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# Gender Effects on Collaborative Online Brainstorming Teamwork

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**ABSTRACT**

It is common for individuals with diverse demographic backgrounds to collaborate through computer-mediated communication (CMC) technologies. Groups with internal diversity are typically considered to be advantageous to group performance due to the presence of different perspectives and the potential to stimulate new ideas. However, intergroup conflicts can also occur in diverse groups, especially for groups with imbalanced composition. Previous studies have pointed out that minority members often suffer from unequal participation and performance pressure, which may further decrease group outcome. Since CMC tools facilitate online collaboration, it is necessary to understand how group composition interacts with the affordances

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**KEYWORDS**

Group Composition; Collaboration; Computer-mediated communication; Gender; Brainstorming

of CMC tools on group collaboration. In this study, we tested three gender compositions (female-majority, equal-gender-composition, male-majority) with two communication contexts (video-text, text-only) and found that both gender composition and communication medium influenced group collaboration. Design implications for online collaboration are provided based on our findings.

**INTRODUCTION**

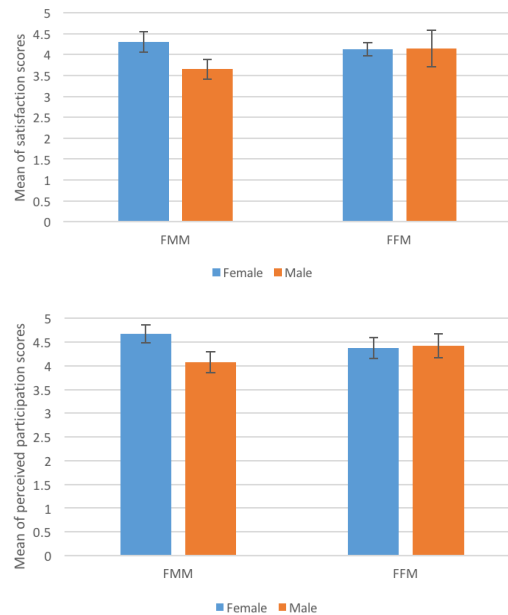
It is generally believed that different experiences, attitudes, and knowledge of diverse members can contribute multiple perspectives and alternative solutions to a problem. Ideally, the divergent thoughts and perspectives will encourage more critical examination and lead to better team performance. Though diversity brings advantages, group-level factors such as group composition [2] have also been shown to influence the performance of groups. Specifically, becoming a solitary member or minority in groups can be detrimental to individual contribution [14] as the minority may experience performance pressure [7] or less likely share their thoughts [11]. Women and racial minorities are more likely to be negatively influenced by their solo or minor status in group [10]. In contrast, men seem to benefit from working solitarily [5].

In design, groups with members of diversity can benefit group brainstorming because the different backgrounds, experiences, and perspectives among group members have the potential to stimulate the generation of creative ideas [8]. However, in a study of brainstorming performance, Herschel [6] found that the brainstorming performance may not depend on gender composition.

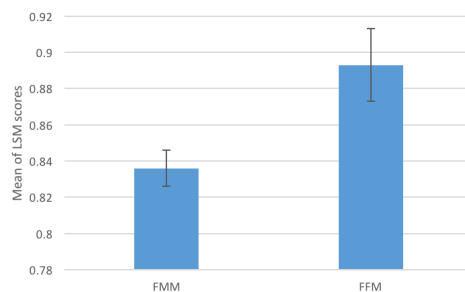
The use of technology could influence participant's perception toward communication, which may further influence the processes of interaction in a team. CMC increases the possibility for diverse individuals to collaborate with one another [9], but merely forming diverse groups may not always lead to positive results. The imbalanced composition of gender may lead to unequal participation [3] or stereotypical role expectations [1]. In a decision-making task mediated by email, female-only groups showed higher-level group cohesion and satisfaction with group work than male-only groups [12]. These studies suggested that the properties of different media may further influence the interaction behavior for groups with different composition. To gain a richer empirical understanding, we conducted two exploratory studies to investigate the influence of gender composition and communication mode on online collaborative brainstorming team.

