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Drinking tea improves the performance of divergent creativity

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ABSTRACT

Previous research has found that tea improves performance on convergent creativity tasks, such as the Remote Associates Test, by inducing a positive mood. However, there is no empirical evidence regarding the effect of tea drinking on performance in divergent creativity tasks. Using two experiments, the current research investigates the relationship between tea consumption and divergent creativity. In both experiments, participants were randomly assigned to two groups and implicitly manipulated to drink tea or water. In experiment 1 ($N = 50$), we used a block-building task as a measure of divergent creativity in spatial cognition. The results showed that the participants who drank tea performed better in the spatial creativity task assigned in the 10 min immediately following tea consumption than did those who drank water. In experiment 2 ($N = 40$), we adopted the restaurant naming task as a measure of divergent creativity in semantic cognition. The results showed that the participants who drank tea received higher scores in the semantic creativity task compared to those who drank water. The current research demonstrates that drinking tea can improve creative performance with divergent thinking. This work contributes to understanding the function of tea on creativity and offers a new way to investigate the relationship between food and beverage consumption and the improvement of human cognition.

1. Introduction

Tea is the second most frequently consumed daily beverage in the world (Hodgson & Croft, 2010). Since tea is important to human life, a vast number of researches have investigated the function of tea. It has been found that tea has beneficial effects on both physical health (Ruxton, Phillips, & Bond, 2015; Shen & Chyu, 2016; Hayat, Iqbal, Malik, Bilal, & Mushtaq, 2015) and cognition (Einöther & Martens, 2013; Dietz & Dekker, 2017; Kuriyama et al., 2006). Recent research for tea's effect on cognition is examining the relationship between drinking tea and creativity (Einöther, Baas, Rowson, & Giesbrecht, 2015). Creativity can be classified into convergent thinking and divergent thinking (Guilford, 1967). While some research has found tea can improve convergent thinking (Einöther et al., 2015), there is no evidence about the relationship between tea and divergent thinking. The purpose of the current research is to test if drinking tea can promote divergent creativity. We will first review the literature and propose our research design.

1.1. Tea and cognition

Cognition is "the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses" (English Oxford Living Dictionary, www.oxforddictionaries.com). It includes perception, attention, memory, emotion, language, decision making, thinking, and reasoning, etc. (Goldstein, 2010). Among these processes, perception and attention are primary level cognition, whereas the processes like memory, thinking, and language are high-level cognition.

Attention is one of the cognitive processes that has been mostly studied in relation with tea. Attention is "the focusing and concentration of mental effort that usually result in conscious awareness of certain aspects of certain stimuli of mental experiences" (Hill, 2001, p.113). It has been found that attention can be improved by drinking tea (De Bruin, Rowson, Van Buren, Rycroft, & Owen, 2011) and this association was attributed to two biological ingredients, caffeine and theanine (Einöther & Giesbrecht, 2013; Einöther & Martens, 2013). Drinking tea that includes 100 mg of caffeine results in a higher Critical Flicker Fusion Threshold, which is an overall index of the central nervous system activity (Hindmarch, Quinlan, Moore, & Parkin, 1998), than drinking water. Consumption of tea containing L-theanine (100 mg) and caffeine (50 mg) improves both speed and accuracy on the attention-switching task and reduces susceptibility to distracting information on the memory task more than drinking tea without L-

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theanine does (Parnell, Owen, & Rycroft, 2006). Drinking tea that contains both L-theanine (97 mg) and caffeine (40 mg) leads to higher accuracy in the attention-switching task than drinking a placebo that includes neither L-theanine nor caffeine (Giesbrecht, Rycroft, Rowson, & De Bruin, 2010).

On the other hand, attention is the cognitive process that plays an important role in many other high-order cognitive processes (Peterson & Naveh-Benjamin, 2017; Varao-Sousa, Solman, & Kingstone, 2017), especially in creativity (Vartanian, Martindale, & Kwiatkowski, 2007; Kasof, 1997; Kharkhurin, 2011). Vartanian (2009) suggested that creative people perform well in creative problem solving tasks, adjusting their attention adaptively to the tasks's level of ambiguity.

Above researches about tea's effect on attention and the relationship between attention and creativity arose scientists' curiosity into the effect of tea on creativity. The current study is mainly focusing on tea's relationship with creativity.

