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Temporal Analysis Method to Visualize Changes in Alternative Uses Test Performance

Ryunosuke Fukada, Kimi Ueda, Hirotake Ishii, and Hiroshi Shimoda

Department of Socio-Environmental Energy Science, Graduate School of Energy Science, Kyoto University, Kyoto, 606-8501, Japan

ABSTRACT

This study proposes a novel method to analyze divergent thinking from a temporal perspective in the Alternative Uses Test (AUT). Focus is placed on fluency and flexibility in 30-second intervals. The fluency is measured by the number of responses, while the flexibility, assessing the quality of ideas, is measured to utilize a new approach incorporating natural language processing. An experiment with 32 students yielded data suggesting a terminal effect in AUT performance, with increased fluency and flexibility observed in the last 30 to 60 seconds of trials. This methodology offers a detailed insight into the impact of changing environmental conditions and stimuli on creative performance over time.

Keywords: Creativity, Creative thinking, Divergent thinking, Alternative uses test

INTRODUCTION

In recent years, with the rapid arrival of the information society, the value of creative thinking in human intellectual work has been increasing. Guilford divided creative thinking into two broad categories: divergent thinking, which generates many diverse ideas from a concept or problem, and convergent thinking, which derives a concluding idea from many ideas (Guilford, 1967).

In research on divergent thinking, it is important to evaluate the performance of divergent thinking, and a variety of divergent thinking evaluation tasks have been studied. One of the most representative divergent thinking evaluation tasks is the Alternative Uses Test (AUT) developed by Guilford (Guilford, 1956, Guilford et al., 1978, Torrance, 1972), in which participants are asked to respond to as many ideas for different uses of the presented objects as possible. For example, if a "sponge" is presented as an object, its original use is to be used for cleaning, etc., but alternative uses include "as a base for fresh flowers" or "as a buffer to prevent furniture from damaging the floor". The performance measures of divergent thinking include fluency, flexibility, and originality, and when evaluating AUT, the number and variety of ideas and the degree of scarcity have been evaluated as scores for each measure (Torrance, 1988).

Although the AUT has been used in many studies because it is easy to implement, past studies have mainly evaluated only the performance of the AUT as a whole, and have rarely attempted to analyze it from a temporal perspective and evaluate its performance at a certain point in time. Analytical methods that focus only on performance as a whole make it difficult to analyze performance from a temporal perspective and assess how responses at a given point in time were affected, even if the people working on the AUT were stimulated or the environment or conditions under which they worked on the AUT were changed.

Therefore, the purpose of this study is to propose a method for analyzing AUT fluency and AUT flexibility from a temporal perspective. After proposing a method for analyzing AUT fluency and AUT flexibility from a temporal perspective, we analyzed experimental data on humans to see if it is possible to confirm changes in divergent thinking performance from a temporal perspective using the proposed method and to confirm the validity of the proposed method.

TEMPORAL ANALYSIS METHOD

In order to analyze performance changes in divergent thinking from a time-based perspective, this study attempted to divide task time into units of tens of seconds and to calculate the performance score in unit intervals. In this study, the length of the unit interval was set to 30 seconds based on the time spent answering the AUT in previous experiments. For example, analyzing 4 minutes of AUT responses would mean dividing the 4 minutes into 8 intervals and evaluating performance in that unit interval. The scores for fluency and flexibility in that unit intervals are calculated. For fluency, the number of responses in that interval was used. For flexibility, we used an automatic evaluation method for flexibility proposed by the authors (Fukada et al., 2023). This method employs natural language processing techniques to obtain an estimate of flexibility by comparing an idea at a given point in time with a conventional idea answered by the same person as that idea, calculating the semantic distance between them, and adding a score representing how much the idea is not similar to the conventional idea. The results are used to estimate the flexibility of the idea. This method reduces the possibility of the evaluator's subjectivity having a significant impact on the results and also allows for a more detailed evaluation of how much the idea increased the flexibility score than when the flexibility score is calculated using the number of types classified manually.

EXPERIMENT

In order to confirm whether the proposed method allows us to observe changes in divergent thinking performance from a time perspective, we conducted an experiment on human participants and conduct an analysis on the data.

Table 1. Objects presented.

