







The Creative Power of Collaborative Pairs in Divergent Idea-Generation Task

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Abstract. The creative power of collaborative pairs in comparison with that of individuals was assessed. Participants were 61 university students who engaged in two kinds of divergent idea-generation tasks, such as thinking of new names for specific categories, i.e. tea and rice. In the first task, new rice brand names were generated by all participants on their own, while in the second task new tea names were generated by half of the participants on their own and by the other half in pairs through brainstorming. Video sequences of collaboration by 20 pairs were annotated with the number of constructive interactions produced. Another 27 university students, as neutral third-party participants, evaluated the quality of the generated ideas with a view to originality and utility. The results suggest that pairs achieved a higher quality of ideas than did individuals and, moreover, that the greater number of constructive interactions produced by pairs contributed to the higher quality of ideas. We expect these findings to be helpful in designing relationality for improving the creativity between people as well as between people and social robots.

Keywords: Creativity · Group size · Collaboration ·
Divergent idea generation task · Constructive interaction · Quality of ideas

1 Introduction

Are people more creative as individuals or in pairs? We investigated the creative power of pairs in comparison with individuals by using divergent idea generation tasks.

We are sometime expected to rustle up a dinner from a few things we have on hand. At work, we are sometime expected to develop innovative products [1, 2]. In our everyday life, we need to generate new ideas to solve various kinds of problems, from immediate matters to elaborate challenging tasks.

ATC21s has addressed creativity as one of the 21st century skills for students to acquire [3]. Furthermore, engaging in creative intelligent tasks is one of the jobs expected to be left to humans after approximately 700 jobs are transferred to robots with artificial intelligence in the coming 20 years [4]. Both of these future expectations

imply the need for people to possess creative power. How, then, can the creative power of people be improved?

In previous studies of the group-size effect in problem solving, it has been reported that group performance is generally superior to the performance of average individuals [5, 6]. However, while most studies have examined the effect of group performance on the number of ideas produced in the divergent idea generation task [e.g. 7], there has been little focus on the quality of such ideas.

In this paper, we focus on the group-size effect, i.e. individuals or pairs, on the quality of ideas by using the divergent idea-generation task of creating new brand names for tea or rice. We measured two kinds of individual abilities: (a) communication skills [8] and (b) active-learning attitudes [9]. We also measured two kinds of performance in pairs: (c) degree of conversational satisfaction as a subjective indicator [10], and (d) number of ideas and (e) number of constructive interactions as an objective indicator. In the education field, a constructive interaction in collaborative group work is regarded as an essential step in developing understanding, improving the learning effect, and solving problems [e.g. 11]. In addition, (f) the names generated in the two tasks were rated in terms of originality and utility by third-party participants.

We compared the originality and utility of ideas based on group size, that is, either individuals or pairs. We analyzed the relationship between the number of constructive interactions produced and the creativity of ideas (i.e. originality and utility) generated by pairs.

2 Method

2.1 Predictions

Group-Size Effects on the Quality of Ideas: We are interested in the relationship between group size and the quality of ideas. We predict that the quality of ideas by pairs is superior to that by individuals in a divergent idea-generation task, just as demonstrated for the number of ideas [5, 6].

Effect of Constructive Interactions Produced in Pairs on the Quality of Ideas: We are also interested in the relationship between the number of constructive interactions produced and the quality of ideas, especially by pairs. We predict that a larger number of constructive interactions produced through collaboration in pairs will achieve a higher quality of ideas, as already shown for the learning effect of problem solving in the classroom [11].

2.2 Divergent Idea-Generation Task

Participants: A total of 61 university students ($M = 30$, $F = 31$, mean age: 20.41 years, $SD: 1.49$) participated in two kinds of name-generation tasks based on the framework of a divergent idea-generation task [7]. In the first task of generating new rice names, all participants engaged in it as individuals. In the second task of generating

new tea names, 21 participants took part as individuals, while the other 40 participants performed it as 20 same-gender pairs. Each pair consists of same gender for minimizing effects of gender differences on interaction. They were randomly assigned to individuals or pairs.