1.2. Tea and creativity

Creativity is generally considered the human capacity to create original and useful ideas to solve problems (Runco & Jaeger, 2012). Creativity can be classified into two detailed and testable components: convergent and divergent thinking (Guilford, 1967). Convergent thinking is a cognitive process involved in solving a certain problem with only a single solution (Zmigrod, Colzato, & Hommel, 2015). Divergent thinking is the ability to offer unlimited solutions to a single problem and is the key component of creativity (Vincent, Decker, & Mumford, 2002).

The Remote Associates Test (Mednick, 1962) is the typical measurement of convergent thinking creativity. In this test, participants are given three words, such as "blue", "cake", and "cottage", and are required to give the solution word that is associated with these three words ("cheese"). The Alternative Uses Task (Guilford, 1967) is the typical measurement of divergent thinking creativity. In this task, participants must generate as many ideas as possible about the usages of a certain object, such as "brick" or "pen".

According to Hommel (2012), convergent creativity and divergent creativity requires different cognitive control either. Convergent creativity needs strong top-down control which focuses on the search for one idea with well-defined search criteria, whereas divergent creativity needs weak top-down control such that one can switch from one idea to another idea within broad search span with less defined search criteria. Applying this strong/weak top-down cognitive control, one would expect that tea's effect on attention brings strong degree of top-down cognitive control, and in turns improve convergent creativity performance. Actually, Isen, Labroo, and Durlach (2004) tested the relationship between iced tea and convergent creativity. They used the Remote Associates Test (Mednick, 1962) to measure convergent creativity. They found that participants who drank iced tea gave more correct answers in the Remote Associates Test than those who drank water. Einöther et al. (2015) also examined tea's positive effect on convergent creativity with RAT, showing that those who prepared and drank tea performed significantly better than those who drank water in high difficult level of RAT.

Researchers have also begun to investigate the effect of tea on divergent creativity. To date, only one study has tested this association. Einöther et al. (2015) used the *alien drawing task* (Ward, Patterson, & Sifonis, 2004) as the measure of divergent creativity and recruited regular tea consumers as participants. However, they did not find a significant effect of tea on divergent creativity performance. The purpose of the current paper is to uncover the relationship between tea and divergent thinking creativity.

Our belief in the relationship between tea and divergent thinking creativity is based on several inferences and evidences. Colzato, Ozturk, and Hommel (2012) investigated the improvement of creativity task performance through meditation and found that meditation based on open monitoring helped to enhance divergent creativity performance. During open-monitoring meditation, one is open to perceive and observe any sensation or thought without focusing on a concept in the mind or a fixed item (Colzato et al., 2012, p1). The essence of meditation is relaxation, and the essence of open-monitoring meditation is "open", "accepting myself as I am", which is much similar to tea's recovery effect from stress (Steptoe et al., 2007). Therefore, one would expect that tea would promote divergent creativity because of its function of promoting relaxation (Dietz & Dekker, 2017) just as meditation does.

A possible mechanism of tea's effect on divergent creativity can be traced to Einöther et al. (2015)'s work, which suggested that preparing and drinking tea can promote positive affect, increasing valence of mood during and immediately after tea consumption (within 10 min from preparing stage). Positive affect is beneficial for creativity (Baas, Dreu, Carsten, & Nijstad, 2008). Therefore, these authors hypothesized that the mechanism of tea's effect on improving creativity is through increased mood valence. In other words, tea consumption is predictive of improved creativity through increased valence of mood.

However, Einöther et al. (2015) did not find empirical support for their assumption for divergent creativity. Although we agree with their reasoning, we believe that their failure to find an effect of tea on divergent thinking creativity is due to the experimental paradigm. Testing the effect of tea on divergent thinking requires a selection of suitable cognitive tasks that encourage and allow multiple solutions rather than a unique solution. Moreover, the performance of the selected cognitive task should not be restrained by other skills that are not related to divergent thinking. Although an alien drawing task may test divergent thinking (Ward et al., 2004), it requires drawing skills that are unrelated to creativity.

