How is One Plus One More than Two? The Interaction between Two Players in Online Co-Creativity Tasks

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(Submitted June 20, 2021; Revised November 3, 2021; Accepted November 28, 2021)

ABSTRACT: This study is one of the first to employ an online interactive creativity task platform to explore one's creativity performance in a paired-player mode. It analyzed the differences between 342 participants' performances in single- and paired-player modes on two creativity tests: The Alternative Uses Task (AUT) and Chinese Radical Remote Associates Test (CRRAT). Potential factors affecting performance in the paired-player mode were summarized based on participants' responses to the AUT and CRRAT to analyze the correlation between the factors and creativity performance. Results showed that playing the AUT or CRRAT, low scorers can improve fluency, flexibility, originality, and performance by referring to response category or another participant's answer, closing the gap between their score and that of the high scorers. These results reveal both the similarities and differences of creativity performance on the two tests in an interactive situation and the correlation between response strategies and creativity performance in the paired-player mode. This study utilized online standardized measurement tools to explore how two persons cooperate in creativity tests to reveal that creativity performance may vary between tasks.

Keywords: Creativity, Divergent thinking, Remote associates test, Interaction, Synergetic

1. Introduction

Creativity refers to the diversity of ideas that one comes up with, and is a cognitive process in which novel and appropriate ideas are produced (Mednick, 1962; Wu et al., 2020a). Currently, most relevant studies have focused on one's internal mechanism (Huang, 2017; Huang et al., 2019; Wu et al., 2020b; Wu et al., 2021), the process in which creativity is developed within a group, and the influencing factors involved (Chang et al., 2009; Walsh et al., 2017; Zeilig et al., 2018). However, few studies have explored the creative thinking process of an individual in a group. In other words, it remains unclear whether people will produce a greater number of original ideas when interacting with others than when working independently. Therefore, this research topic can deepen the understanding of both individuals and groups' creative thinking process.

Divergent thinking and insight problem-solving are typical creative thinking processes involving different internal mechanisms (Lin & Lien, 2013) that are assessed using diametrically orthogonal tasks (Wakefield, 1992). Divergent thinking concerns producing ideas of different types via free association, wherein novel ideas are produced (Guilford, 1956). It is often evaluated using the Alternative Uses Task (AUT) (Torrance, 1974; Hsu et al., 2012) from three aspects: fluency (number of the ideas produced), flexibility (the heterogeneity of one's responses), and originality (novelty and appropriateness of one's responses). In contrast, insight problem-solving refers to the problem-solving process in which individuals discover the relationship between stimuli that results in an "aha!" moment (Fleck & Weisberg, 2013; Weisberg, 2015; Wu et al., 2020b); therefore, it is often measured using insight problems and Remote Associates Tests (RAT) (Knoblich et al., 2001; Bowden & Jung-Beeman, 2003; Huang, 2017). Empirical studies have found no significant correlation between divergent thinking and insight problem-solving (Lin et al., 2005).

Overall, the internal processes that people undergo when working independently or when interacting with others are different, for an individual may be influenced by others' ideas in interactive situations. Meanwhile, this influence may exert an impact on their divergent thinking and insight problem-solving, and one may produce a greater number of more innovative ideas in divergent thinking tasks or better ideas in insight problem-solving tasks in interactive situations. Therefore, clarifying how others' viewpoints affect an individual's idea production will help to reveal an individual's thinking process in interactive situations, thus further enhancing the understanding of how one plus one may be better than two in this context.

1.1. Creativity: From individual to group levels

Creativity is defined from varied perspectives due to different research interests and backgrounds. However, the following two models of creativity are widely discussed: the 4Ps model of creativity, which refers to product, personality, place, and process (Rhodes, 1961), and the multi-dimensional model (involving mysterious, psychoanalytic, practical, psychometric, cognitive, social personality, and confluence approaches) (Sternberg & Lubart, 1999). The cognitive process of creativity is mentioned in both models, suggesting that how individuals produce creativity has been a continuous concern for researchers.