Procedure: All participants were asked to generate as many new rice names as possible within one minute to measure their own creative ability. They engaged in the rice-name-generation task as individuals and worked independently. Next, after randomly dividing participants into two groups, i.e. individuals or pairs, they were asked to generate as many new tea names as possible within three minutes to compare the creativity of individuals with that of pairs. This second task of generating tea names was repeated three times with the same groups, and their performances were video-recorded. Then, they were asked to take both a communication skills test and an active-learning attitudes test. Pairs were also asked about their degree of satisfaction in communication.

Parameters: This paper used the following subjective or objective parameters as analytical indicators for measuring the creativity of participants.

Subjective Indicators: The following three parameters were assessed by the participants on their own performance as subjective indicators.

- (a) Score of communication skills test: Total score of the communication skills test for every participant [8].
- (b) Score of active-learning attitudes test: Total score of the active-learning attitudes test for every participant [9].
- (c) Degree of conversational satisfaction: Eighteen questions on the paired participants' degree of satisfaction with the conversation of the partner in their pair using an eight-point scale [10] for every two-person group.

Objective Indicators: The following two parameters were assessed by the three annotators as objective indicators.

- (d) Number of ideas: Total count of ideas for new rice names within one minute or for new tea names within three minutes in each experimental trial.
- (e) Number of constructive interactions: Total count of constructive interactions from video sequences in first and third trial of pair. A constructive interaction consists of two roles, *task-doing* and *monitoring*. A previous study reported that the exchange of roles between two participants through collaboration facilitates learning [11]. All utterances were classified into two kinds of speech acts: understanding and non-understanding. The speech acts of understanding include three labels: self-evident, proposal, and confirmation. The speech acts of non-understanding include three labels: searching, criticism, and question. One constructive interaction is counted from the first speech act of understanding and the last speech act of non-understanding.

2.3 Third-Party Evaluation of Quality of Ideas

Participants: A total of 27 university students ($M = 9$, $F = 18$, mean age: 20.48 years, $SD: 1.91$) who did not participate in the two name-generation tasks engaged in an evaluation experiment as neutral third-party participants.

Procedure: All participants were asked to evaluate every name of rice or tea on its originality and utility as measures of the quality of ideas.

Parameters: This paper used the following parameters as analytical indicators for measuring the quality of ideas.

Originality: In this experiment, a new name with higher originality is defined as a novel name that evaluators had never before seen. Total score of originality in every new idea for a rice or tea name was calculated using a five-point scale. Examples of tea names with higher originality are as follows: *Ikkyu-san mo tanoshinda ocha* (tea that Ikkyu-san enjoyed drinking), *Otousan no aizyou ga komotta ocha* (tea that's like a father's affection), *Shizuoka kenmin ga kirai na ocha* (tea that a citizen of Shizuoka prefecture does not like), *Sawayaka na kaze no youni* (tea like a fresh breeze), *Ochazuki ni yoru ochazuki no tameno ocha* (tea for a tea lover by a tea lover).

Utility: In this experiment, a new name with higher utility is defined as a suitable name for a product put on the actual market. Total score of utility in every new idea for a rice or tea name was calculated using a five-point scale. Examples of tea names with higher utility are as follows: *Ajiwai* (tasty), *Kaori* (aroma of tea), *Umami no shizuku* (a drop of tasty tea), *Koiuma* (strong and tasty tea), *Wa no megumi* (a blessing of Japanese style).

3 Results and Discussion

3.1 Relationship Between Group Size and Quality of Ideas

Group Size and Number of Ideas

Tables 1 and 2 show the descriptive statistics value for the number of ideas in the new tea name generation task. A three-way mixed-design ANOVA on the number of ideas for the names of tea (group sizes * gender * trials ($2 * 2 * 3$)) did not reveal any significant effect for group size ($F(1,37) = 2.48$, $p = .12$, $\eta_p^2 = .05$), gender ($F(1,37) = .37$, $p = .55$, $\eta_p^2 = .01$), or number of trials ($F(2,37) = 0.02$, $p = .98$, $\eta_p^2 < .01$). It also did not show significance of any interaction among factors for the number of ideas: between group size and gender ($F(2,74) = 1.43$, $p = .24$, $\eta_p^2 = .03$), between group sizes and trials ($F(2,74) = .17$, $p = .85$, $\eta_p^2 < .01$), or between gender and trials, ($F(2,74) = 1.20$, $p = .31$, $\eta_p^2 < .01$). Table 3 shows the ANOVA table for the number of ideas in the new tea name generation task. From the results, group size, gender and trials did not seem to affect the number of ideas.