1.3. Overview of the present research

The current study tested the hypothesis that drinking tea promotes creativity with divergent thinking by adopting two tasks that measure spatial cognitive creativity and semantic innovative creativity. In experiment 1, we used a block-building task to measure divergent thinking. Playing blocks may be associated with the improvement of spatial reasoning (Jirout & Newcombe, 2015). Casey et al. (2008) used a block-building task as their spatial measure to investigate whether block-building activities enhance children's spatial skills. Moreover, Jirout and Newcombe (2015) found that playing with blocks is positively associated with spatial skills. In experiment 2, we used a creativity measurement task, similar to the pasta-naming task (Steffens, Gocłowska, Cruwys, & Galinsky, 2016), as a measure of divergent thinking. The pasta-naming task measures ideational fluency, which is an essential element of creativity (Steffens et al., 2016). Both tasks meet the requirements of being related to divergent creativity without being restrained by other skills unrelated to divergent thinking.

Additionally, we adopted the implicit priming experimental paradigm such that participants were unaware of the independent variable manipulation (Hong, Morris, Chiu, & Benet-Martinez, 2000). Tea consumption was manipulated implicitly by serving tea and water during the greeting stage of the experiment, so the participants did not realize that drinking was the crucial part of our study. This research design helped us exclude the potential compound effect of the experience induced by making tea themselves during tea preparation.

To sum, current research aims to examine the hypothesis that tea consumption promotes divergent creativity, the main effect hypothesis (H1). We also hypothesize that this improvement is due to that tea drinking can lead to a positive mood which is beneficial for divergent creativity, the mediation hypothesis (H2). We ran experiment 1 to test the main hypothesis, and experiment 2 to retest the main effect and to investigate mood's mediation effect. Particularly, we are mainly focusing on acute effect of tea on creativity, and creativity is measured within 10–25 min after tea drinking. In other words, we are mainly

interested in the psychological function on creativity that may happen in very short period of time after drinking.

2. Experiment 1

2.1. Method

2.1.1. Participants

Fifty university students (22 males) were recruited from the campus Bulletin Board System (BBS). Their mean age was 23.73 years (SD = 2.11). We paid $6 to each participant for his or her involvement.

2.1.2. Design

This study included two parallel consumption conditions: a cup of black tea (Lipton, a well-known brand but anonymous to participants, approximately 150 mL) and a cup of water, both served at a drinkable temperature of 42 °C. In both conditions, the amount of drink consumption was coded. The participants were randomly allocated into two groups, resulting in 26 participants in the tea group and 24 in the water group.

2.1.3. Procedure

A receptionist (experimenter A) received one participant at a time in room A to operate our independent variable: pouring a cup of tea (or water) for every participant.

Then, the receptionist asked each participant's name, mobile phone number and ID number as well as questions related to educational background. This warm-up stage was designed to manipulate the independent variable, during which the participant drank the tea (or water). The cups provided to the participants were disposable and were removed in front of every participant to ensure clean cups. The amount the participant drank was recorded by the receptionist.

To let the participants drink as much as possible, the receptionist also poured herself a cup of the same drink. She spoke with the participant while drinking the beverage for three minutes so that the participant could have enough time to finish the drink.

Then, the participants were guided to room B and were received by experimenter B (who did not know whether the participant consumed tea or water). Experimenter B showed the participant the block play task instructions and then began to count the time.

The instructions for block play were as follows:

A toy factory is going to launch a new type of block and needs some block construct examples. Please build a block design that you think is attractive with as many blocks as you can in the given time. *There are several judges next door whose duty is to rate your work. After you complete your block building, two photos of it will be taken and sent to these judges. Your scores will determine how much extra money you can earn.*

We used the word "attractive" rather than "creative" because we believed that the former is more understandable and meaningful to participants. Nevertheless, the two words share a similar essence of meaning. "Creative" is more abstract, whereas "attractive" is more concrete, and they are closely related to one another when describing a block-building result. Creativity is a necessary input of an attractive block-building work, and attractiveness is the output of creativity. To encourage the participants do their best, we told them they would earn extra money depending on their rating, although the actual payment was equal for every participant. Every participant had a maximum of 10 min to build a block design. When the time was up, experimenter A entered and took two photos for each block construct, one in quarter view and one from eye level (see Fig. 1 for details).

Measurement of divergent thinking creativity: We recruited 10 university students who had never attended the experiment and were blinded to the purpose and the conditions of the experiment to rate the creativity of every block construction. The rating was composed of four dimensions: degree of innovativeness, aesthetic appeal, unification, and grandness. Innovativeness measures how new and unusual the construction is, aesthetic appeal measures how beautiful it is, unification measures how well every part of the blocks integrates together as a whole, and grandness measures how stately and magnificent it is. The rating was on an 11-point Likert scale (0 = "*absolutely no*", 10 = "*absolutely yes*"). We calculated the mean of 4 dimension ratings (α = 0.94).