Moreover, creativity research from the social personality perspective emphasizes that creativity is a product of the interaction between individuals and their external environment (Csikszentmihalyi, 1988; Littleton et al., 2008; Glăveanu et al., 2018), while creativity research from the convergence perspective believes that creativity consists of multiple components, with cognitive, personality, and environmental factors taken into consideration (Bronfenbrenner, 1979). These two perspectives focus on the impact of the external environment on individual creativity (Woodman et al., 1993). The majority of creativity studies on relevant environmental and cultural factors have been conducted in groups, which can be divided into four levels based on the number of group members (which is often less than six): individuals, groups, organizations, and culture (Magyari-Beck, 1993). Previous studies have been often conducted at the individual, organizational, and cultural levels, while few have been conducted in a group with a small number of members or with a focus on the creativity of individuals within a group. Thus, there is little research on individuals' cognitive processes when cooperating with group members.

A typical theory about creative processes at the individual level is the stage theory of creativity development (Wallas, 1926), which includes four phases: preparation, incubation, illumination, and verification. Preparation focuses on learning and understanding problems to gather relevant information, knowledge, and skills. If individuals do not successfully gain solutions in this stage, they will not focus on a problem. Instead, they will shift their focus to other tasks; a phase known as incubation. During this stage, individuals' thoughts are not confined by the linear or logical way of thinking which facilitates the formation of their creative achievements. During illumination, individuals have an "aha!" experience. They achieve insight into one or many solutions and form initial creative results. The last stage is verification, during which individuals will examine, evaluate, and determine whether a solution is viable according to both internal and external standards, which they then modify solutions with and move into another cycle. The stage theory is of great importance to creativity research (Kaufmann, 2003).

Moreover, Amabile (1988) pointed out that the creative thinking process for a group consists of five stages: presentation, preparation, generation, validation, and assessment, as follows. First, a group is informed of the problem to be solved, or decides on it by themselves (presentation). Then, all resources are collected from the group members for the problem (preparation). The group then comes up with ideas to solve the problem (generation). The group assess and select their produced ideas (validation). Finally, the group evaluates the result of their labor (assessment). When the group outcome is determined, the whole creative process comes to an end. However, the creative process moves back to the presentation stage if the outcome has room for improvement. Leonard and Swap (1999) proposed a five-stage process for group creative thinking based on divergent thinking, convergent thinking, and stage theory that involves individuals' creative thinking process (Wallas, 1926). This includes: preparation, innovation opportunity, divergence: generating options, incubation, and convergence: selecting options.

In sum, the creative thinking process at both the individual and group levels experience the following stages: preparation, incubation, and validation (Wallas, 1926; Amabile, 1988; Leonard & Swap, 1999). The biggest difference between the processes at the individual and group levels lies in the way that creative ideas come to their minds during the illumination stage. For individuals, their inspiration may come from existing knowledge or previous experience. Group members' ideas may be affected by others, resulting in them coming up with original ideas that are different from what they had produced. In short, when group members produce creative ideas together, some members produce creative ideas based on their personal experience or knowledge, and their ideas are influenced by the ones that other group members propose. The biggest difference between creative thinking at the individual and group levels is that a group member produces ideas in interactive situations; that is, they come up with an idea based on others' responses as well as their knowledge and experience.

1.2. Creativity assessments: Dual-process perspective

The AUT and RAT have different types of tasks (Wakefield, 1992), and correspond to divergent thinking and insight problem-solving, respectively (Lin et al., 2012). The concept of divergent thinking derives from the structure-of-intellect theory (Guilford, 1956), which advocates that creativity is a loop of the intelligence structure. Guilford (1956) divided divergent thinking into the following different dimensions: fluency (the ability to produce many ideas), flexibility (the ability to produce heterogeneous ideas), originality (the ability to produce novel and original ideas), and elaboration (the ability to embellish an idea by adding details). It can be seen from these four dimensions that divergent thinking produces a variety of products via ideation from different perspectives. Guilford (1956) also pointed out that divergent thinking is the key to creativity, and the more ideas people produce, the more likely they are to form creative ideas. Accordingly, divergent thinking serves as a theoretical foundation for multiple creativity tests (Clapham, 2010).

RAT, developed by Mednick (1968) based on associative theory, consists of open-ended questions with close-ended answers (Wakefield, 1992), and is often used to evaluate one's insight problem-solving ability (Bowden & Jung-Beeman, 2003; Huang, 2017; Wu et al., 2020b). An RAT question is comprised of three seemingly irrelevant English stimuli words, which are selected from normative data, and requires participants to find an English word that can be paired with the three stimuli to form meaningful expressions. For instance, an RAT question could consist of the three stimuli of "blood," "music," and "cheese," and a possible solution to the question could be the word "blue" for it can be paired with the stimuli to create three meaningful expressions: "blue blood," "blue music," and "blue cheese."

