

Effects of Network Connectivity and Functional Diversity Distribution on Human Collective Ideation

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Human collective tasks in teams and organizations increasingly require participation of members with diverse backgrounds working in networked social environments. However, little is known about how network structure and the functional diversity of member backgrounds would interact with each other and affect collective processes.

To address the above gap in the existing literature, here we conducted three sets of human-subject experiments which involved 617 university students who collaborated anonymously in a collective ideation task on a custom-made online social network platform. In each experimental session, 20~25 anonymous participants were arranged to form a social network according to their backgrounds (Fig. 1) and collaborated on text-based collective ideation tasks for two weeks. The performance of collective ideation was characterized using multiple metrics, including the number of generated ideas, the best/average quality score of final submitted ideas (evaluated by third-party experts), semantic diversity of generated ideas quantified using machine learning-based word embedding methods, and post-experiment survey results on participants' overall experience. More details of the experimental settings and results can be found in the full paper published elsewhere.

We found that spatially clustered collectives with assortative background distribution tended to explore more diverse ideas than in other conditions (Fig. 2), whereas collectives with random background distribution consistently generated ideas with the highest utility (Fig. 3A) and collectives with disassortative background distribution consistently generated better ideas on average (Fig. 3B). We also found that higher network connectivity (Fig. 1D) may improve individuals' overall experience but may not improve the collective performance regarding idea generation, idea diversity, and final idea quality.

These seemingly puzzling results may be understood by

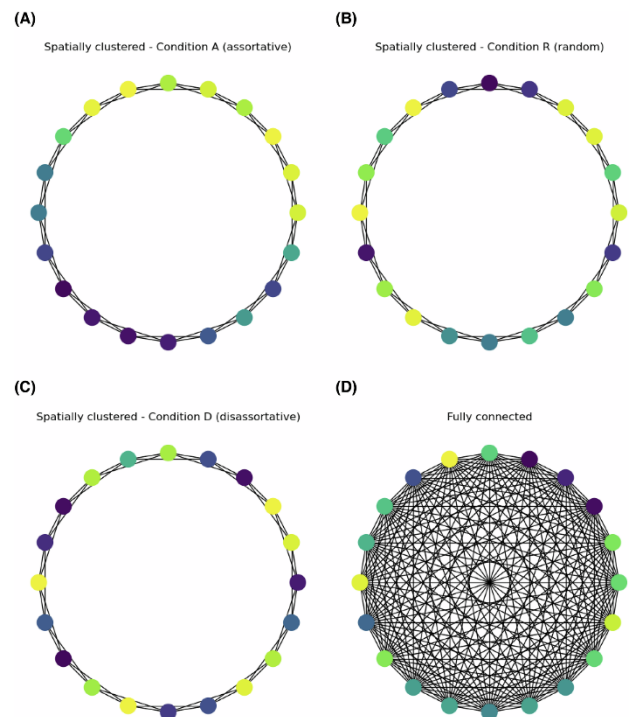


Figure 1: Social network structures used in the experiments.

A Spatially clustered regular network with background distribution of Condition A (assortative). **B** Spatially clustered regular network with background distribution of Condition R (random). **C** Spatially clustered regular network with background distribution of Condition D (disassortative). **D** Fully connected network. Note: Participants were represented by nodes in the graphs colored according to their backgrounds. Similar/different background participants hold similar/different colors, respectively.

considering the idea generation and propagation as evolutionary processes and how much background diversity each generated idea was exposed to locally. Namely, in Condition A (Fig. 1A), generated ideas are