2.2. Results

A general linear model analysis showed that the creativity scores of the block buildings for the tea group ($mean$ = 6.54, SD = 0.92) were significantly higher than those for the water group ($mean$ = 6.03, SD = 0.94) after controlling for gender and volume consumed [F (1.48) = 5.56, p = 0.023, η_p^2 = 0.108, observed power = 0.637 (see Figs. 1 and 2)].

We coded the volume the participants drank as 1 = drank nothing, 2 = drank one-third of a cup, 3 = drank one-third to two-thirds, and 4 = drank more than two-thirds. The data showed that the tea group's mean volume was 2.65, and the water group's volume was 2.71. Four participants drank less than one-third of a cup and none drank nothing.

2.3. Discussion

The results provide preliminary support for our hypothesis that drinking tea can promote divergent creativity. The results are also consistent with Einöther et al.'s (2015) expectation that tea consumption should contribute to divergent creativity. This experiment demonstrates for the first time the effect of tea on divergent creativity. Notice that in both conditions, the participants did not drink much; moreover, it did not take much time for the participants to finish the task. Thus, even with a limited amount of tea consumption (approximately half of a cup) within a limited time (approximately 3 + 10 min), tea may promote divergent creativity. The block-building task we used here is a spatial cognition creativity task that is free from other restrictions such as drawing skills, and there is no threshold for each participant to bring into full play his or her divergent thinking creativity.

Moreover, in experiment 1, we used a procedure in which the experimenter rather than the participant prepared the tea drink. Thus, we ensured that the concentration and temperature of the tea was equal for every participant in the tea group. Moreover, this helped exclude the possible compound effect of the experience of tea preparation.

However, we did not control mood in experiment 1, and thus we do not know whether mood was the mechanism of the relationship between tea and divergent thinking creativity, so in experiment 2 we measured participants' mood with Affect Grid (Russell, Weiss, & Mendelsohn, 1989) after drinking. Moreover, we used a spatial cognitive task to measure divergent thinking creativity. We do not know whether our findings of tea's effect on divergent creativity can be replicated by other types of divergent creativity tasks. In experiment 2, we test whether the findings in experiment 1 can be generalized to other types of cognitive domains, such as semantic analysis tasks. By doing so, we can examine whether the effect of tea on divergent creativity can be replicated.

3. Experiment 2

3.1. Method

3.1.1. Participants

Forty students (20 males) were recruited from campus BBS. Their mean age was 23.0 years (SD = 1.86). We paid $6 for each participant's involvement. Among these participants, 8 had never drunk tea and were evenly distributed between the tea group and the water group. The average amount the participants drank in daily life was approximately 390 mL per month.

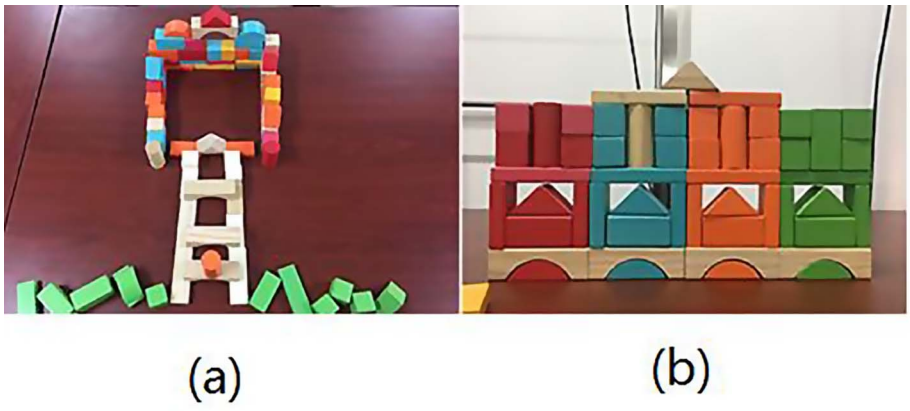

Fig. 1. Pictures of (a) a high creativity score block building and (b) a low creativity score block building.