Empirical studies have found that RAT has a strong correlation with insight problem-solving (Huang et al., 2012; Chang et al., 2016). In the Chinese-speaking field, Jen et al. (2004) compiled a Chinese RAT (CRAT) that is applicable to the Chinese language based on the pairing of Chinese characters by referring to the RAT by Mednick (1968), and is the first RAT that is suitable for Chinese native speakers to test creativity. Thereafter, CRATs based on Chinese two-character word pairing and Chinese radical pairing, respectively, have been compiled (Huang et al., 2012; Chang et al., 2016) at three levels for Chinese characters (i.e., Chinese radicals, Chinese characters, and Chinese two-character words) (Wu, 20119; Hung & Wu, 2021). Among the three CRAT tests, the Chinese Radical Remote Associates Test (CRRAT) (Chang et al., 2016) has high criterion-related validity which is suitable for the assessment of insight problem-solving abilities.

In sum, AUT and RAT, which represent different dimensions of creativity, are both important tools for the assessment of creativity performance. It is worth exploring whether people are inspired by others' ideas when two people perform a creativity task in a concerted effort to either produce more original ideas or find it easier to solve remote associates problems in groups rather than independently. The use of an online platform can help to understand one's performance in a two-member group (Hong et al., 2016).

1.3. The Present study

Previous studies on the creative thinking process focused only on individual-level (Wu et al., 2021) or group-level (Walsh et al., 2017; Zeilig et al., 2018) contexts. Few studies have approached the production of creative ideas in interactive situations. Therefore, it is still difficult to understand how individuals with different existing abilities produce more creative ideas in the course of group interactions. The current study aims to analyze the differences of one's performance on AUT and CRRAT in the single- and paired-player modes by utilizing an online interactive creativity task platform. In addition, this study explores the correlation between the involved factors and the paired-player mode according to participants' responses and strategies.

To explore individuals' creativity in interactive situations, this study adopted the interactive creativity task platform as its main research tool to collect participants' responses to AUT and CRRAT in the single- and paired-player modes. Then, it analyzed the possible response strategies that a participant could use to complete creativity tests in the paired-player mode based on their responses, such as referring to others' answers or sticking to one's thoughts. Their performance on the two creativity tests in the single- and paired-player modes was compared, and the correlation between the count of a response strategy and the creativity performance in the paired-player mode was analyzed. Thus, the effects of interaction between group members on diverse creativity might be examined.

In interactive situations, research participants have access to others' responses, which may be inspirational for them (Littleton et al., 2008; Glăveanu et al., 2018). Therefore, the current study assumes that one's performance on the AUT and CCRAT in the paired-player mode will be better than that in the single-player mode.

Meanwhile, it presumes that in a two-member group, participants with lower scores on the creativity tests in the single-player mode will improve their scores, so the gap between the low- and high-score groups is expected to narrow.

Moreover, this study supposes that the more that one of the two-member groups refer to the response of the other group, the better their performance will be in the paired-player mode. In short, one who often refers to the answer of another in a two-member group will produce homogeneous ideas on the AUT, so they will score more in all dimensions of divergent thinking and have a higher accuracy rate on the CRRAT. This study examines the differences in individual creative performance in single- versus paired-player modes. We analyze the relationship between creative performance and response strategies to clarify how different skills held among group members produces creative ideas in interactive situations, thus exploring how "one plus one may be better than two." The study will provide empirical evidence for two-member collaborative creativity theory.

2. Methods

2.1. Participants

This study recruited 342 adults as research participants, of which 98 were male and 244 were female. They were aged between 20 and 30, with an average age of 23.34 (*SD* = 2.79). All were native Mandarin speakers with at least some college education. They were randomly matched to form two-member groups to finish creativity tasks in the paired-player mode anonymously. This experiment passed the examination of the Institution Review Board (IRB). All participants took part in the research only after they understood it and had signed the informed consent form. They were rewarded with NT$ 300 when they finished the task.

2.2. Measures

The study performed the experiment using the online interactive creativity task platform, which was developed by the researcher. The interface includes a test question display section, response display section, question-answering section, the time remaining, and the operating mode, as shown in Figure 1. The platform has two operating modes: single- and paired-player. In the paired-player mode, a participant has access to another's response. Participants cannot communicate directly with others on the platform. They can only improve access to answers by referring to other participants' responses. This platform includes two versions of AUT and CRRAT, respectively. Each test has a guide and answer pages. All tests are automatically scored. The experimenter controls order of implementation, operation mode (single-play or paired-player), and allotted answer time for each test according research requirements.