Table 1. Descriptive statistics value for the number of ideas in the tea name generation task.

	Ave.	Median	Mode	S.D.	Min.	Max.
1 st trial	12.32	10	10	13.04	0	83
2 nd trial	12.20	10	4	10.38	0	59
3 rd trial	12.31	9	6	9.44	2	38
Total	36.83	28	24	30.94	4	180

Table 2. Descriptive statistics value for the number of ideas in the tea name generation task: stratified by group size, gender and trials.

Group size	Gender	1 st trial		2 nd trial		3 rd trial	
		Ave.	S.D.	Ave.	S.D.	Ave.	S.D.
Individuals	Female	10.44	4.39	11.89	7.47	12.44	6.77
	Male	18.50	21.99	16.25	16.51	17.25	14.86
Pair	Female	10.91	6.77	11.09	6.04	9.18	4.71
	Male	7.67	4.44	8.44	4.53	9.44	2.98

Table 3. The ANOVA table for the number of ideas in the new tea name generation task.

	SS	df	MS	F	p
Group size	758.73	1	758.73	2.48	.12
Gender	113.05	1	113.05	0.37	.55
Group size * Gender	438.92	1	438.92	1.43	.24
Trials	0.91	2	0.46	0.02	.98
Group size * Trials	8.14	2	4.07	0.17	.85
Gender * Trials	17.58	2	8.79	0.36	.70
Group size * Gender * Trials	58.95	2	29.47	1.20	.31

Group Size and Originality or Utility of Ideas

Table 4 shows the descriptive statistics value for the evaluation score of originality and utility of ideas in the new tea name generation task. Tables 5 and 6 shows the descriptive statistics value for the evaluation score of originality or utility of ideas stratified by group size, gender and trials.

Table 4. Descriptive statistics value for the evaluation score of originality and utility of ideas with a five-point scale in the new tea name generation task.

	Ave.	Median	Mode	S.D.
Originality	2.41	2.40	2.00	0.53
Utility	2.85	2.82	3.00	0.58

Table 5. Descriptive statistics value for the evaluation score of originality of ideas with a five-point scale in the tea name generation task: stratified by group size, gender and trials.

Group size	Gender	1 st trial		2 nd trial		3 rd trial	
		Ave.	S.D.	Ave.	S.D.	Ave.	S.D.
Individuals	Female	2.22	0.36	2.30	0.44	2.25	0.39
	Male	2.41	0.49	2.40	0.53	2.54	0.65
Pair	Female	2.41	0.54	2.47	0.55	2.58	0.58
	Male	2.30	0.46	2.48	0.50	2.48	0.53

Table 6. Descriptive statistics value for the evaluation score of utility of ideas with a five-point scale in the tea name generation task: stratified by group size, gender and trials.

Group size	Gender	1 st trial		2 nd trial		3 rd trial	
		Ave.	S.D.	Ave.	S.D.	Ave.	S.D.
Individuals	Female	3.02	0.57	2.86	0.57	2.95	0.60
	Male	2.80	0.61	2.65	0.55	2.64	0.58
Pair	Female	3.07	0.47	2.99	0.52	2.84	0.57
	Male	3.00	0.51	3.01	0.59	3.00	0.60

A three-way ANOVA on the score of the quality of ideas according to originality and utility (group size * gender * number of trials (2 * 2 * 3)) showed a main effect for trials (originality: ($F(2,1518) = 6.42, p < .01, \eta_p^2 = .01$) in Table 7 utility: ($F(2,1518) = 7.69, p < .01, \eta_p^2 = .01$) in Table 8). There were also significant differences in interaction between group size and gender (originality: ($F(1,1518) = 19.94, p < .01, \eta_p^2 = .01$), utility: ($F(1,1518) = 21.78, p < .01, \eta_p^2 = .01$)). Post-hoc comparisons revealed that the score of originality of ideas in the third trial of the tea-name-generation task was demonstrated to be significantly greater than that in the first trial ($F(1,996) = 12.29, p < .01, \eta_p^2 = .01$ in Table 9), although the score of utility of ideas in the third trial was demonstrated to be significantly lower than that in the first trial ($F(1,996) = 13.45, p < .01, \eta_p^2 = .01$ in Table 10).

