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# "Close, and ye shall find": eye closure during thinking enhances creativity

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**ABSTRACT** Facilitation of creative thinking is an important element for innovation. It has been suggested that cognitive resources are involved in creative thinking; however, little evidence of this involvement has been found. To address this issue, the present study focuses on eye closure, which saves more cognitive resources than open eyes. Forty participants experienced both close-eyed and open-eyed conditions, and all of them were asked to generate new names for rice and tea. The results revealed that in the close-eyed condition, participants generated 1.6-times more divergent (unrestricted and flexible) ideas than in the open-eyed condition, suggesting that closing eyes during thinking enhances creativity. Our findings provide empirical evidence for the necessity of cognitive resources in creative thinking.

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## Introduction

Creativity is an important capability required of us, especially as scientists. One of the aims of creativity research is to reveal how new ideas can be generated. Several studies have provided some hints. For example, a positive mood boosts the generation of new ideas (Davis, 2009; Isen et al., 1987; Yamada and Nagai, 2015). A negative mood, particularly anger, also improves creativity (Baas et al., 2011). Additionally, certain body postures and physical action improve creative thinking (Hao et al., 2017; Oppezzo and Schwartz, 2014) and observing ambiguous figures that can be interpreted in two ways, such as Rubin's vase, enhances performance in creative tasks (Wu et al., 2016). Thus, as mentioned above, various ways to facilitate creative thinking exist.

Some researchers have suggested a cognitive model of creative thinking by incorporating a relation between cognitive resources and creative thinking (e.g., Mumford et al., 1991). The model proposed by Mumford et al. (1991) assumes that cognitive resources should be consciously invested in creative thinking; this involvement is also indicated by a study that addresses the effect of mind wandering (i.e., distraction from the task at hand and thinking about something else) on creative thinking (Baird et al., 2012). Baird et al. (2012) have reported that individuals who experience a high frequency of mind wandering tend to solve problems more creatively than those who experience a low frequency of the experience. Several studies have also argued that mind wandering is more frequent while doing an easy task (i.e., a task requiring fewer cognitive resources) because more cognitive resources are available (Smallwood and Andrews-Hanna, 2013; Smallwood and Schooler, 2006; Thomson et al., 2013). Hence, creative thinking may be facilitated when enough cognitive resources are available. Thus, a hypothetical model (Mumford et al., 1991) and previous findings (Baird et al., 2012) suggest that creative thinking requires cognitive resources. To further examine this issue, the present study focuses on a simpler method of enhancing creativity—simply closing the eyes.

The eye-closure effect is a phenomenon whereby memory recall is promoted when people close their eyes (e.g., Perfect et al., 2008). Two hypotheses have been proposed to explain the reason behind the occurrence of the eye-closure effect (Vredeveldt et al., 2011). One is the cognitive load hypothesis, which proposes that eye closure facilitates a recall because it increases an individual's available cognitive resources (Natali et al., 2012; Vredeveldt et al., 2011). The other is the modality-specific interference hypothesis, which suggests that a recall of visual information is facilitated by blocking the interference of visual information from the external environment (e.g., Wagstaff et al., 2004). Although the discussion as to which hypothesis is correct continues, both these hypotheses assume that eye closure saves more cognitive resources available for an ongoing task (i.e., recall) than open eyes.

The present study aims to investigate the influence of eye closure on creative thinking. In our experiment, participants were asked to generate new ideas by experiencing both close-eyed and open-eyed conditions while thinking. As discussed above, more cognitive recourses are saved during eye closure (Natali et al., 2012; Vredeveldt et al., 2011; Wagstaff et al., 2004); thus, creative thinking would be facilitated more under close-eyed conditions than under open-eyed conditions if thoughts require considerable cognitive resources, as indicated by previous studies (Baird et al., 2012; Mumford et al., 1991).

## Methods

**Participants**. Forty Japanese undergraduate students (20 males; mean age 21.63 years) participated in the experiment. The experiment was approved by the ethics committee of Kyushu University (approval number: 2017–004) and conducted according to the guidelines established by the Helsinki Declaration. Before the experiment, we obtained written informed consent from all of the participants.

