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Interaction between Body and Environment in Creative Thinking

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Abstract

The purpose of this study is to examine the effects of the interaction between body and environment on the creative thinking process, mainly with regard to insight problem solving. Previous studies have focused on the factors that provide impetus for insight and creativity, and their components. In order to clarify the cognitive mechanism behind insight and creativity, researchers have used psychometric approaches. Some case studies describe the performance of outstanding artists and scientists. On the other hand, some studies have pointed out that creativity depends not only on one's ability but also on environmental factors. However, the environmental factors that the previous studies suggested were cultural or social factors. They did not imply the physical environment.

Recent studies on embodied and situated cognition suggest that complex behavior does not necessarily emerge from a complex mechanism. Complex behavior may be explained by simple sensory-motor coordination. Human behavior, including creative thought, is no exception. This paper hypothesizes that creative thought depends on the interaction between the thinker's body and the physical environment in the problem situation.

To test this hypothesis, the "buttonhole puzzle" which is a task to test creativity was employed in this study. In the experiments, participants were provided with objects of one of three different sizes (7×7 cm, or 12×12 cm, or 14×14 cm), and were asked to solve the problem. Then, the participants' hands were measured.

The results of the experiment indicate that the size of the hands of the participants that solved the problem differed with the given object size. This suggests that the performance of insight problem solving is influenced by the physical environment and the thinkers' body.

Keywords: insight problem solving; affordance; embodied cognition

Literature Review

Many researchers interested in the insight problem-solving process have focused on the mechanisms of insight ("aha" experience) because of the drastic and dramatic change that characterize it. In previous studies, some researchers surveyed the performances by outstanding scientists and artists, and latent factors related to the ability to gain insight were explored using multivariate analyses (Gilhooly and Murphy, 2005). Recent studies have proposed theories that can explain the cognitive processes of insight problem solving (Suzuki & Hiraki, 1997; Knoblich, Ohlsson, Haider, & Rhenius, 1999; MacGregor, Ormerod, & E.P. Chronicle, 2001) and computational models that can replicate insightful problem-solving behaviors (Terai & Miwa, 2006). Using neuroimaging, the role of the right hemisphere of the brain in the creative process was clarified (Bowden & Jung-Beeman, 2003).

On the other hand, previous studies have pointed out that creativity and insightful thinking depend not only on one's

ability but also on environmental factors. For example, Csikszentmihalyi (1996) pointed out that changing the environment rather than individual efforts is more effective for improving creativity. However, the environmental factors suggested by previous studies implied not the physical environment but cultural or social factors.

Recent studies on embodied and situated cognition suggest that complex behavior does not necessarily emerge from a complex mechanism. Recent studies on cognitive science and artificial intelligence try to explain some intelligent behavior from the standpoint of *situated cognition* and *embodied cognition*.

In perception studies, many researchers have pointed out the importance of the relationship between the agent and the environment. Gibson (1979) suggested that people acquire the information through their perception and motor action. He termed the information *affordance*. It is defined as information on an object and an environment that allows an individual to perform an action in the environment. An affordance that an agent obtains depends on the relationship between the agent's body and the environment. For instance, if you face a puddle on the way home and you do not want to spoil your shoes, you can choose various actions. If the puddle was smaller than your stride, you could step over the puddle. If the puddle was twice as large as your stride, you could jump across it. If the puddle was more than twice the size of your stride, you could try a different route. Such decisions depend not only on the structure of the environment (in this case, the size of the puddle) but also on the agent's body (size of agent's stride). Both factors affect the decision. For example, Warren (1984) showed that the height of a climbable step is up to 0.88 times the persons' leg length. It was reported that the width between obstacles that persons can pass through without rotating their shoulder is more than 1.3 times the persons' shoulder (Warren & Whang, 1987). Mishima reported that persons stride across a hurdle if the height of the hurdle is lower than 1.07 times their leg length. However, if the height of the hurdle is greater than the length, the persons go under the hurdle (Mishima, 1994).

