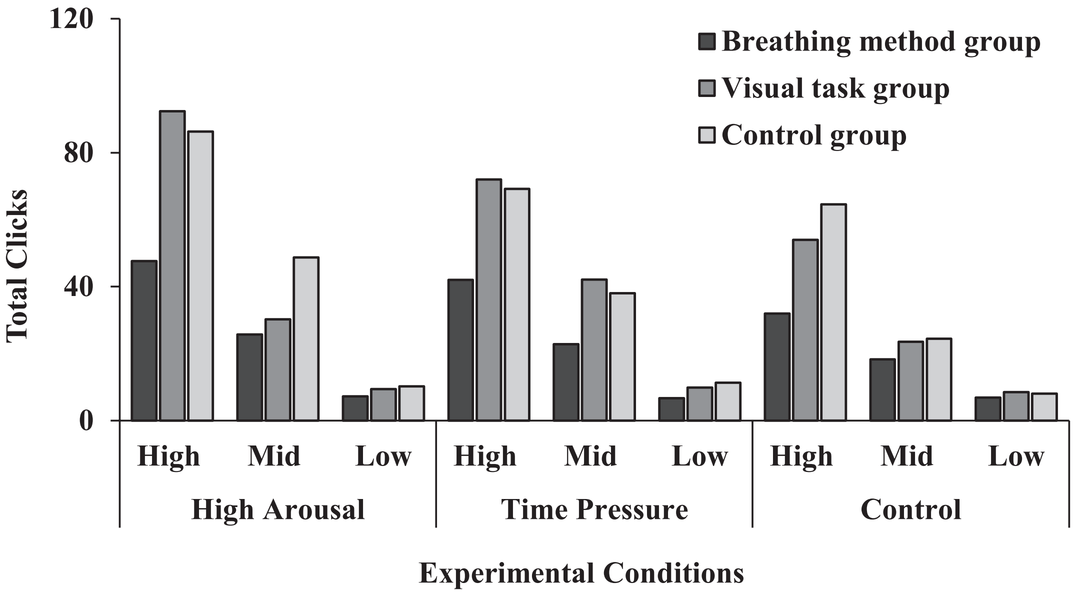

FIGURE 3. Total Clicks

conducting a Ryan multiple comparison test, a marginal difference ($p < .10$) was observed in the high difficulty level under time pressure and control conditions. A significant difference was observed in the other conditions (all $p < .05$). In the medium difficulty condition, a significantly higher number of clicks was observed under the high arousal and time pressure conditions compared to the control condition (all $p < .05$).

After performing a post-hoc test for the first-order interaction between the type of preliminary preparation and the difficulty level, the simple main effect of the type of preliminary preparation in the high difficulty condition was found to be significant ($F(2, 126) = 10.59$, $p < .001$). Thus, upon performing a multiple comparison, the breathing method group completed the water-pipe task within a significantly lower number of clicks compared to the visual task and control group. (all $p < .01$).

4. Discussion

From the research results, as well as Figures 2 and 3, it was observed that as the difficulty level rises, so do the required time and total number of clicks. This can be considered a suggestion that this configuration, difficulty set by the number of clicks, was valid.

From the results of the multiple comparisons of arousal conditions under the high and medium difficulty conditions, it was found that as the arousal condition rises, the total number of clicks also increases. This demonstrates that even though the tasks are identical in difficulty, efficiency decreases more in emergency situations compared to normal conditions. Additionally, this result reflects that of our previous research results, which suggests that this phenomenon is sound to some degree (Ueda et al., 2013; Ueda et al., 2011).

Further, from the results of the multiple analysis of the type of preliminary preparation in the high difficulty condition, when conducting Breathing Retraining, the required time was shortened in the highest difficulty condition and the total number of clicks was lessened as well. This was the most important result for the research goal and was evident when comparing the visual task group and the control group. Therefore, it can be said that executing Breathing Retraining beforehand leads to an increase of performance in high-difficulty tasks in contrast to doing nothing or placing an interval between tasks. That is, the research results demonstrate that tasks done after conducting Breathing Retraining are completed faster and more efficiently. In addition, according to the data from each graph, this improvement effect was also produced in high-arousal situations defined as emergencies. This suggests that even in emergency situations, the performance-improving effect of Breathing Retraining is maintained.

Moreover, Breathing Retraining has been a technique used mainly for patients who suffer from panic syndrome or anxiety disorders. From this research result, however, it was confirmed that it has a substantial effect on healthy individuals as well.

Originally, one of the reasons Breathing Retraining was deemed to have an effect on patients who suffer from panic syndrome, is that there are individuals who are more susceptible to hyperventilation compared to healthy individuals. Performing Breathing Retraining can be a part of therapy for those individuals prone to hyperventilation (Antony & McCabe, 2004). Especially for people who suffer from panic syndrome, daily practicing of this breathing technique can help them internalize the tenet of cognitive-behavioral therapy which asserts that what they fear will not be actualized when they are having an attack. However, there are patients who do not seem affected by Breathing Retraining because there are individual differences in disposition and condition.

Nevertheless, even though the test subjects for this experiment are all healthy individuals and they do not conduct a daily Breathing Retraining practice, an improvement in performance was still observed. The reason is considered to be similar to that of it being used for patients who suffer from panic disorders.

Healthy individuals also breathe faster than necessary when experiencing stress or fear. Conducting Breathing Retraining beforehand can mitigate subjective stress or inclinations to anxiety and, as a result, performance post-Breathing Retraining can be improved. Further, the reason an improvement was observed without daily breathing training could be because healthy individuals, unlike patients who panic, do not possess a strong anticipatory anxiety that they will have an attack. As a result, breathing could be regulated in several Breathing Retraining executions, which possibly led to an alleviation of subjective stress.

In addition, abdominal breathing is used in Breathing Retraining. Abdominal breathing has been found to reduce the concentration of the stress hormones adrenaline, noradrenaline, and cortisol (for example, Tanaka, Nagaita, Yano, Kobayashi, & Sakakibara, 2011). It is observed that this is not solely during abdominal breathing, but this effect is sustained to some extent even after returning to normal breathing (for example, Kataoka & Shibuya, 2002). Breathing Retraining not only leads to a drop in psychological stress, but also physiological stress. As a result, its potential in improving performance is high. A deep evaluation of the relationship between physiological indicators and performance must be conducted, hereafter.

In conclusion, there was no significant difference between the visual task group and the control group in any of the analysis results. This suggests that conducting a simple visual task beforehand is equal to doing nothing beforehand. This research analysis shows that practicing proper breathing tasks before tasks (not merely placing an interval in between) in emergencies results in better task efficiency.

Since this study was performed in a laboratory setting, the effects of Breathing Retraining must be revaluated using tasks akin to those encountered in realistic settings.

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