Figure 1. Interface of the interactive creativity task platform

2.2.1. Divergent thinking test

This study compiled two divergent thinking tasks—Straw-Alternative Uses Task (S-AUT) and Bottle-Alternative Uses Task (B-AUT)—by referring to the existing AUTs, such as unusual uses of bamboo chopsticks (Wu et al., 1998) and newspapers (Hsu et al., 2012). In addition, this study gathered research samples as normative data to calculate scores for fluency, flexibility, and originality. Participants' scores from computer-based calculations had stable scorer consistency (*rs* = .99, .92, .97, .97, .92, and .95). There was convergent validity between the computer scores and typical divergent thinking tasks (*rs* = .79, .54, .58, .75, .51, and .60), and discriminant validity between the computer scores and CCRAT (*rs* = .05, .10, .14, .17, .18, and .18).

2.2.2. The CRRAT

A total of 40 CRRAT questions were selected from the item pool compiled by Chang et al. (2016). The questions were divided into two parts, with an even number of test questions of the same degree of difficulty—CRRAT A and CRRAT B. Each CRRAT question was composed of three Chinese radicals: "女" (nü; female), "子" (tzu; son), and "禾" (ho; standing grain). Participants were required to propose a Chinese radical that could be paired with the three Chinese cues to create meaningful and commonly used Chinese characters. For example, "乃" (nai; be) was one solution. The CRRAT participants were given one point for each correct answer. CRRAT A and B had stable internal consistency (Cronbach's α = .80, .79), good criterion-related validity with insight problem-solving (*rs* = .48, .38), and CWRAT (*rs* = .58, .48).

2.3. Procedure

This study was conducted in groups. The researcher explained the purpose and schedule, and asked participants to sign the informed consent form. Participants performed creativity tests (S-AUT, B-AUT, CRRAT A, and CRRAT B) on the interactive creativity task platform. All tests lasted for 10 minutes in a counterbalanced design. Participants performed different tasks in the single- and two-player modes. For example, participants perform S-AUT and CRRAT A in the two-player mode if they complete B-AUT and CRRAT B in the single-player mode.

2.4. Data analysis

The scores of fluency, flexibility, and originality in the two divergent thinking tests and the accuracy rates of CRRAT A and CRRAT B were calculated, respectively. The participants' scores for the divergent thinking tests and CRRAT A and B in the single- and two-player modes were compared with those who had higher scores from the two-member groups as the high-score group, and those who had lower scores as the low-score group. A two-way analysis of variance (ANOVA) was adopted to explore differences in the AUT and CRRAT scores, with the groups (high- and low-score groups) and the modes (single- and two-player modes) as variables. Thus, individuals' creativity performance was approached in interactive situations.

This study set two indicators for a creativity test to represent how an individual reacts to another's answer based on their responses to the AUT and CRRAT questions, with the hope of understanding how individuals interact with each other when performing creativity tests in the two-player mode. First, two indicators of category co-occurrence (CC) and priming originality (PO) were set to analyze the responses to AUT; the former referred to the situation wherein an individual looked at another's response and came up with a homogeneous answer, while the latter referred to the situation wherein an individual looked at another's response and produced a homogeneous answer, but of high originality (which received a score greater than 0). The ratios of the two indicators to the total valid responses ((CC count)/(Number of valid responses) and (PO count)/(Number of valid responses)) were calculated. Moreover, "Follow Others" (FO) and "Insist Myself" (IM) were two indicators used to analyze the responses to CRRAT; the former referred to the situation wherein an individual looked at another's response and wrote down a similar answer, whereas the latter referred to when an individual gave a different answer in the same situation. This study calculated the counts of FO and IM in the two-player mode.