Table 7. The ANOVA table for the evaluation score of originality of ideas with a five-point scale in the new tea name generation task.

	SS	df	MS	F	p
Group size	3.31	1	3.31	12.08	<.01
Gender	1.26	1	1.26	4.62	.03
Group size * Gender	3.52	2	1.76	6.42	<.01
Trials	5.46	1	5.46	19.94	<.01
Group size * Trials	0.56	2	1.28	1.03	.36
Gender * Trials	0.14	2	0.07	0.25	.78
Group size * Gender * Trials	1.25	2	0.62	2.28	.10

Table 8. The ANOVA table for the evaluation score of utility of ideas with a five-point scale in the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Group size	8.88	1	8.88	27.87	<.01
Gender	3.37	1	3.37	10.58	<.01
Group size * Gender	3.24	2	1.62	5.09	<.01
Trials	6.71	1	6.71	21.07	<.01
Group size * Trials	1.15	2	0.57	1.80	.17
Gender * Trials	0.30	2	0.15	0.46	.63
Group size * Gender * Trials	1.56	2	0.78	2.44	.09

Table 9. Descriptive statistics value for the evaluation score of originality of ideas with a five-point scale in the new tea name generation task: stratified by trials.

	Ave.	<i>S.D.</i>	Total number of evaluated ideas
1 st trial	2.36	0.48	475
2 nd trial	2.41	0.52	532
3 rd trial	2.47	0.58	523

Table 10. Multiple comparisons in trials for the evaluation score of utility of ideas with a five-point scale in the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Between 1 st trial and 2 nd trial	3.65	1	3.65	11.23	<.01
Between 2 nd trial and 3 rd trial	0.06	1	0.06	0.81	.67
Between 1 st trial and 3 rd trial	4.61	1	4.61	13.45	<.01

As a result of the simple main effect, female participants showed a higher score of originality in pairs than in individuals ($F(1,1526) = 27.67, p < .01, \eta_p^2 = .02$), although male participants did not show any significant difference between performance in pairs and in individuals ($F(1,1526) = 0.37, p = .54, \eta_p^2 < .01$) (Fig. 1). On the other hand, male participants showed a higher score of utility in pairs than in individuals ($F(1,1526) = 39.54, p < .01, \eta_p^2 = .03$), although female participants did not show any significant difference between performance in pairs and in individuals ($F(1,1526) = 0.51, p = .48, \eta_p^2 < .03$) (Fig. 2).

We did not find any correlation between the communication skills of participants and their score of idea quality (originality: $r = -.10$, utility: $r = -.03$). We also did not find any correlation between the active-learning attitude of participants and their score of idea quality (originality: $r = .04$, utility: $r = .07$).

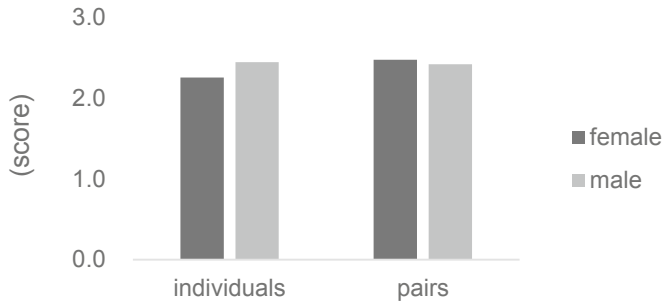


Fig. 1. Relationship between group size and the evaluation score of originality of ideas.

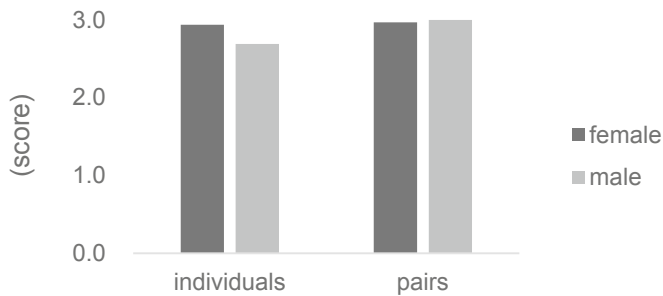


Fig. 2. Relationship between group size and the evaluation score of utility of ideas.