**STUDY 1– GENDER DIVERSITY IN FACE-TO-FACE SETTING****Participants and Procedure**

We first examined the effect of gender composition on group collaboration in a common face-to-face communication setting. Twenty-four participants (aged 18–30 yrs) were recruited and formed 8 triads. Four of them consisted of 2 females and 1 male (FFM). The other 4 triads consisted of 2 males and 1 female (FMM). Participants were randomly assigned to one of the group settings (FMM, FFM). Participants did not know each other prior to the study. Participants were first asked to perform an individual brainstorming task for 15 minutes as a practice. In this individual practice, the experiment space was divided into 3 partitions. Participants were assigned to one of the



**Figure 1: The measures of satisfaction and perceived participation in FMM (female-minority) and FFM (female-majority) group in the face-to-face setting.**



**Figure 2: LSM scores for FMM and FFM group in the face-to-face setting.**

partitions according to the order of their arrival. After the individual practice, participants sat together and performed a group brainstorming task for 20 minutes. The chairs were placed in an equilateral triangle so as to eliminate the power status effect.

Two brainstorming tasks were used in this study: the “extra thumb task” and the “wing task” [15]. The extra thumb task asked the participants to think about the benefits and the drawbacks if they had an extra thumb on both hands. The wing task asked the participants to imagine if they had wings on their back and the benefits and the drawbacks associated with them. We counterbalanced the order of these two tasks in the individual and the group brainstorming settings. After completing the tasks, the participants were asked to fill out an online questionnaire on perceived participation and satisfaction. Each question is examined on a 5-point Likert scale where 1 refers to Strongly Disagree and 5 Strongly Agree.

Language Style Matching (LSM) is a metric that analyzes the use of function words produced by each individual in a conversation [4]. It has shown that LSM can well predict the social and relational dimensions in groups in both face-to-face and computer-mediated communication. To calculate LSM score, we first measured the use of function words (e.g., *auxiliary verbs* like “to be” or “to have”; *articles* like “a, an, the”) by each group member. For each member, we used LIWC, an automated text analysis tool, to count the percentage of total words for each type of the function words [13]. Since Chinese language does not have the linguistic category of article, we only included the rest eight LSM categories in our calculation. Then, we compared each participant’s function word usage with that of the remaining group members’ to get the LSM scores for each participant. We standardized the LSM score to make the result fall between 0 and 1. The score close to 1 represents a higher degree of matching language style. Finally, we averaged the score to get the final LSM score for that category (e.g., personal pronouns). The final LSM score of the group was then calculated by averaging the eight LSM scores. Table 1 shows the equation used in calculating LSM score.

## Results

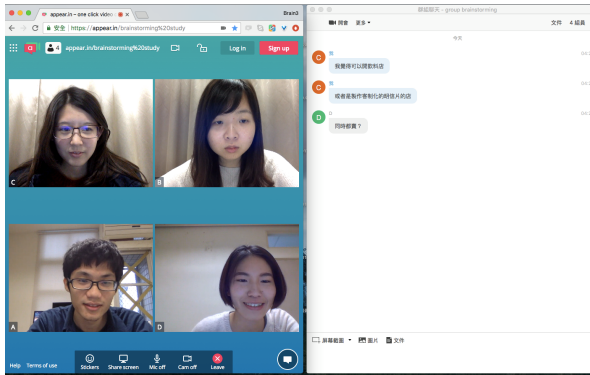
We conducted a two-sample t-test to analyze the effect of gender nested within different group compositions (FMM, FFM) on our dependent measures, individual satisfaction, and LSM score. Figure 1 shows the distributions of the two measures by gender and by group composition. Although we did not find significant effects of gender on either perceived participation or satisfaction, male individuals in FMM groups tended to perceive less satisfaction than female; while in FFM groups, male and female individuals were seen to be more equal on the two measurements.

A two-sample t-test with two gender compositions on the LSM score was conducted to further understand the effect of gender composition on in-group relation. Figure 2 shows the means of the LSM score of the two compositions. The results showed that FFM groups had a significantly higher LSM score than FMM groups ( $p=0.04$ ), which indicated that groups with more female members were more cohesive than groups with fewer females. These findings demonstrated that the proportion of female member in a group was potentially positively related to group satisfaction.