3. Results

3.1. Divergent thinking test

The two-way ANOVA results showed that the interaction effect between groups and one- and paired-player modes reached the level of significance in terms of fluency [$F(1, 340) = 26.28$, $p < .001$, $\eta^2 = 0.07$], flexibility [$F(1, 340) = 11.06$, $p = .001$, $\eta^2 = 0.03$], and originality [$F(1, 340) = 23.77$, $p < .001$, $\eta^2 = 0.07$]. The high- and low-score groups had significant main effects in terms of the scores for different indicators (Fs = 55.01, 55.79, 45.91, $ps < .001$, $\eta^2_s = 0.14, 0.14, 0.12$). Nonetheless, the scores for the two different modes showed no significant difference (Fs =1.32, 0.28, 0.01, ps = .251, 599, 981, $\eta^2_s < 0.01$). Further analysis of the main effects indicated that the high-score group had a significantly better performance than the low-score group in terms of fluency [$F(1, 680) = 39.56$, $p < .001$, $\eta^2 = 0.10$], flexibility [$F(1, 680) = 31.88$, $p = .001$, $\eta^2 = 0.09$], and originality [$F(1, 680) = 33.34$, $p < .001$, $\eta^2 = 0.09$] in the single-player mode. Moreover, the high-score group had significantly higher scores than the low-score group [Fs = 10.22, 8.14, 8.98, ps = .001, .002, .002, $\eta^2_s = 0.03, 0.02, 0.03$] in the paired-player mode, but the effect size significantly decreased.

As shown in Table 1, the gap in AUT scores between the high- and low-score groups narrowed, as the low-score group improved the score [Fs = 7.90, 3.92, 11.77, ps = .003, .029, .001, $\eta^2_s = 0.02, 0.01, 0.03$] whereas the performance of the high-score group did not improve and even slightly declined [Fs = 19.70, 7.42, 12.00, $ps < .005$, $\eta^2_s = 0.05, 0.02, 0.03$]. In addition, the average flexibility and originality scores for each response were calculated with fluency as the denominator, and the corresponding results revealed that the average flexibility for the high-score group in the paired-player mode significantly improved [$t(170) = 2.39$, $p = .018$, Cohen's $d = 0.18$], whereas the average originality showed no noticeable changes [$t(170) = -1.18$, $p = .242$, Cohen's $d = 0.09$]. Conversely, the low-score group did not show any considerable changes in average flexibility [$t(170) = 0.08$, $p = .940$, Cohen's $d = 0.01$] and average originality [$t(170) = 1.48$, $p = .141$, Cohen's $d = 0.11$] in the paired-player mode. The results suggest that the interactive (i.e., paired-player) mode exerts a different impact on the high- and low-score groups in terms of divergent thinking.

Table 1. Descriptive statistics of two creativity tests between the two groups

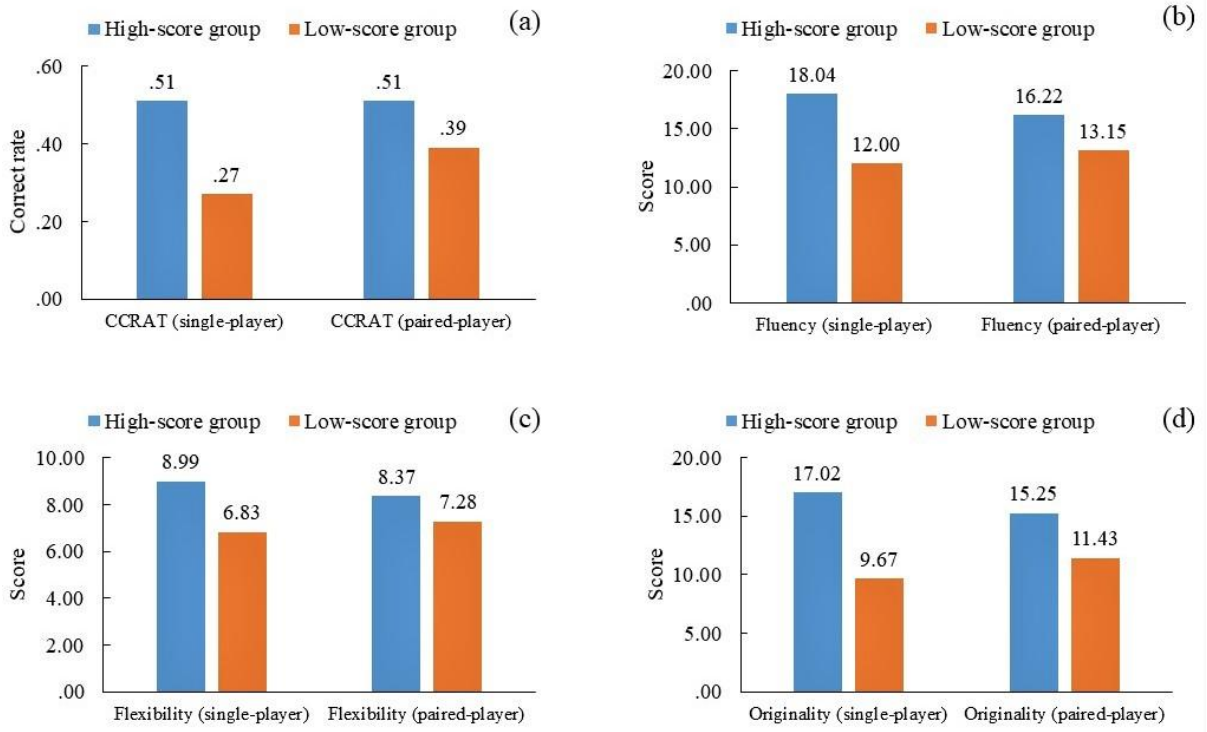
	High-score group		Low-score group	
	Mean	Standard deviation	Mean	Standard deviation
Divergent Thinking Test				
Fluency (single-player)	18.04	6.31	12.00	5.22
Fluency (paired-player)	16.22	7.02	13.15	6.43
Flexibility (single-player)	8.99	2.49	6.83	2.29
Flexibility (paired-player)	8.37	2.85	7.28	2.36
Originality (single-player)	17.02	8.95	9.67	6.46
Originality (paired-player)	15.25	9.51	11.43	8.09
Chinese Radical Remote Associates Test				
CCRAT (single-player)	.51	.15	.27	.15
CCRAT (paired-player)	.51	.18	.39	.2