3.2 Relationship Between Constructive Interaction and Quality of Ideas

Twenty pair was divided into two groups by using average number of constructive interaction; (i) higher group: pair was produced larger number of constructive interaction than average, and (ii) lower group: pair was produced smaller number of constructive interaction.

Number of Constructive Interaction and Number of Ideas

Tables 11 and 12 show the ANOVA tables for the number of ideas in 1st and 3rd trials of the new tea name generation task.

Table 11. The ANOVA table for the number of ideas in 1st trial of the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Higher/lower group	185.36	1	185.36	6.56	.01
Gender	97.20	1	97.20	3.44	.07
Higher/lower group * Gender	17.85	1	17.85	0.64	.43

Table 12. The ANOVA table for the number of ideas in 3rd trial of the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Higher/lower group	16.26	1	16.26	1.14	.29
Gender	0.80	1	0.80	0.06	.81
Higher/lower group * Gender	51.70	1	51.70	3.64	.06

The two-way mixed design ANOVA on the number of ideas in the first trial of the tea-name-generation task (gender * higher/lower group (2 * 2)) showed a main effect for the higher/lower group ($F(1,36) = 6.56, p = .01, \eta_p^2 = .15$). There was no significant difference in the main effect for gender ($F(1,36) = 3.44, p = .07, \eta_p^2 = .09$). There was also no significant difference of interaction between the higher/lower group and gender ($F(1,36) = 0.63, p = .43, \eta_p^2 = .02$). Figure 3 shows the average number of ideas with the higher or lower group in 1st trial. This figure’s results suggest that the participants in the higher number of constructive interactions produced a larger number of ideas in the first trial of tea-name generation with two-person groups.

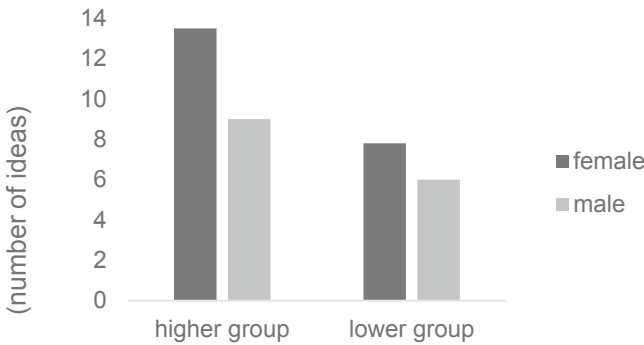


Fig. 3. Relationship between higher/lower number of constructive interactions and the average number of ideas in the first trial of the tea-name-generation task in pair.

Number of Constructive Interaction and Creativity of Ideas

Tables 13, 14, 15 and 16 show the ANOVA tables for the originality or utility of ideas in 1st and 3rd trials of the new tea name generation task.

Table 13. The ANOVA table for the evaluation score of originality of ideas in 1st trial of the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Higher/lower group	0.02	1	0.02	0.44	.51
Gender	0.13	1	0.13	2.42	.13
Higher/lower group * Gender	0.01	1	0.01	0.01	.92

Table 14. The ANOVA table for the evaluation score of originality of ideas in 3rd trial of the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Higher/lower group	0.86	1	0.86	8.38	<.01
Gender	0.04	1	0.04	0.42	.52
Higher/lower group * Gender	0.10	1	0.10	0.94	.34

Table 15. The ANOVA table for the evaluation score of utility of ideas in 1st trial of the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Higher/lower group	0.15	1	0.15	2.27	.14
Gender	0.05	1	0.05	0.68	.41
Higher/lower group * Gender	0.04	1	0.04	0.61	.44

Table 16. The ANOVA table for the evaluation score of utility of ideas in 3rd trial of the new tea name generation task.