**Table 1: The equation for calculating LSM score**

$$LSM_{pp1} = 1 - \left( \frac{|pp_1 - pp_{G_1}|}{pp_1 + pp_{G_1}} \right)$$

$$LSM_{pp} = \frac{(LSM_{pp1} + LSM_{pp2} + LSM_{pp3})}{3}$$



**Figure 3: The interface of the video-text condition, consisting of a video window on the left and a chat window on the right. For text-only condition, the video window on the left is removed and the chatroom window is in full screen size.**

## STUDY 2– GENDER DIVERSITY IN ONLINE SETTING

### Participants and Procedure

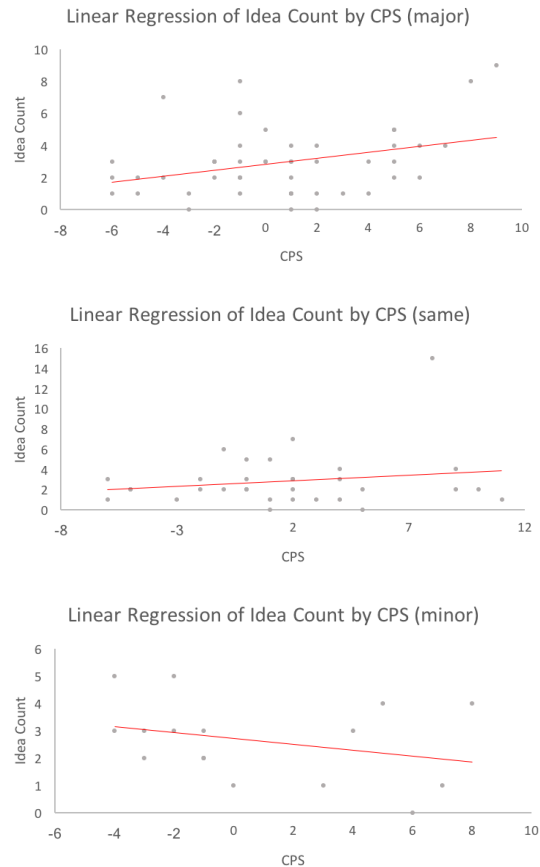
In study 2, we further analyzed the effects of gender composition in online CMC setting. Two communication modes were examined in this study: video-text media and text-only media. We recruited 96 participants from the campus for a lab study and formed three types of group: male-majority group (FMMM), equal-gender group (FFMM) and female-majority group (FFFM). The mean age of all participants was 22.07 ( $SD = 2.11$ ). Participants were randomly assigned to one of the group compositions and they did not know each other prior to the experiment. A brainstorming task which is considered to be more gender-neutral was used in this study. The task asked participants to generate ideas for a new business to fill a space left vacant by a poorly managed restaurant.

A pre-questionnaire of Creative Personality Scale (CPS) and a post-questionnaire consisted of manipulation check (whether the task is gender-neutral or gender-biased;  $M = 4.04$ ,  $SD = 0.43$ , indicating the participants considered it gender neutral), satisfaction, perceived participation and quality of communication experience were used in this study [5]. We used appear.in (<https://appear.in>) and zoom (<https://zoom.us>) to conduct the experiment (see Fig. 3). Appear.in is an online video collaboration tool, which allows multiparty to conduct video conferencing. Zoom is another group collaboration software used as an instant messaging tool to allow participants to communicate by texting. Audio was not allowed in both conditions to avoid potential influence.

The experiment was conducted in a laboratory divided into four separated partitions to accommodate four-person collaboration. As the participants arrived, individuals were separated into each partition in order to simulate remote collaboration. The experimenter then gave a detailed instruction about the tasks. Groups were asked to discuss the task for 15 minutes. After idea generation, groups were asked to list their ideas on a Google sheet, which was previously created by the experimenter for each group. Upon completion, participants were told to take feasibility and creativity into consideration and select top 7 ideas in 25 minutes. This phase was designed to encourage participants to have more discussion on their ideas. After completing the task, participants were asked to fill out a post-questionnaire about the discussion experience.

### Results

We examined the performance at both group level and individual level. At the group level, the ideas generated by different gender compositions did not make a significant difference. At the individual level, we ran a mixed model ANOVA with gender composition (majority, minority and same) and media (text-only, video-text) as independent variable and the number of ideas as the dependent variable. The result showed a significant interaction effect ( $F[1,94]=3.64$ ,  $p=.03$ ). When individuals belonged to the majority in groups, they generated more ideas when using text-only communication media.