Note. S = single-player; T = two-player; CCRAT = Chinese Radical Remote Associates Test. *N* for Divergent Thinking Test = 342; *N* for CCRAT = 318.

3.2. The CRRAT

The two-way ANOVA results showed that the groups and modes had significant interaction effects on the accuracy rate of the CCRAT [$F(1, 316) = 35.82$, $p < .001$, $\eta^2 = .10$]. Both the group [$F(1, 316) = 111.91$, $p < .001$, $\eta^2 = .26$] and the mode [$F(1, 316) = 37.76$, $p < .001$, $\eta^2 = .11$] had significant main effects. The analysis of the main effects indicated that the high-score group had a better performance than the low-score group, both in the single- [$F(1, 632) = 73.81$, $p < .001$, $\eta^2 = .19$] and two-player [$F(1, 632) = 17.91$, $p < .001$, $\eta^2 = .05$] modes, but the effect sizes declined. In addition, Figure 2 shows that the low-score group had a better performance in the two-player mode than in the single-player mode [$F(1, 316) = 73.57$, $p < .001$, $\eta^2 = .19$], whereas the high-score group showed no significant difference in both modes [$F(1, 316) < .001$, $p = .99$, $\eta^2 < .01$], suggesting that the gap between the low- and high-score groups narrowed due to the increase in score of the low-score group. This finding reveals that the interactive mode has no significant impact on the CRRAT performance of the high-score group.

Figure 2. Performance of the high- and low-score groups on the AUT and CRRAT in two modes



3.3. Potential factors during interactive creativity

This study analyzed the strategies that individuals used when performing the AUT and CRRAT in the two-player mode. First, the low-score group (M_{CC} = .45, SD_{CC} = .33; M_{PO} = .28, SD_{PO} = .22) employed the CC and PO (*ts* = 2.39, 2.25, *ps* = .02, .03, Cohen's *ds* = .26, .24) more frequently than the high-score group (M_{CC} = .37, SD_{CC} = .30; M_{PO} = .23, SD_{PO} = .21) in the AUT. Relevant analysis results showed that the CC had a significant correlation with fluency (r = .12, p = .03) and originality (r = .12, p = .03) in the two-player mode, whereas it had no significant correlation with flexibility (r = .01, p = .80) in the two-player mode. However, the PO had no significant correlation with the above indicators in the two-player mode (*rs* = .04, -.06, .03, *ps* = .41, .27, .54).

Moreover, the low-score group (M_{FO} = 4.13, SD_{FO} = 3.12) had a greater number of FO counts [$t(316) = 3.36$, p = .001, Cohen's d = .38] in comparison with the high-score group (M_{FO} = 3.04, SD_{FO} = 2.63). However, the two groups had no noticeable differences in IM counts ($t(316) = 0.87$, p = .39, Cohen's d = .10). Relevant analysis results showed that the FO counts had a significant positive correlation with the two-player mode (r = .46, p < .001) and no significant correlation with IM counts (r = -.03, p = .55), suggesting that an individual is more likely to have a higher accuracy rate if they are more able to refer to another's response in the two-player mode.