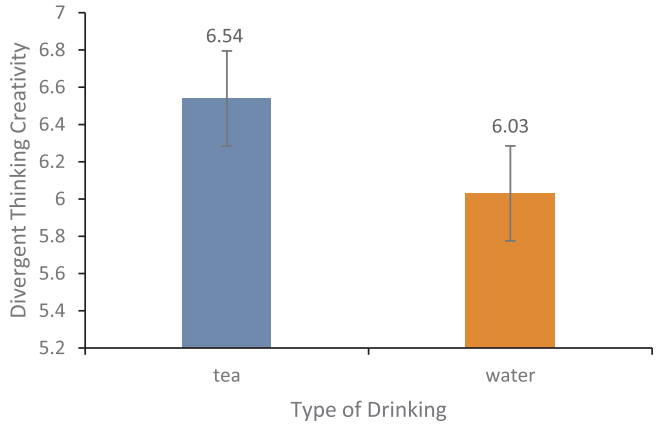

Fig. 2. Creativity scores in the block-playing task for the two groups (experiment 1).

3.1.2. Design

The participants underwent the same 3-min warm-up stage as in experiment 1. The participants were randomly allocated into two groups, resulting in 20 participants in the tea group and 20 in the water group. However, in our final data analysis, we excluded one participant who drank nothing, and this participant came from the water group. As a result, we had 19 participants in the water group and 20 in the tea group.

3.1.3. Procedure

We retained every procedure in the warm-up stage, including the tea and water treatments, as in experiment 1. We changed only the task that measured creativity to examine our hypothesis. Given that several studies have found an association between tea drinking and positive mood and a relationship between positive mood and creativity (Einöther et al., 2015; Einöther, Rowson, Ramaekers, & Giesbrecht, 2016), it has been suggested that positive mood may explain the mechanism of the relationship between tea drinking and creativity. Therefore, we added a measure of the participants' mood using the Affect Grid (Russell et al., 1989) at the end of the warm-up stage. According to Russell et al. (1989), the Affect Grid assesses the degree of valence and arousal. The participants were asked to mark how they felt on a 19 × 19 grid with valence on the horizontal axis, ranging from unpleasant to pleasant, and arousal on the vertical axis, ranging from sleepy to active.

After the warm-up stage, the participants were led to room B. Experimenter B in room B (who did not know whether the participant consumed tea or water) explained the instructions of the ramen restaurant-naming task and gave them the task paper, which was a form with 50 blanks.

The instructions for the naming task were as follows:

There is a newly opened ramen (noodle) shop, and we are recruiting shop names for it. Please write as many names as possible that you think are cool and attractive within 20 min. There are some judges in the next room who are responsible for evaluating and selecting the appropriate shop names. We will give your final name list to them to rate. Your scores will determine how much extra money you can earn.

Similar to experiment 1, we used the words "cool and attractive" rather than "creative" because we believed that the former is more understandable and meaningful to participants. The name must be attractive to be considered creative, and a creative name draws the attention of the judges by standing out.

After 20 min, experimenter B notified the participants that the trial time was up and asked them to wait in place. Then, experimenter A entered and removed the paper with the participant's ramen shop names.

In the last step, the participants were asked to complete the tea consuming habit questionnaire, which was the same as in experiment 1 with two additional questions about the participant's perceived degrees of mental involvement and body involvement (Einöther et al., 2015). The degree of perceived physical effort may be associated with more positive affect (Einöther et al., 2015). One question was, "Please rate the degree of your mental and body involvement during the naming task". These questions were rated on a 10-point Likert scale (1 = "absolutely uninvolved", 10 = "entirely involved").

Measurement of divergent thinking creativity: We recruited 10 students who had never attended the experiment and were blinded to the purpose of the experiment to rate the creativity of each ramen restaurant name. One judge did not finish the rating; thus, we received 9 judges' ratings. The rating was composed of two dimensions: innovativeness (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014) and playfulness (Bateson & Nettle, 2014). We proposed these two dimensions for two reasons. First, we usually evaluate a restaurant name based on innovativeness and playfulness in a real-life context. Furthermore, a good name must be innovative and playful. In particular, a creative name should be innovative, and an innovative name reflects the performance of creativity. Second, a more positive mood may lead to more playful names suggested by the participant. The lowest score was 1, and the highest score was 10. An example of a name that received a low innovativeness score is "Ramen Family", and an example of a name that received a high innovativeness score is "No Ramen Here".

The scores of innovativeness and playfulness for each participant were the average ratings of all eligible names he or she created.