**Figure 4: Linear regression results of idea count by CPS, examined with three gender conditions.**

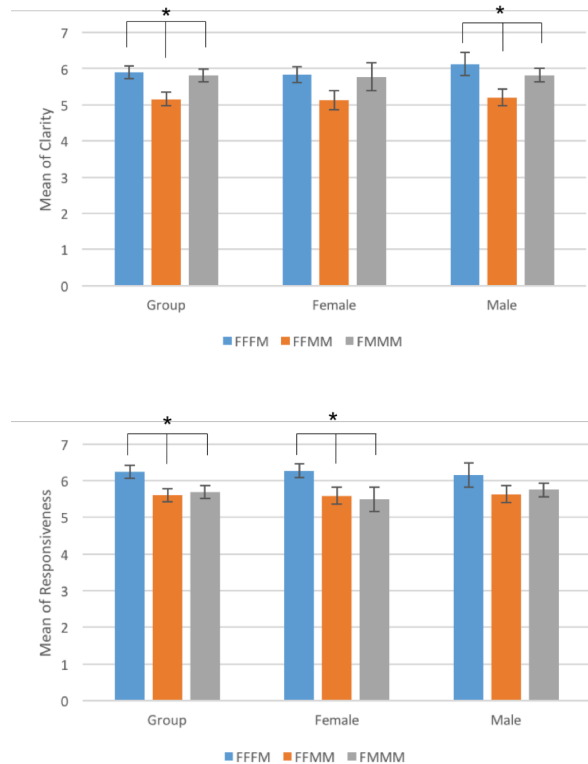
We also ran a linear regression on the CPS score and each individual's idea count. We found that CPS was positively related to idea count only in the “majority” groups ( $r=.34$ ,  $p=.02$ ). In addition, even though other analyses of CPS and idea count did not show significant relationship, we observed that when individuals were the minority in the group, their CPS scores were slightly negatively related to their idea counts (see Fig. 4). The observations demonstrated that the situation of being minority or majority in the group may have an impact on their performance.

Then, we conducted a mixed model ANOVA with gender composition and media as independent variables and the quality of communication experience, satisfaction, and perceived participation as dependent variables. At group level, the results showed a main effect of gender composition on clarity ( $F[1,22]=5.09$ ,  $p=.02$ ) and responsiveness ( $F[1,22]=3.63$ ,  $p=.05$ ). The clarity of equal-gender-composition group was lower than that of the other two gender compositions (female-majority, male-majority) and the female-majority group had the highest responsiveness among the three groups. No main effect of gender composition was found on satisfaction ( $F[1,22]=.96$ ,  $p=.40$ ) and perceived participation ( $F[1,22]=.51$ ,  $p=.62$ ). Moreover, we found that when using text-only media, the score of participation of the equal-gender-composition group (FFMM) was significantly lower than that of the other two compositions (FFFM, FMMM) ( $F[1,22]=4.89$ ,  $p=.02$ ). However, when using video-text media, there is no significant interaction.

At the individual level, the results showed a main effect of male on the scale of clarity ( $F[1,46]=3.50$ ,  $p=.04$ ), meaning males in the FFMM group had the lowest score compared with males as the majority and males as the minority (see Fig. 5). For female, the effect was not significant ( $F[1,46]=2.15$ ,  $p=.13$ ). There is also a main effect of female on the scale of responsiveness ( $F[1,46]=3.61$ ,  $p=.04$ ), where female as the majority in group had the highest score compared with the other two compositions (see Fig. 5). The effect for male was not significant ( $F[1,46]=0.90$ ,  $p=.42$ ). A significant interaction of gender proportion and media mode was also found ( $F[1,94]=5.16$ ,  $p=.01$ ) on the scale of perceived participation: When female was the majority in the group, they had higher score of perceived participation when using text-only media; however, if they were in the equal-gender group, they got higher score when using video-text media. As in study 1, we compared the LSM score for each group. We ran a mixed model ANOVA on LSM score with the three group compositions and the two media modes. The results did not show a significant difference ( $F[1,22]=1.92$ ,  $p=.18$ ).

## DISCUSSION

In this study, we present an empirical contribution by identifying the effects of visual channel of CMC on group performance and its interaction effect with different gender compositions. Generally, the results showed that visual channel may benefit equal-gender groups by increasing participation. For female-majority groups, text-only media may be more helpful to their collaboration. For male-majority groups, the presence of visual channel may not have significant difference. Also, our findings showed that female-majority groups were more responsive. Therefore, in order to create a better communication environment in gender-imbalanced situations, especially where female is the minority, an interactive robot can be designed to act as a



**Figure 5: The influence of gender composition on clarity and responsiveness at the group level and the individual level.**

#### ACKNOWLEDGMENTS

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person with high cooperation and responsiveness to encourage female members' engagement and participation. As we found in our results that gender composition influenced group collaboration, online collaboration tools can be designed to mitigate the effects. For example, we may use avatars or create a virtual environment to reduce the salience of being minority or majority in the group. Further investigation is needed to generalize the results and generate clear design implications for future collaboration tools, especially supporting gender imbalanced groups.

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