GUNGEN-Heartbeat: A Support System for High Quality Idea Generation Using Heartbeat Variance

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SUMMARY We propose an idea generation support system known as the “GUNGEN-Heartbeat” that uses heartbeat variations for creating high quality ideas during brainstorming. This system shows “an indication of a check list” or “an indication to promote deep breathing” at time beyond a value with variance of heart rates. We also carried out comparison experiments to evaluate the usefulness of the system.

key words: brainstorming, smartwatch, checklist method, deep breath, variance of heart rate

1. Introduction

There is an abundance of data availability on the internet and research on the analysis of the so-called big data has been on the rise. However, the data involving ideas such as suggestions for improvement that can be used as is are scarce. Therefore, a mechanism for idea creation is required, such as a mechanism that a skilled facilitator guides [1]. Moreover, not only big data, but also the involved parties must create ideas to arrive at solutions for familiar concerns.

Brainstorming [2], which is a popular method for idea creation, focuses on the quantity of the generated ideas rather than the quality. Therefore, in this study, we consider the improvement of the quality of the ideas at the time of idea generation. We believe that the physical condition of the participants is related to idea generation, and this research uses heart rate as a parameter; this choice is based on a previous study, which reported that when people become drowsy while driving, their heart rate variance increases [3].

In this study, we aim to develop a support system for high quality idea generation using screen displays, taking into consideration the physical condition of the participants during brainstorming. Specifically, the relationship between idea generation and idea quality is analyzed using heartbeat as a parameter. Based on the results, the variance is first calculated from the time-series data of the heartbeat of each participant. Next, it is suggested that the changes in the value encourage the user to generate an idea or to change his mind by deep breathing. We then verify that a high quality idea is generated.

2. Related Research

There are various studies on heart rate variability [4]. For instance, it is known that when sleepiness increases, the variance value is large, but when awake, the variance value decreases [3].

Brainstorming is a representative method of idea generation developed by Alex F. Osborn. Postponed judgment, liberation, quality than quantity, and bond improvement are its rules [2]. He also formulated a checklist method [2], in which ideas are creatively generated by answering a prepared checklist. There is a commonly used method for constructing a checklist using questions that apply to: (1) conversion, (2) application, (3) change, (4) enlargement, (5) reduction, (6) substitution, (7) rearrangement, (8) reverse, and (9) combination [2].

Wang et al. proposed the Idea Expander to create ideas through photography [5], [6]. During brainstorming in multiracial groups, they compared the influence of a picture displayed in the content of the chat (between the groups) on the idea. According to the results, although it was clear that the cultural background of the creators is deeply related to the ideas generated by looking at the picture, the quality of the created ideas was not affected [6]. There was only a slight increase in the number of ideas created using this system [5]. Moreover, the picture display does not consider the physical condition of the participant when the idea was created.

3. Implementation of an Idea Generation Support System GUNGEN-Heartbeat Using Heartbeat Variance

3.1 System Configuration

GUNGEN-Heartbeat includes a brainstorming system (GUNGEN-Spiral II [7]) and a heart rate processing system. The heart rate processing system uses acquired heart rate data. The following procedure is involved: A smartwatch (G Watch R (LG)) was used to measure the heart rate. The results obtained using the G Watch R are observed to be comparable to the professional heart rate measuring equipment [8]. The heart rate data is sent from the G Watch R to a smartphone (Nexus 5 (LG)) via Bluetooth and to a PC. The previous 10 heart rates including the latest heart rate are obtained. The variance of the moment is calculated and a message is displayed on a smartphone. The heart rate of a human being at rest is normally around 70 beats/min.

 Manuscript received March 26, 2019.
 Manuscript publicized June 28, 2019.
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DOI: 10.1587/transinf.2019HL0001
3.2 Function

3.2.1 Judgment Method

A preliminary experiment (the theme of the idea generating method was “the ultimate game”) was conducted on eight students, who are in their twenties, using only GUNGEN-Spiral II [7]. The subjects were asked the following question: “What was the first or second best idea?”; and the ideas considered as “the first or second best idea” accounted for about 55% (9/16) of the total ideas that appeared after the variance changed by more than 10 values. On the other hand, 75% (12/16) of the ideas that the subjects considered as “the first or second bad idea” were those that had appeared after the value of variance exceeded 10. While it is difficult to identify the moment when a good idea is generated, it is believed that the moment when a bad idea is generated can be identified by detecting the increase in the variance value. The preliminary experiment yielded an average of 20.1 ideas in 15 minutes.