3.2. Results

3.2.1. Naming task score

In total, 1307 names for the ramen restaurant were collected from 40 participants. After deleting ineligible names (those that included location names and those that contained only the word "Ramen"), 1104

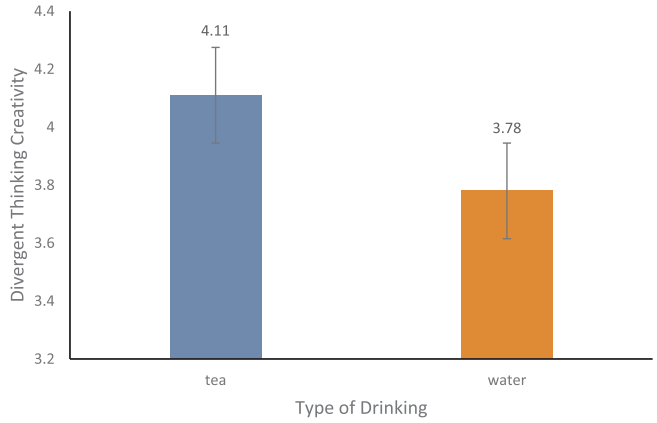

Fig. 3. Scores of the innovativeness dimension in the naming task for the two groups (experiment 2).

names remained. We excluded two judges' ratings to reach a coefficient of internal consistency of 0.733 (the two judges' ratings had low correlations with others).

Using a MANOVA that controlled for gender, the volume the participants drank, whether they drank tea regularly and the number of restaurant names, we found that, consistent with our hypothesis, participants in the tea group received significantly higher scores (*mean* = 4.11, *SD* = 0.49) in innovativeness compared to those in the water group (*mean* = 3.79, *SD* = 0.45) [$F(1, 37) = 5.18$, $p = 0.029$, $\eta_p^2 = 0.129$, observed power = 0.600]. We did not identify any significant differences between the two groups in the ratings of playfulness [$F(1, 37) = 2.42$, $p = 0.129$, $\eta_p^2 = 0.065$, observed power = 0.328] or in the number of names [$F(1, 37) = 0.014$, $p = 0.908$, $\eta_p^2 = 0.000$; Fig. 3] after controlling for the same variables. Interestingly, we equally split the names of every participant into two parts according to the written order and got two new scores: the first half naming scores and the second half ones. After controlling for the same variables, MANOVA manifested that it is the second half scores that mainly contributed to the differences in innovativeness between the tea group (*mean* = 4.03, *SD* = 0.52) and the water group (*mean* = 3.72, *SD* = 0.48) [$F(1, 38) = 5.56$, $p = 0.024$, $\eta_p^2 = 0.134$, observed power = 0.631]. There was no significant difference in innovativeness between the water group (*mean* = 3.83, *SD* = 0.57) and the tea group (*mean* = 4.15, *SD* = 0.57) in the first half naming scores [$F(1, 38) = 3.24$, $p = 0.080$, $\eta_p^2 = 0.083$, observed power = 0.418].

Finally, unlike previous findings, there were no significant differences in the scores of valence [$F(1, 38) = 2.82$, $p = 0.102$, $\eta_p^2 = 0.073$, observed power = 0.373] and arousal [$F(1, 38) = 0.023$, $p = 0.880$, $\eta_p^2 = 0.001$, observed power = 0.053] between the tea group and the water group with regard to perceived mental involvement [$F(1, 38) = 2.93$, $p = 0.095$] or body involvement [$F(1, 38) = 0.050$, $p = 0.825$].

3.3. Discussion

The results of experiment 2 replicated the findings of experiment 1, showing that drinking tea can be significantly beneficial for divergent creativity. We observed the same effect of tea in both the spatial cognitive test and the semantic test. It seems that drinking tea has a solid and consistent positive effect on divergent creativity. More importantly, we found that the effect of tea on divergent creativity performance took place at the second half period of the experiment, revealing that the role of tea is to keep the performance of divergent creativity for a relatively long-lasting period of time. We may infer that coming up with more ramen restaurant names at the second half of the task is apparently more difficult than the first half of the task and needs more creativity thinking, because during the first half of the test participants had already written out most ideas that they could think of. This result is in line with Einöther et al. (2015)'s findings that the response time of tea group was faster than that of water group only for difficult level RAT, whereas there was no difference for easy level RAT.