These previous studies make two important suggestions. First, complex behavior can be explained by simple sensory-motor coordination. Second, such behavior is supported by the interaction between the environment in which the agents behave and the persons' body. Because our basic behavior is characterized by such features, this paper considers that even human behavior, including creative thought, may not be an exceptions. This paper hypothesizes that creative thought depends on the interaction between the thinker's body and the physical environment in a problem situation. This study

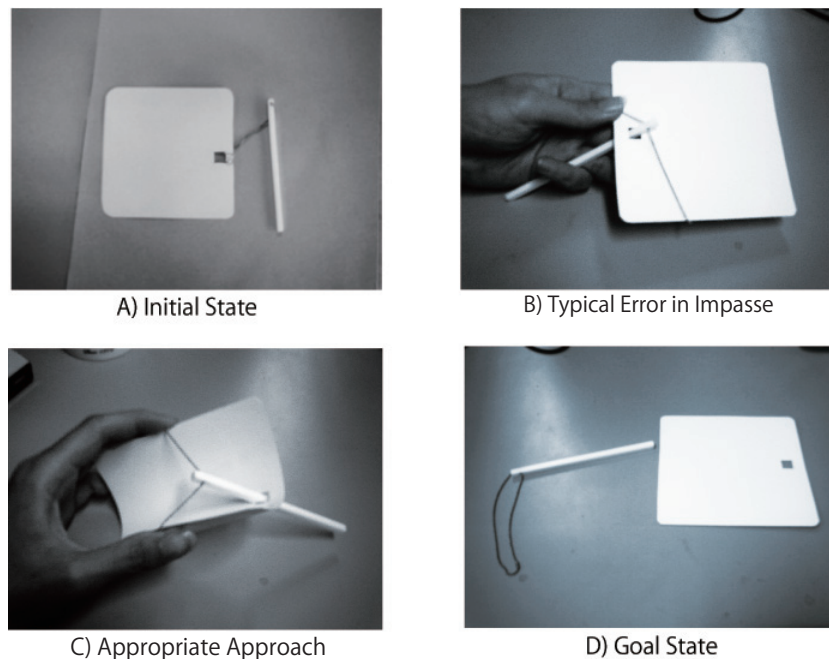


Figure 1: The Buttonhole Puzzle

examines the hypothesis by conducting psychological experiments.

First, the buttonhole puzzle, which is a kind of an insight problem, is employed. In the initial state of this problem, a plastic plate is chained to a plastic stick. The goal of the task is to separate the plate and the stick. This task may seem very easy. However, many participants could not solve the puzzle in 10 minutes without hints (see experiments 1 and 2). To separate the plate and the stick, the plate has to pass through the chain. However, the length of the chain is too small for the plate to pass through. The key to the problem is to bend the plate. The participant could pass the plate through the chain if they bent the plate.

How can participants realize the solution? When do participants try to bend the plate? This paper hypothesizes that both the size of the puzzle (environmental factor) and the size of the participants' hands (the physical factor) affect the performance of the task. If the plate is bigger than the participants' hands, the participants will have to use both hands in order to bend the plate. If the plate is smaller than the participants' hands, the participants can bend the plate with either one hand or both hands. In other words, if the puzzle properly fits into the participants' hands, the participants could identify the "bend" affordance more easily. The more there are ways to bend the plate, the more possible it is for the participants to realize that the plate needs to be bent.

In order to examine this hypothesis, two psychological experiments were conducted. In experiment 1, the buttonhole puzzle was used. This puzzle consists of a 14 cm square plastic plate, a 14 cm long plastic stick, and a 24 cm long chain.

The plastic plate is 0.4 mm thick. This was the minimum thickness for the plate so that it did not bend by the weight of the chain and stick.

Experiment 1

Method

Participants The participants were 34 undergraduate students.

Materials and Procedure Participants were given the 14 cm buttonhole puzzle and were told to solve the puzzle for 10 minutes. They were told to take apart the puzzle in any way, without breaking the chain.

After the problem-solving task, both the hands of all participants were measured. First, the participants were told to open their forefinger and thumb as wide as possible and put their fingerprints across a line. The participants placed their forefinger and thumb firmly over the line on a recording paper and marked the fingerprints on the line using an ink pad. Second, the distance from the forefinger to the thumb was measured and was determined as the hand size. In this study, the hand size is defined as the maximum distance between the edge of the fingerprint of the forefinger and that of the thumb.

Results and Discussion

Twelve out of 34 participants solved the puzzle in 10 minutes. The average hand size of the participants was 17.48 cm. A comparison of the hand sizes of the participants who solved the puzzle and of those who did not showed that both groups were not significantly different ($t(31) =$