Assuming that the value of heart rate variance increases, it is possible that bad ideas that are subsequently generated by subjects who are, for example, “drowsy”. A message is displayed on the smartphone at the moment when the variance of the user’s heart rate exceeds 10.

3.2.2 Display of Checklist

A checklist of 23 items was used to stimulate idea generation. The question corresponding to each of the following items was displayed in the checklist: (1) conversion, (2) application, (3) change, (4) enlargement, (5) reduction, (6) substitution, (7) rearrangement, (8) inversion, and (9) combination. Figure 1 shows an example of the screen display ((4) enlargement).

3.2.3 Deep Breathing

We displayed a message prompting the user to take a deep breath as a method focused on stabilizing the heartbeat (Fig. 2).

4. Experiments and Discussion

4.1 Outline of Experiments

The subjects were asked to brainstorm while wearing the smartwatch. In this study, three experiments were conducted. In Experiment 1, the checklist method was displayed on the screen; in Experiment 2, the screen display prompted deep breathing; and in Experiment 3, no system (heart rate processing system) was used. At the end of each experiment, the subjects were presented with a questionnaire with the following question: “What percentage of the generated ideas was good?” (in 10% evaluation in percent). In addition, each subject was asked to do a five-point evaluation (1: I don’t think so at all; 2: I don’t think so; 3: I can’t say either; 4: I think so; 5: I strongly think so). Furthermore, at the end of each experiment, three people in addition to the subjects looked at the screen, the ideas generated from the experiments conducted by each subject on the screen, and evaluated (provided answers in 10% of the steps).

4.2 Experimental Method

A smartwatch (G Watch R) was attached to the arm of each of the 15 students (8 males and 7 females) of Wakayama University, who were in their twenties, and brainstorming was performed three times for 10 min using GUNGEN-SPIRAL II. The following were the brainstorming themes: “the ultimate rice,” “the ultimate eco car,” “the ultimate SNS,” “the ultimate alarm clock,” “how can Wakayama become famous in the world,” “A4 paper usage,” “a week in new products to raise public awareness as much as possible,” “to expand newly opened restaurants,” “how to make people cry,” “how to become rich,” and “an ideal work environment.” The subjects were asked to brainstorm on 3 out of the abovementioned 11 themes. The order of the experiments is counterbalanced.

(1) Experiment 1: Checklist Method

The experiment was performed after explaining to the subjects that one of the checklists will be displayed at random to make it easier to generate an idea.

(2) Experiment 2: Deep Breathing

The experiment was conducted after explaining to the subjects that they should display each time they go out to take a deep breath.

(3) Experiment 3: System not used

The experiment was conducted after explaining that the subjects were to do nothing for 10 minutes.

Figure 3 shows the setting of the experiment: The idea was presented on the PC screen (GUNGEN-SPIRAL II was used), and a smartphone (Nexus 5) was placed to the right of the screen (Exp.2 deep breathing).

4.3 Experimental Results

Figure 4 shows an example of heart rate variance (Exp-
Table 1 Examples of ideas.

| How can Wakayama Become Famous in the World | An Ideal Work Environment |
|--------------------------------------------|---------------------------|
| Improve transportation convenience         | Good salary               |
| Film a movie based on Wakayama             | Break time and work time are quite divided |
| Create an environment in which foreigners can easily migrate | Human relations in the workplace are not messed up |

Table 2 Average number of ideas.

|       | Exp. 1     | Exp. 2     | Exp. 3     |
|-------|------------|------------|------------|
| Mean  | 17.4 (65.2)| 19.4 (61.2)| 18.3 (41.0)|

Table 3 The number of display times and length of display.