For Practice Task	For Main Task
plastic shopping bag and sponge	T-shirt, aluminum foil, washtub, bed sheet, plastic bottle, broom, pillow, chopping board, pencil, desk pad, splitable chopsticks, socks, paper cup, cardboard box, butterfly net, and baseball bat

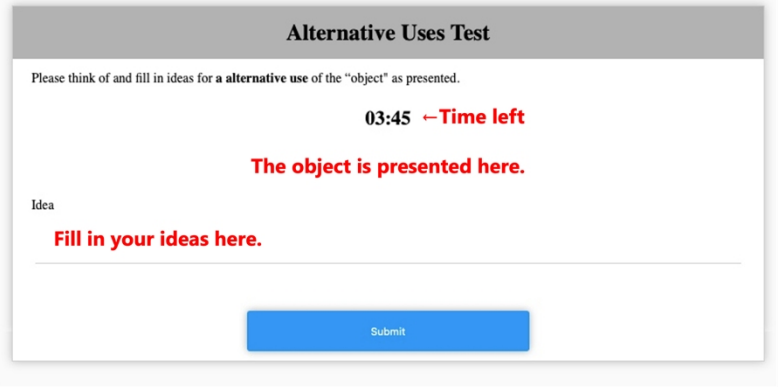

Figure 1: Screen display of application for AUT.

In this study, participants worked on AUT on a web application. The screen display of the application for answering tasks is shown in Figure 1. The number of objects presented in the AUT was 2 for the practice task and 16 for the main task. These objects are listed in Table 1. Participants were given 4 minutes per object, with a 30 second or 5 minute break between each trial. The responses obtained were used to calculate fluency and flexibility per unit of time in the method described above. They participated in the experiment with the procedure shown in Figure 2.

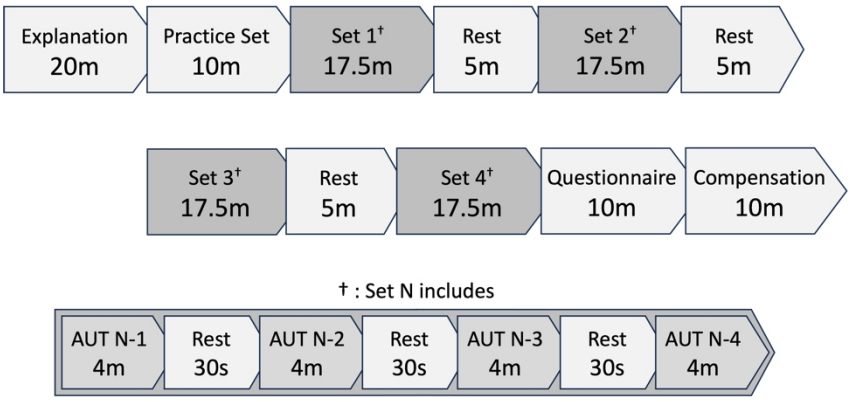

Figure 2: Protocol of the experiment.

32 undergraduate and graduate students at Kyoto University participated in this experiment. They are native Japanese speakers and can type on a keyboard. They participated in this experiment with a reward of 3,000 yen.

RESULT

For the analysis in this experiment, data from participants with even a single object that had zero responses were invalidated. After processing the invalid data, all 32 participants' data were included in the analysis.

Fluency in 30-second intervals is shown in Figure 3. The vertical axis represents the average scores for fluency in that 30 seconds per object per participant. As shown in Figure 3, the overall trend is a large increase up to the second interval, followed by a monotonic decrease. However, it can be seen that the trend turns to an increase in the last 30 seconds.

Flexibility in 30-second intervals is shown in Figure 4. The vertical axis represents the average scores for flexibility in that 30 seconds per object per participant. However, care should be taken when comparing this graph with the fluency graph. In the flexibility evaluation using the method proposed in the study, the first idea is calculated with the amplification of the flexibility score as 0, because there is no previous idea and no object for comparison. Therefore, in the first 30 seconds of the section, there are many first ideas, and since they do not add up to a score, the flexibility scores is small. Hence, the meaning is different from that shown in Figure 3 of fluency and cannot be simply compared. Figure 4 shows that the overall trend of flexibility is a significant increase at the beginning, followed by a monotonic decrease. Furthermore, in the last 30 seconds, the trend turned to an increase.