Notice that the average naming scores are not high. There may be several reasons. First, our participants were university students who had no related innovation-design experience of naming a restaurant before and they had only 20 min to involve in the task. Second, in fact, there all existed high-score names, medium-score names and low-score names in almost every participant's final naming works such that the final average scores were not very high.

However, the results did not show that mood could be a mechanism for explaining how drinking a cup of tea could significantly improve divergent creativity. In experiment 2, drinking tea and perceived mental involvement or body involvement did not influence the degree of valence and arousal. There are several possible explanations. First, unlike previous studies (Einöther et al., 2015, 2016), we did not purposely recruit tea drinkers as participants. Moreover, we used an implicit priming experimental design such that participants had no expectations for being treated with tea and the identity of being a regular tea drinker did not appear in their mind when they came to our experiment. No participants were aware that drinking (tea vs. water) was part of the experiment, and none of them was involved in the drinking preparation. This manipulation may explain why there was no significant difference in mood between the two groups because in our experiments, no particular experience was introduced due to a special procedure such as tea preparation. Our implicit priming manipulation separated the effect of tea itself from that of a tea experience or the feeling that is induced by tea preparation. Moreover, the current research did not consider whether the participants were regular tea drinkers; we were interested in the effect of a cup of tea on divergent creativity and on common people, a more generalized effect. Thus, we suggest that the mood mechanism or the attention mechanism may be suitable for regular tea drinkers with the experience of tea preparation. There may exist another undiscovered mechanism from implicitly drinking tea to divergent creativity.

4. General discussion

The aim of our research was to test whether drinking tea would improve divergent thinking creativity and if this association could be mediated by mood. Using two experiments with two different tasks, we got similar findings. Experiment 1 demonstrated that tea consumption improved performance in block building, which is a spatial creativity task. Consistent with the results of experiment 1, experiment 2 showed that those who drank tea received higher scores in innovativeness in the ramen restaurant-naming task, which involved semantic processing creativity. But experiment 2 didn't find the mediation effect of mood on the relationship between tea consumption and divergent creativity. Therefore our research hypothesis H1 was supported whereas hypothesis H2 was not.

We are the first to empirically demonstrate that tea drinking improves divergent thinking creativity, which confirmed our research hypothesis. Our findings are consistent with previous research showing that tea drinking is positively related to creativity (Einöther et al., 2015; Isen et al., 2004). For example, Einöther et al. (2015) showed that tea consumption promoted convergent thinking. Our work expanded these findings by showing that tea consumption can also promote divergent creativity.

Our research also demonstrated the external validity of the effect that tea consumption could have on the performance of divergent thinking across two experiments and different types of creativity tasks. Specifically, we used a spatial creativity task (block building) and a semantic creativity task (naming a ramen restaurant). This use of different samples and tasks and dependent measures across the experiments also demonstrates the robustness and generalizability of the

effect.

Moreover, we contribute to the literature in the methodological aspect by using adapted experimental paradigms and identifying more appropriate divergent creativity measurement tasks. Although previous studies provide strong logic for why tea consumption promotes creativity, they suffered from a methodological problem. Einöther et al. (2015) was the first to distinguish the effects of drinking tea on convergent and divergent creativity using the Remote Associates Test and an alien drawing task (Ward et al., 2004). However, that study did not identify a significant effect of tea on divergent thinking compared to that on convergent thinking. It is possible that the alien drawing task requires drawing skills which may interfere the measurement of pure creativity. To solve this methodological problem, we adopted a spatial cognitive task and a semantic cognitive task that we believe can better reflect the creativity performance without possible interference or restrains from skills not related to creativity.

Finally, our research adopted a more elaborate manipulation of the independent variable. We controlled the temperature of tea and water to the same temperature of 42 °C for both experimental conditions in each study. Researchers have found that physical warmth and coldness have different influences on performance in several creativity tasks (IJzerman, Leung, & Ong, 2014). Considering this, we minimized the interference of the physical temperature of the drink by controlling the temperature. We also controlled the concentration of black tea by serving similarly prepared tea by the experimenters.

4.1. Limitations and implications for future research

Our research has some limitations. First, we did not identify any significant differences in the playfulness of ramen restaurant names between the two groups in experiment 2. We measured the playfulness of the ramen restaurant names based on the work of Bateson and Nettle (2014), who found that participants whose self-reported playfulness scores were high reported relatively high creativity scores and offered more alternative uses of a certain object. Although drinking tea improves cognitive creativity, it may not significantly increase the level of playfulness compared to drinking water. This result is reasonable because tea consumption leads to calmness, a moderate level of arousal, and alertness (Einöther & Martens, 2013), and these mental states are unrelated to playfulness.