**Creative task**. We asked the participants to complete two creative tasks—to generate new names for rice and tea. Originally, the task developed by Dijksterhuis and Meurs (2006) required participants to generate new names for pasta. However, Yamada and Nagai (2015) modified the task for Japanese participants by asking them to generate new names for rice instead of pasta because Japanese people are unfamiliar with names for pasta. The participants had to complete this task twice because they engaged in both close-eyed and open-eyed conditions. Thus, we asked them to generate new names for tea (Japanese people are generally familiar with names for tea) in addition to rice. Five examples of nonexistent rice names ("Kura-hikari," "Shima-hikari," "Sora-hikari," "Toyo-hikari," and "Mine-hikari") and five examples of nonexistent tea names ("Kura-cha," "Shima-cha," "Sora-cha," "Toyo-cha," and "Mine-cha") were presented along with an explanation of the task. The previous study, which used the pasta task, defined the pasta names ending "i" as convergent items (Dijksterhuis and Meurs, 2006). According to a previous study (Yamada and Nagai, 2015), the names ending in "hikari" and "cha" were defined as convergent items because they reflect a fixed thought process that focuses on the examples. On the other hand, we defined the names that do not end in "hikari" and "cha" as divergent items because they reflect an unrestricted thought process that requires creativity.

**Procedure**. After providing instructions for the task, the participants were given one minute to generate new names and were asked to enter the generated names. The participants experienced two eye conditions: close-eyed and open-eyed. In the close-eyed condition, they closed their eyes while generating new names; in the open-eyed condition, they watched a video of geometrical figures while generating new names. One task was assigned to those in one condition and the other task was assigned to those in another group. The task assignment and order of the eye conditions were counterbalanced across the participants.

**Analysis**. The number of new names for rice and tea, which were generated by the participants, was counted, and the names were classified into divergent or convergent items on the basis of the aforementioned criteria. Creative task performance in the two conditions was compared on the basis of a Bayesian approach using R and the R package RStan (Stan Development Team, 2017). The R and Stan codes are available at GitHub Gist (R code: https://goo.gl/6RcKuM; RStan code: https://goo.gl/9VHRQz). The parameter estimates were obtained by using MCMC sampling with four chains of 50,000 iterations each and no thinning (the first 25,000 iterations were used as a warm-up). To test our prediction, we used a GLMM. We conducted a binomial GLMM because the response variable was dichotomous (divergent items and convergent items in total items). A fixed effect was estimated for the conditions (close-eyed vs. open-eyed). Thus, we analyzed the effect of experimental manipulation on the proportion of divergent items in the total items by conducting a logistic transformation of the proportion. In addition, we controlled the variance between participants as a random effect and assumed that the prior distribution of the variance between participants followed normal distribution. We used the R-hat for convergence assessment. If the R-hat indicated close to 1.0 and $<1.1$, the MCMC sampling was interpreted as having a good convergence.

**Table 1 The summary of each parameter**

| Parameter | Mean | | 95% CrI | | No. eff | R-hat |
|---|---|---|---|---|---|---|
| | Estimate | Odds ratio | Estimate | Odds ratio | | |
| Intercept | −0.59 | 0.55 | [−1.03; -0.15] | [0.36; 0.86] | 86,991 | 1 |
| Conditions | 0.47 | 1.60 | [0.04; 0.90] | [1.04; 2.46] | 100,000 | 1 |

No. eff indicates number of effective samples. The total number of samples in the present study is 100,000 samples, calculated by multiplying the difference between 50,000 and 25,000 by 4.

Although the mean and the 95% credible interval (CrI) were used as representative values of the estimated parameters, we transformed them to odds ratios and adopted the odds ratios of each parameter for interpretation because we had conducted logistic transformation. Furthermore, if odds ratios indicate 1, no difference exists between the close-eyed and open-eyed conditions in the proportions of generated divergent items.

## Results

We compared the proportion of divergent items between the two conditions in order to investigate the influence of eye closure and open eyes on creative thinking (see the Methods section for details on statistical methods). The R-hat diagnostic indicated good convergence for all parameters because all R-hats were <1.1. Information regarding estimates and odds ratios is provided in Table 1. The results of the odds ratio in the slope indicated that the proportion of generating divergent items in the close-eyed condition was on an average 1.6 times higher than the proportion generated in the open-eyed condition ($M = 0.47$, Odds ratio = 1.60). Additionally, the lower limit of the 95% CrI in odds ratio was larger than 1, which means that the close-eyed condition had sufficient effect on the generation of divergent items (95% CrI = [0.04; 0.90], Odds ratio of 95% CrI = [1.04; 2.46]).