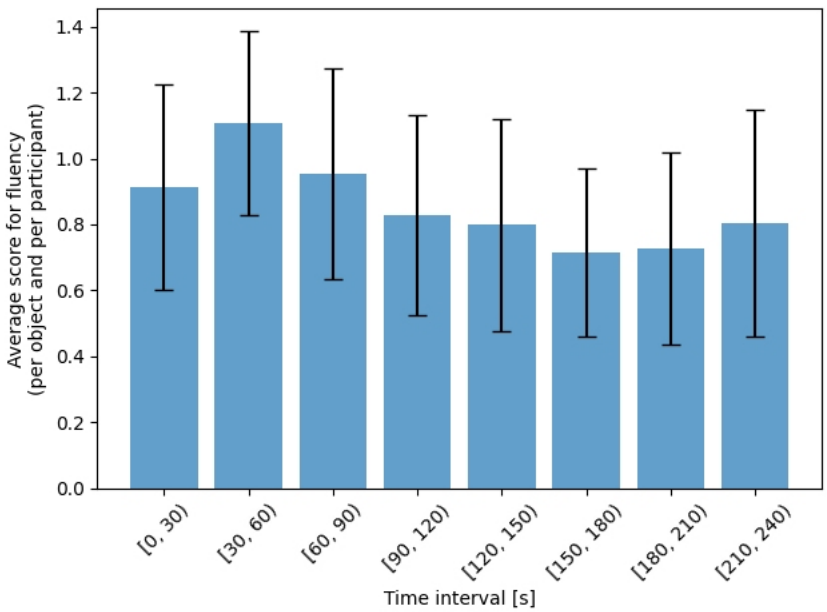

Figure 3: Average score for fluency (per object, per participant) in each interval.

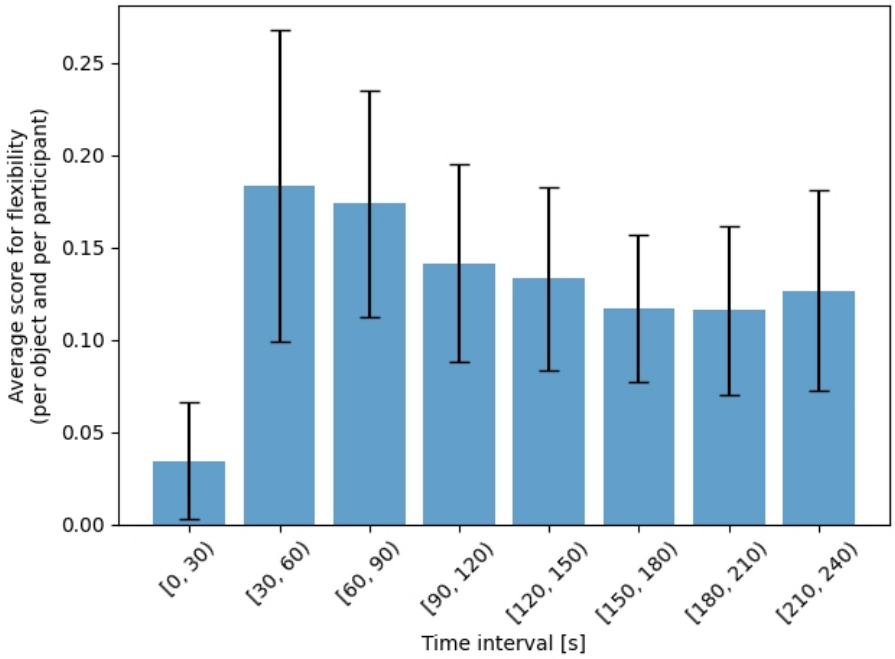

Figure 4: Average score for flexibility (per object, per participant) in each interval.

DISCUSSION AND CONCLUSION

In this study, we proposed a method for analyzing fluency and flexibility from the temporal perspective. Using this method, we analyzed the results of experiments on human subjects and were able to visualize the trends in fluency and flexibility per unit time as shown in Figure 3, and Figure 4. The large increase in fluency/flexibility in the first two intervals, as shown in Figure 3 and Figure 4, can be attributed to the fact that at the beginning, one can easily access the ideas that he/she comes up with at the ready. However, after easily accessible ideas are generated, it gradually becomes more difficult to come up with new ideas. Therefore, the overall trend was a monotonically decreasing increase in fluency and flexibility after the second interval.

Baer et al., suggested that there is an inverse U-shaped relationship between time pressure and creativity (Bear et al., 2006), and that performance may improve under appropriate time pressure. Based on their suggestions, the increasing trend in the last interval indicates that time pressure had a positive impact on the participants. In summary, it is an advantage of the proposed methodology that it can provide detailed insight into these changes in performance over time. This method also makes it possible to discuss the impact of changes in environmental conditions and stimuli on performance over time.

This study has several limitations. The first is the unit interval setting. In this study, the unit interval was set to 30 seconds based on the results of previous experiments. If this unit interval is made too long, the incremental trend in the last interval in this study may not be visualized, and if it is made too short, there may be intervals in which no ideas are answered at all. Further

study of how long it takes for each idea to be answered should be done to establish the length of this unit interval.

Another limitation concerns the way flexibility was assessed: as mentioned in a reference to the results, this study assumed that the first idea amplifies the flexibility score by 0. Therefore, it is difficult to simply compare the graphs for fluency and flexibility. It may be possible to analyze fluency and flexibility in a consistent method by evaluating the range of amplification of flexibility scores in a non-zero method, such as by comparing this first idea with the original usage.

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