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Higher/lower group	0.12	1	0.12	1.10	.30
Gender	0.45	1	0.45	4.04	.05
Higher/lower group * Gender	0.04	1	0.04	0.37	.55

The two-way ANOVA on the quality of ideas in the third trial of the tea-name-generation task (gender \times higher/lower number of constructive interactions (2×2)) showed a main effect for the higher/lower number of constructive interactions on the originality of ideas ($F(1,36) = 8.38, p < .01, \eta_p^2 = .19$), although there was no significant difference in the main effect on the utility of ideas ($F(1,36) = 1.10, p = .30, \eta_p^2 = .01$). There was no significant difference in the main effect for gender (originality: $F(1,36) = 3.44, p = .07, \eta_p^2 = .09$, utility: $F(1,36) = 4.04, p = .05, \eta_p^2 = .10$). There was also no significant difference in interaction between the higher/lower number of constructive interactions and gender (originality: $F(1,36) = 0.63, p = .43, \eta_p^2 = .02$, utility: $F(1,36) = 0.37, p = .55, \eta_p^2 = .01$). Figure 4 shows the average score for the originality of ideas with the higher or lower number of constructive interactions. From this figure, it can be seen that the participants with the higher number of constructive interactions produced higher originality of ideas in the third trial of tea-name generation with two-person groups.

We did not find any correlation between the conversational satisfaction in pair and their score of idea quality (originality: $r = .08$, utility: $r = -.27$).

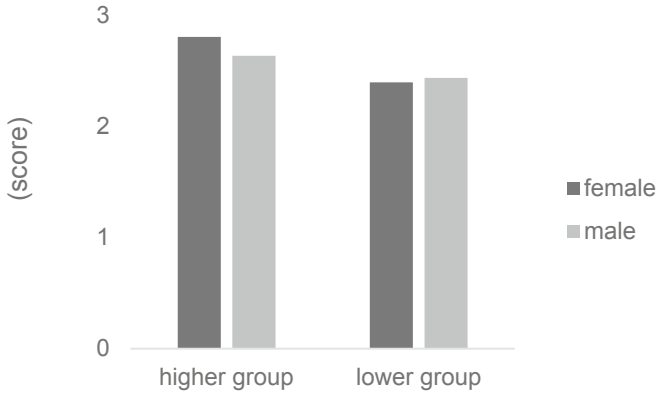


Fig. 4. Relationship between higher/lower number of constructive interactions and the average score for the originality of ideas in the third trial of the tea-name-generation task in pair.

4 Discussion

4.1 Group-Size Effects on Quality of Ideas

Group size affected the quality of ideas in terms of originality and utility in the divergent name-generation task, although it did not affect the number of ideas. The quality of ideas in pairs is superior to that in individuals. Thus, our prediction might be partly supported, even though the results on the quantity of ideas showed different tendencies from those in previous studies. This appears to be caused by participants making more contributions to the quality of ideas in the presence of others. This effect is called social facilitation [12].

4.2 Production of Constructive Interaction Affects Both Quantity and Quality of Ideas

Producing a larger number of constructive interactions increased the quality of ideas in the third trial, while it increased the number of ideas in the first trial. The production of constructive interaction includes making propositions or giving critical opinions to the partner [11]. In the first trial, a pair producing a larger number of constructive interactions affects the number of ideas. On the other hand, such a pair in the third trial might frequently change between the two roles of task-doer and monitor. This is caused by participants making more contributions to the quality of ideas with the higher quality of interaction with each trial.

5 Conclusions

In this study, we examined the creative power of collaborative pairs in divergent idea-generation tasks in comparison with that of individuals. The results suggest that the quality of ideas, i.e. originality and utility, in pairs was superior to that in individuals.

It was also suggested that a larger production of constructive interactions through the collaboration of pairs enhanced the quality of ideas. On the other hand, there was little contribution of individuals' communication skills or active-learning attitudes to the quality of ideas.

These findings could be applied to the relational design [13] between people as well as people and social robots to improve the creativity of people. When the optimal framework of relations for facilitating collaboration of pairs is established, the creativity of people would improve as a result of increasing the constructive interaction within the pair. Previous studies on human-robot learning showed that social robots provided constructive interaction to students for learning or problem solving in the classroom [11]. Similarly, social robots would support the emerging creativity of people by producing constructive interaction through collaboration with people (e.g., [14]). Robots with artificial intelligence would become support-givers for enhancing the creativity of people rather than simply competitors for jobs currently held by humans [4].

As future work, we will examine the group-size effect [15] on the quality as well as number of ideas. In particular, we are interested in how larger group size induces social loafing [12, 16] from the viewpoint of the quality of ideas.

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