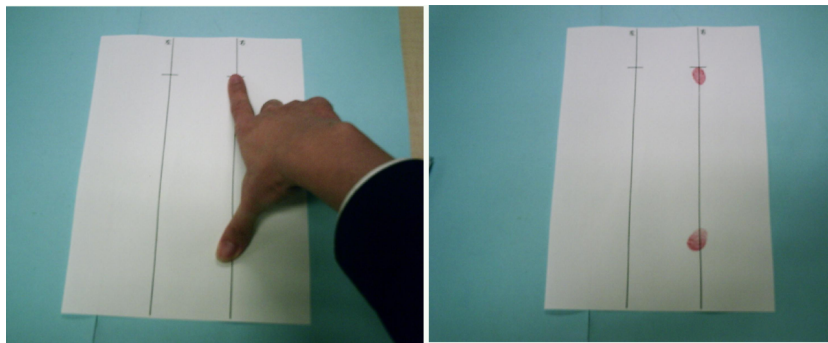


Figure 2: The method for measuring participants' hand size

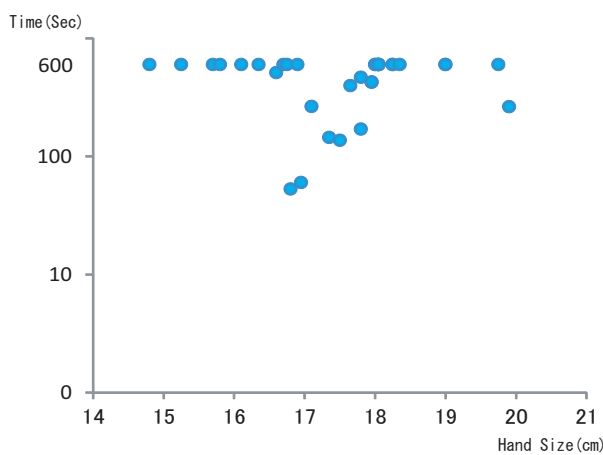


Figure 3: Participants' hand size and time taken to solve the puzzle in experiment 1

0.52, *n.s.* *EffectSize* = 0.092). Figure 1 shows the relationship between the hand size and the time taken to solve the puzzle. The results show that not only participants whose hands were small but also those whose hands were large did not solve the puzzle.

It is probable that the size of the plate is so small that participants cannot acquire the affordance of bending the plate. As in the prior example, who would bother to jump across a tiny puddle when one could step over it? Though it is dangerous to jump across a huge and deep puddle, it is safe, but unnatural, to jump across a tiny puddle. Mishima (1994) reported that there were few participants who bothered to go under a hurdle whose height was small enough to allow one to stride over. This result indicates that body sizes that can acquire affordances from objects may have a lower limit and an upper limit. Thus, We hypothesized that if the size of the puzzle is small, the hand size of the participants who notice the appropriate approach is correspondingly small.

Experiment 2

Method

Participants and Design The participants were 61 undergraduate students. Thirty-four participants were the same as those who participated in experiment 1. Twenty-seven participants were assigned to the 7 cm group.

Materials and Procedure Participants were assigned to one of two groups: 14 cm group and 7 cm group. In the 14 cm group, the participants were given the 14 cm version of the buttonhole puzzle and told to solve the puzzle for 10 minutes. In the 7 cm group, the participants were told to solve the 7 cm version of the buttonhole puzzle for 10 minutes. The participants were told to take apart the puzzle in any way they could, without breaking the chain. The 7 cm version consists of a 7 cm square plastic plate, a 7 cm long plastic stick, and a 10 cm long chain. The plastic plate is 0.4 mm thick in the 14cm version. The plastic plate is 0.2 mm thick in the 7cm version. After the problem-solving task, both the hands of all participants were measured in the same manner as in experiment 1.

Results and Discussion

Table 1 shows the number of participants who solved the puzzle and the average hand size. According to the results of a *t* test, the hand sizes in both groups were not significantly different ($t(59) = 1.22, n.s., EffectSize = 0.145$). To analyze the problem-solving performance, the percentages of correct answers by both groups were compared. In the 14 cm group, 12 of the 34 participants solved the puzzle in 10 minutes on their own. In the 7 cm group, 3 participants solved the puzzle. The percentages of correct answers by both groups were significantly different ($\chi^2(1) = 4.746, p < 0.05, Cramer'sV = 0.28$). This result implies that if the participants' hands were relatively larger than the size of the puzzle, it became hard to solve the puzzle. However, the 7 cm version of the buttonhole puzzle was considered to be too small for the participants to manipulate it easily. The percentage of correct answers in the 7 cm group may be because of the difficulty in handling the

Table 1: Results of experiment 2

group	14 cm	7 cm
hand size of participants	17.48 cm	17.11 cm
number of resolvers	12(n = 34)	3(n = 27)

Table 2: Results of experiment 3

group	14 cm(n = 34)	12 cm(n = 35)
hand size (total)	17.48	16.92
hand size (resolvers)	17.61	16.09
number of resolvers	12	13

plate. Following these points, in experiment 3, the 12 cm version of the buttonhole puzzle, which was slightly smaller than the 14 cm version, was employed.

Experiment 3

Method

Participants and Design The participants were 69 undergraduate students. Thirty-four participants were the same as those who participated in the experiment 1. Thirty-five participants were assigned to the 12 cm group.