|       | Number of times | Number of seconds | Average seconds |
|-------|-----------------|-------------------|-----------------|
| Exp. 1| 2.5 (2.4)       | 74.6 (421.6)      | 26.3 (139.8)    |
| Exp. 2| 3.1 (3.3)       | 96.0 (5784.0)     | 28.6 (335.5)    |
| Exp. 3| 3.1 (2.6)       | 120.0 (7693.3)    | 33.1 (328.1)    |

Table 4 Questionnaire result of Experiment 1.

| Evaluation by the person | Third-party evaluation |
|--------------------------|------------------------|
| Percentage of ideas that you think is good (%) | 52.6 | 62.4 |

Table 5 Questionnaire result of Experiment 2.

| Evaluation by the person | Third-party evaluation |
|--------------------------|------------------------|
| Percentage of ideas that you think is good (%) | 56.0 | 64.0 |

Table 6 Questionnaire result of Experiment 3.

| Evaluation by the person | Third-party evaluation |
|--------------------------|------------------------|
| Percentage of ideas that you think is good (%) | 45.3 | 54.1 |

Table 7 Questionnaire result of overall system.

|                                      | Mean value (five grades) |
|--------------------------------------|--------------------------|
| Was the system easy to use?          | 3.9 (0.2)                |
| Was it a bother to wear a smartwatch?| 1.6 (0.7)                |

The corresponding analysis of variance was performed for the number of ideas in Experiments 1–3 (Table 2). The results showed that $p = 0.46$ and there was no significant difference.

4.4 Discussion

The “percentage of ideas considered good” by subjects and third parties of each experiment (Tables 4 to 6) was eval-
uated by multiple comparisons of the corresponding non-parametric data. Note that Ryan’s method was used for multiple comparisons, and Wilcoxon signed rank sum test was used for comparison between two groups [9].

In the evaluation performed by the subjects, \( p = 0.0046 \) between Experiment 2 and Experiment 3, and there was a significant difference at significance level 1% or less. In addition, \( p = 0.0077 \) was obtained between Experiment 1 and Experiment 3, and there was a significant difference at the 5% level of significance (5% instead of 1% level of significance due to the multiple test using Ryan’s method). Between Experiment 1 and Experiment 2, the results showed that \( p = 0.20 \) and there was no significant difference. In other words, in the subject’s evaluation, when either a checklist or deep breathing suggestion was displayed on the screen, the proportion of ideas considered to be better was significantly higher than when there was no display.

Furthermore, according to the third-party evaluation, \( p = 0.00065 \) between Experiment 2 and Experiment 3, and there was a significant difference at a significance level of 1% or less. Also, \( p = 0.00147 \) between Experiment 1 and Experiment 3, and there was a significant difference at the 1% level of significance. There was no significant difference between Experiment 1 and Experiment 2 with \( p = 0.35 \). In other words, even in the third-party evaluation, when either a checklist or deep breathing suggestion was displayed on the screen, the proportion of ideas considered better was significantly higher than when nothing was displayed. Moreover, the results of the free-description questionnaire also indicated that deep breathing was a switch of feelings.

The following problems were identified: the checklist display needed to be changed more frequently, i.e., 2.5 times on an average, because of the increase in the number of items (23 items in this system), or keep displaying some length. In addition, since the quality of the generated ideas was evaluated instinctively, there was no strict definition for the quality of a good idea, and even if the heart rate differed depending on the person, the uniform variance was 10.

5. Conclusion

We proposed GUNGEN-Heartbeat, a system that uses heart rate variability to support high quality idea generation during brainstorming. This system performs “display of checklist” or “display to prompt deep breathing” when the variance of heart rate exceeds 10. A comparative experiment was conducted to verify the usefulness of the system: In the evaluation of the quality of the ideas by the subjects and third party alike, when either a checklist or deep breathing suggestion was displayed on the screen, the proportion of ideas considered better was significantly higher than when there was no display. In particular, in the case of “display promoting deep breathing”, the evaluation improved as the significance level was 1%.

In future studies, it is necessary to improve the system by improving the method of heart rate analysis and method of displaying the checklist.

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