Second, we did not measure the biological ingredients of the tea that the participants consumed. The literature has demonstrated that there are at least two factors of tea consumption, dose and time, that may biologically influence consequent cognitive processing. Einöther and Martens (2013) concluded that two biological ingredients, caffeine and theanine, have beneficial effects on attention, which is an indispensable part of cognitive function. A cup of tea generally contains 35–61 mg (average 48) of caffeine and 4.5–22.5 mg (average 13.5) of theanine. In the majority of studies that investigated the effect of tea consumption on cognitive performance, tea contained more than 50 mg of caffeine or theanine (Bryan, 2008). Thus, the amount of tea ingredients our participants absorbed was relatively small (the majority of our participants drank about 1/3–2/3 cup of tea, which contained limited amount of caffeine and theanine). Also, theanine facilitates long-term sustained attentional processing rather than short-term moment-to-moment attentional processing during the entire time frame of a difficult visuospatial task (Gomez-Ramirez, Kelly, Montesi, & Foxe, 2009), and it takes approximately 30–60 min for tea's biological ingredients to influence attention, alertness, and brain concentration (Einöther et al., 2015). Since our divergent creativity tasks took only 10–20 min and relatively small amount of tea consumed, we can attribute the tea's effects on divergent creativity performance to psychological effects more than physiological effects. Future research can examine this issue by priming participants' conceptual perception of tea without the direct consumption of tea. Further, by extending the time period of tea consumption and task performance, future research can more deeply investigate the physiological effects of tea on creativity. Future studies can clarify the effect of tea ingredients by examining the specific effect of tea so that we can tell whether and to what extent the effect of tea on creativity is physiological or psychological. For example, studies should be conducted to determine whether the positive effect of creativity improvement is because of the ingredients themselves or other effects, such as the process of preparing tea oneself, tea's special aroma, or tea as a traditional drink different from pure water. There could even be a mixed effect of tea that is the combination of physiological and psychological effects.

Third, we did not identify the role mood plays as the mechanism in the relationship between tea and creativity. We measured the participants' affective states with the Affect Grid, but we did not identify any differences between the two groups, which is inconsistent with the literature (Einöther et al., 2015; Isen et al., 2004). This result may be attributed to our implicit experimental paradigm; all participants reported that they were unaware that drinking tea or water was the necessary part of the manipulation after the experiment. However, in the study by Einöther et al. (2015), all participants were recruited under the condition that they were regular tea drinkers who drank tea at least 5 times a week. The tea group was also involved in the entire preparation process of tea, whereas the water group was just served one cup of water. Thus, we may infer that different pleasure levels between the tea group and the water group might be caused by different treatments rather than the tea itself. Given that we didn't find that the mood is the mechanism for the effects of tea, a possible assumption is that people may already setup a mind-set about the function of drinking tea (Wang, Zhu, & Wang, 2014). It has been found that people believe that those who drink tea have a particular set of personal characteristics such as "smart", "innovative", "elegant", "self-confident" and "steady" (Wang et al., 2014). It is possible that when people expose to tea, they might be primed to behave in the way that they think a tea drinker should do, because tea may activate related mind-set or mental processes, which, as a priming, becomes operative and guides inferences in following cognitive processes (Hong et al., 2000). We call for more research to clarify this issue.

In conclusion, tea consumption can improve divergent thinking creativity in spatial cognitive processing and semantic processing tasks. Future research can examine the specific mechanism by identifying which variables mediate or moderate the effects of tea consumption on divergent thinking creativity.

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Author Contributions

L.W. and Y.W. conceived the main research idea. L.W. and Y.H. made the research design. Y.H., E.W., Y.C., and S.L. ran the experiments. Y.H. and L.W. performed the statistics. All authors were involved in the manuscript preparation.

Appendix

The instruction for the warm-up stage in experiment 1 & 2:

"Welcome to our lab! Sit down, please and have a cup of tea (water), first. Our experiment requires you to calm down. Please put your phone to silent mode or turn it off and do not use it during the experiment. Next, we will ask you some personal information for the sake of payment."

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