Materials and Procedure Participants were assigned to one of two groups. In the 14 cm group, the participants were given the 14 cm version of the buttonhole puzzle and were told to solve the puzzle for 10 minutes. In the 12 cm group, the participants were told to solve the 12 cm version of the buttonhole puzzle for 10 minutes. The participants were told to take apart the puzzle in any way, without breaking the chain. The 12 cm version consists of a 12 cm square plastic plate, a 12 cm long plastic stick, and a 20 cm long chain. The plastic plate in both versions is 0.4 mm thick. After the problem-solving task, both the hands of all participants were measured in the same manner as in experiment 1.

Results and Discussion

Table 2 shows the number of participants who solved the puzzle and the average hand size. The percentages of correct answers by both groups were compared. In the 12 cm group, 13 out of 35 participants solved the puzzle in 10 minutes on their own. The percentage of correct answers was not significantly different ($\chi^2(1) = 0.025, n.s., Cramer's V = 0.02$). According to the results of the t test, the hand sizes of both groups were not significantly different ($t(67) = 1.854, n.s., EffectSize = 0.221$).

In the 12 cm group, the hand sizes of the participants who solved the puzzle successfully were significantly smaller than that of the participants who failed to solve the puzzle ($t(33) = -3.239, p < 0.01, EffectSize = 0.491$). This result suggests that there is an upper limit to the hand sizes

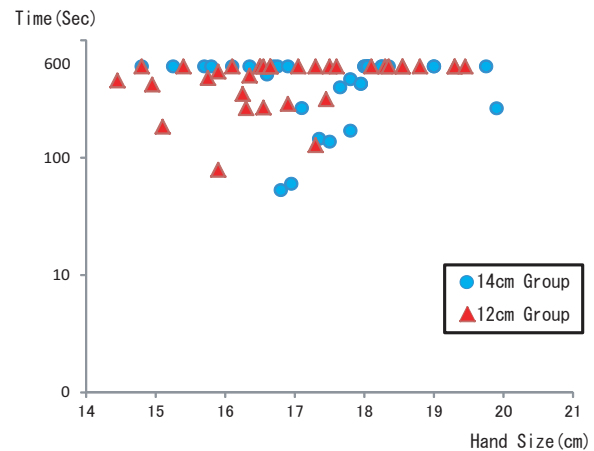


Figure 4: Hand size of participants and time taken to solve the puzzle in experiment 3

of participants who solved the 12 cm version of the buttonhole puzzle. In addition, the hand sizes of the participants who solved the puzzle in the 12 cm group were significantly smaller than that of the participants in the 14 cm group ($t(23) = 4.367, p < 0.01, EffectSize = 0.673$, see Figure 4). These results suggest that the hand sizes of the participants who found the appropriate approach to the puzzle differed depending on the size of the puzzle.

General Discussion

In this paper, the hypothesis that both the size of the puzzle (environmental factor) and the size of the participants' hands (physical factor) affects the performance of the task was examined by three psychological experiments using a buttonhole puzzle. The results of experiment 1 did not support the original hypothesis. They showed that those with large hands could not always find a creative solution in the buttonhole puzzle. Following the results, the hypothesis was modified and examined in experiment 2. The modified hypothesis was that body sizes that can acquire an affordance from objects have a lower and upper limit; thus, if the object size is small, the hand size of the participants who find the appropriate approach is correspondingly small. The results of experiments 2 and 3 supported this modified hypothesis. According to the results of the experiments with the various versions of the buttonhole puzzle, it is not necessary that participants with particular hand sizes find it easy to solve any type of the buttonhole puzzle. On the other hand, it is not necessary that there is a buttonhole puzzle of a particular size that is easy for any participant to solve. The performance on the puzzle depended on the relationship between the size of the puzzle and that of the participants' hands. These results suggest that the participants' body and given objects affect creative thinking.

Conclusions

The participants' body and the size of a given object affect the performance in a creative problem-solving task. The findings of this study suggest the following: First, creativity is not simply determined by prior knowledge and mental ability. The measurement of creativity on the basis of questionnaire responses cannot evaluate the influences of the participants' body and of the surrounding environment.

Second, these results suggest the factors that provide impetus to creativity. Where does a creative idea come from? We tend to consider that it is necessary to search for materials in long-term memory in order to formulate a creative idea. The results of experiments show that some participants bent the given flat plate into other shapes and searched for new ideas on the basis of the bent plate. This implies that the transformation of the object inspired the participants to formulate novel ideas. It depended on the probability of the plate being bent, which in turn depended on the size of the participants' hands and the size of the object. This implies that our body influences the accessibility to external objects and the environment.

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