## Discussion

The results of the study showed that participants who experienced the close-eyed condition produced more unrestricted and unfixed ideas than those who experienced the open-eyed condition. Thus, our hypothesis is supported. Closing the eyes is considered to prevent visual information from interfering and decreasing cognitive resources (Vredeveldt et al., 2011). Therefore, the present study indicates that creative thinking is modulated by the amount of cognitive resources that are available when performing a task. Our study provides evidence for the relation between creative thinking and cognitive resources, which is suggested by the hypothetical model (Mumford et al., 1991).

In addition, we conducted a post hoc analysis on gender differences in the effect of eye closure on creative thinking because some previous studies on creativity suggested gender differences in creativity (for a review see Baer and Kaufman, 2008). However, the results did not show the effect of gender[1].

The question then is what kind of cognitive process is related to eye closure. Wallas (1926) proposed a four-stage process of creative thinking: preparation, incubation, illumination, and verification. The preparation stage involves analyzing, defining, and setting up a problem. In the incubation stage, while one is consciously engaging in other work or relaxing, an unconscious processing continues to work on the problem. Illumination is the stage when an idea suddenly occurs. Finally, at the verification stage, the idea is evaluated, re-found, and developed. In the present study, participants closed or opened their eyes while they thought about new names for rice and tea and this action influenced the quality of the ideas. Considering the present findings in relation to the four-stage process (Wallas, 1926), the eye-closure effect possibly involves the preparation stage. Thus, we speculate that allocating ample cognitive recourses to a thought process during the preparation stage is important for the generation of creative ideas.

One might argue that a video of geometrical figures used in open-eyed condition captured a lot of resources and a static object was more suitable than the video. The video had relatively less complex and intense motion components and amusing information because the video used here was a repetitive change of simple geometrical figures. Therefore, the consumption of cognitive resources seems not to be so different between watching the video and a static image. Future research will focus on the effect of visual information on creative thinking in the open-eyed condition.

Although the previous studies have found several ways to raise creative thinking (Baas et al., 2011; Davis, 2009; Hao et al., 2017; Isen et al., 1987; Oppezzo and Schwartz, 2014; Wu et al., 2016; Yamada and Nagai, 2015), the present study revealed that one of the simplest ways, eye closure, improves creativity. This finding of the present study is possibly applied in the field of education or business in the future. The limitations of the present study suggest several possibilities for future cognitive psychological research on creative thinking. First, additional research is needed to identify the cause of the enhancement of creativity that results from eye closure. There are two possible reasons for this relation: retention of cognitive resources necessary for creative thinking resulted from eye closure or blocking of thought interference by distractive visual inputs. Second, creative tasks, such as the Remote Associates Test, which measure the ability to have insight during problem solving, should be incorporated into studies in order to clarify the extent of the enhancement of such creativity (Bowden and Jung-Beeman, 2003; Mednick, 1962). Third, although we used eye closure as a method of retaining cognitive resources, whether this interruption method is effective in visual modality remains unclear. In studies on memory recall, the eye-closure effect has been investigated by interrupting visual and auditory inputs (Vredeveldt et al., 2011); however, only visual interruption has been shown to enhance memory. It is interesting to further conduct experiments testing the effect of interruption of the input in other modalities (e.g., auditory or vestibular) on creative thinking. Future studies on creativity may use noise-canceling headphones, Ganzfeld masks, or isolation tanks.

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## Note

1 The *post hoc* analysis was conducted in the process of peer-review. This analysis was equivalent to adding gender as a fixed effect to the main analysis. The results indicated that the 95% CrI in odds ratio included 1, which means that the gender difference was not significant (95% CrI = [−0.35; 1.15], Odds ratio of 95% CrI = [0.70; 3.16]).

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## Data availability

The datasets analyzed during the current study are available in the Dataverse repository: https://doi.org/10.7910/DVN/NZ4VQU

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## Author contributions

All authors conceived and designed the experiment. FY conducted the experiment. FY, KK and YY analyzed the data. All authors wrote the manuscript.

## Additional information

**Competing interests:** The authors declare no competing interests.