4. Discussion

This study explores the differences in individuals' creative processes between divergent and convergent thinking in interactive situations. It employs an online interactive creativity task platform to gather participants' AUT and CRRAT performances in the single- and two-player modes, which differs from the previous studies that use pen-and-pencil tests to gather data about individuals' creativity performance. The online platform not only provides participants' scores for each dimension, but also records their question-answering process and responses. The results showed that those who obtained lower scores in the divergent thinking test in the single-player mode had a better performance in the two-player mode, especially on fluency, flexibility, and originality. Conversely, those who had a better AUT performance in the single-player mode had lower scores in the two-player mode, suggesting that the gap in the divergent thinking performance between the two groups had narrowed in interactive situations.

Moreover, the gap between the two members of a group for the CRRAT accuracy rate had also narrowed; individuals with a lower accuracy rate in the single-player mode improved their performance in the paired-player

mode, while others with a higher accuracy rate had no considerable changes in the paired-player mode. Additionally, this study found that in the paired-player mode, the more often an individual referred to others' responses, the more likely they would achieve higher scores on the divergent thinking test (especially for fluency and flexibility) and the CRRAT. These results reveal the similarity and difference between individuals' performance on the two creativity tests in interactive situations, and the possible correlation between their response strategies and their performances in the paired-player mode.

This study set the participants' performance in the single-player mode as their existing capability and found that the mode had interaction effects. The scores of those with high existing capabilities declined in fluency, flexibility, and originality on the divergent thinking test in the two-player mode. Conversely, those with low existing capabilities showed a considerable increase in the scores on the divergent thinking test in the two-player mode. The results reveal that performing the AUT in the two-player mode exerts different impacts on the high- and low-score groups. The performance of those with low existing capabilities may be improved due to their reference to the answers of those with high existing capabilities, whose answers give the low-score group inspiration and enable them to produce a greater number of more original ideas. However, the average flexibility score ((Flexibility score)/(Fluency score)) and average originality score ((Originality score)/(Fluency score)) of those with high existing capabilities in the two-player mode were not lower than their corresponding scores in the single-player mode. This decrease in their scores on the divergent thinking test may be attributed to their lower willingness to answer questions when the other group members referred to their ideas, which affected their fluency.

What is worth mentioning is that the extent to which both the low-score group improved their performance and the scores of the high-score group declined was different. In other words, in the paired-player mode, those with high capabilities still had a better performance than those with lower scores, even though they improved the low scorers' divergent thinking by referring to the ideas of those with high capabilities, suggesting that the collaboration in the paired-player mode only partially improved the divergent thinking performance of those with low capabilities.

In addition, individuals' CCRAT scores in the two-player mode significantly increased. Further examination on the impact of the mode on participants with different existing capabilities found that in the two-player mode, only those with low existing capabilities improved their performance, whereas those with high existing capabilities had no change in their scores. This finding reveals two phenomena. First, those with low existing capabilities can refer to another's response when performing the CRRAT in the two-player mode. This enables them to come up with an answer that they are not able to think of independently and to spend less time answering certain test questions when they are able to refer to another's, which allows them to have more time for other questions and to come up with better answers, thus improving their performance in the two-player mode. However, those with high existing capabilities did not have a better performance in the two-player mode, indicating that those with low existing capabilities brought limited assistance to them. Moreover, individuals could refer to another's response when performing the CRRAT consisting of close-ended questions, but the responses of the high- and low-score groups were not completely the same. This finding suggests that individuals do not completely refer to another's response but may refer to another's response strategy, resulting in differences between the two groups.

In sum, this study found that the paired-player mode exerted different impacts on one's performance on the divergent thinking test and CRRAT, especially for those with high capabilities. The AUT and CRRAT can be differentiated in terms of task types (Wakefield, 1992). The AUT is composed of a close-ended question with open-ended solutions, whereas the CRRAT consists of open-ended questions of fixed patterns that have close-ended answers. The AUT respondents freely associated the task with target-related concepts, which can be explained via the associative hierarchy (Mednick, 1962). Highly creative people have a greater chance to produce more original ideas, while those with low creativity tend to come up with fewer creative ideas. However, the AUT sets time limits on one's response, but no limits on the number of their solutions. In interactive situations, those with high capabilities may have lowered their willingness to think of more solutions after considering that their ideas may be referred to, which resulted in their fluency score decreasing in the paired-player mode than in the single-player mode.

However, their average flexibility and originality scores in the two modes remained unchanged, suggesting that their creativity performance did not get worse in the paired-player mode. Those with high capabilities in the CRRAT did not slightly decrease as well. They were required to finish the same number of test questions in the single- and paired-player modes, and put on the same performance. This may result from the ceiling effect of one's creative performance, or the shortage of motivation to deliver a better performance or reference target. In

sum, the paired-player mode facilitates the improvement of the creativity performance for those with low capabilities, but has limited effects on those with high capabilities.

This study further explores the relationship between potential factors and one's performance in the paired-player mode. In terms of the divergent thinking test, a high percentage of those with low capabilities referred to the response of the other members in the paired-player mode, thus producing more unique ideas. In addition, the CC rate was positively correlated with the fluency and originality scores in the paired-player mode, while the PO rate had no correlation with divergent thinking. In interactive situations, the way one referred to the other (i.e., FO or IM) was conducive to divergent thinking, but the original ideas produced this way were independent from the scores of the divergent thinking test.

In this respect, those with low capabilities often referred to the answer of the other group members in the CRRAT (i.e., FO), which had a positive correlation with the accuracy rate, whereas the IM had no correlation with the accuracy rate. This finding indicates that FO is more helpful to lift the accuracy rate of one's CRRAT (close-ended questions). These results also suggest that, generally, FO exerts a positive impact on one's creativity performance in the paired-player mode, which means that one is able to produce more original ideas and is more likely to solve remote associates' problems if referring to others' responses in the paired-player mode and gaining inspiration. However, this synergetic effect only occurred for those with low capabilities in this study.

4.1. Limitations and future research

This study has some limitations regarding its implementation. First, the online interactive creativity task platform only enabled participants to access the response of their group members before coming up with other solutions in the paired-player mode. This function sufficed when conducting this study, However, technically speaking, it did not enable the two group members to interact with each other during the question-answering process, which means that two group members could not talk to each other and discuss test questions (Pifarré, 2019). Thus, this platform remains to be improved in subsequent research.

In addition, this study found that the AUT performance of the high-score group in the single-player mode slightly declined in the paired-player mode, potentially because they were not happy to see the fruit of their labor being plagiarized, which reduced their motivation to deliver a good performance on the divergent thinking test. This speculation needs to be verified by more empirical experience via interviews or the manipulation of modes (like cooperative or competitive modes). The high-score group in the single-player mode did not deliver a better performance in the paired-player mode, possibly because of a limited response time, participants' motivation to answer questions, and the ceiling effect of one's creativity. The possible causes cannot be verified in this study, so they remain to be confirmed in future studies.

5. Conclusion

This study is the one of the first to use an online interactive creativity task platform to discuss the difference in the creativity performance between two modes. The comparison of the high- and low-score groups' AUT and CRRAT performances in the two-player mode examined the impact of the two-player mode on creativity. The results showed that the low-score group refer to the response of the other group members and significantly improved their creativity performance in the two-player mode, while the high-score group did not significantly increase their AUT and CRRAT scores. Further analysis of the impact of the two-player mode on the divergent and convergent creativity revealed that the CCRAT accuracy rate increased while the AUT scores did not show a noticeable increase. In short, one plus one is not greater than two under any circumstances, which may be attributed to the mode.

The results reflect the importance of mutual observation between group members in the process of group creation. Teachers can guide students to open their minds and learn from group members, so that students with different capacities can come up with a variety of ideas through observing and imitating ideas of other group members. Furthermore, this study analyzed how people with different capacities might improve their creative performance by referring to the others' answers. This study adopted an online standardized measurement tool to conduct preliminary research on how two participants perform on creativity tests in a concerted effort, which expands the potential contributions of co-creativity research.

Acknowledgement

This work was financially supported by the "Institute for Research Excellence in Learning Sciences" of National Taiwan Normal University (NTNU) from The Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan. We also thank the Ministry of Science and Technology, Taiwan, R.O.C. for funding this study, through projects on "How is one plus one more than two? Exploring the process and training of creative thinking and creative product under interactive situations: From measurement, mechanisms to neural plasticity" (MOST108-2410-H-003-080) and "How do individuals display their creativity in groups? The moderation effects of intrinsic and extrinsic factors, brain structure and interactive mobile teaching" (MOST109-2628-H-003-005-MY2).

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