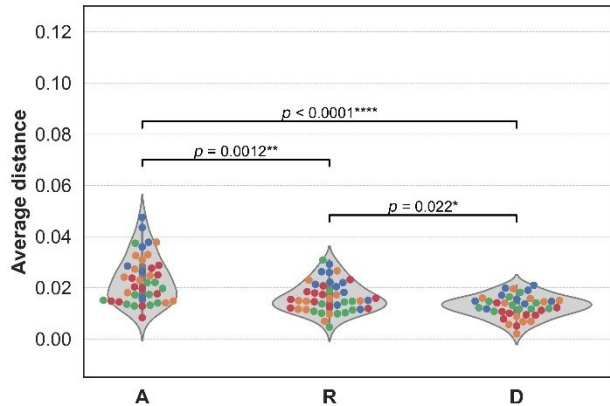


Figure 2: Comparison of average distances between ideas among three background distribution conditions in the Spatially Clustered Slogan Writing (SC-SL) experiment. Each dot in these violin plots represents the average value of distances between ideas of a collective for a single working day. The p -value annotation legend is as follows. *: $0.01 < p \leq 0.05$, **: $0.001 < p \leq 0.01$, ****: $p \leq 0.0001$. The Wilcoxon signed-rank test with Bonferroni correction was used. Data points regarded as outliers were removed in this analysis.

exposed to human participants that were relatively homogeneous, and thus those ideas only need to meet relatively simple, consistent criteria to be successful in spreading. In Condition D (Fig. 1C), in contrast, ideas are exposed to and evaluated by very different human participants, and thus those ideas must satisfy a wide variety of (possibly inconsistent) criteria, necessarily making them conservative and mistake-proof. These two situations may be analogized to the widely discussed “exploration” (variation-driven dynamics in creative conditions) vs. “exploitation” (selection-driven dynamics in critical conditions) spectrum. We hypothesize that collectives in Condition R (Fig. 1B) achieved the right balance in the middle of this exploration vs. exploitation spectrum and thereby found the best ideas most frequently (Fig. 3A), and meanwhile, that collectives in Condition D (Fig. 1C) had a high ability to filter out potentially problematic ideas and generate ideas that can be commonly accepted by most participants, achieving the highest average score (Fig. 3B). These results and interpretations altogether paint an evolutionary picture of collective ideation processes in which ideas are the evolving “artificial life”. This suggests that the structure and composition of a collective with regard to functional diversity of participating individuals should be considered and designed according to their evolutionary implications.

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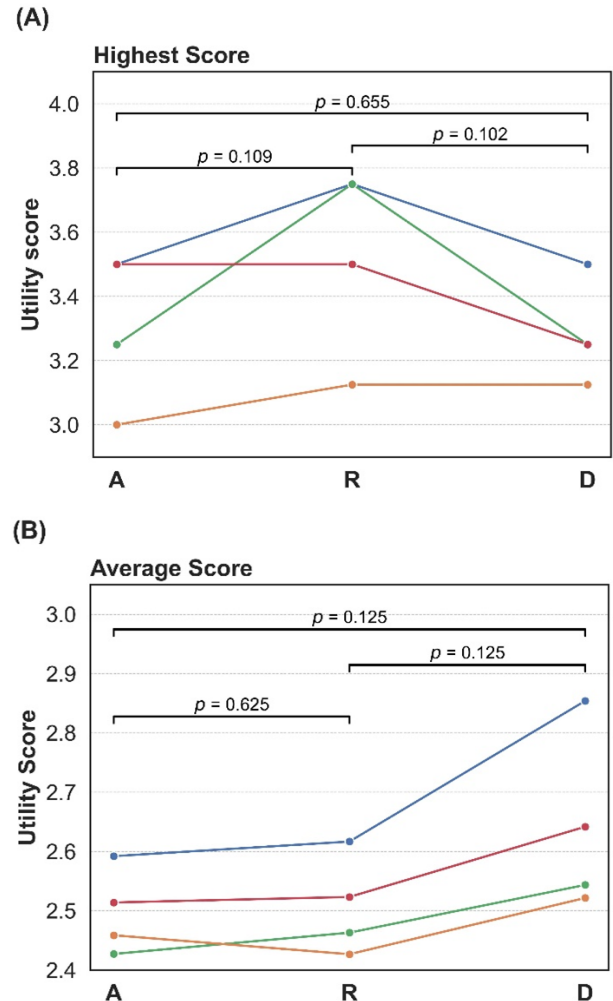


Figure 3: Comparison of idea quality among three background distribution conditions in the Spatially Clustered Slogan Writing (SC-SL) experiment. Results from four sessions were plotted as four curves in each plot. (A) Highest score of final ideas. (B) Average score of final ideas. The Wilcoxon signed-rank test with post-hoc comparison was used for all tests. Since there were only four sessions of the experiments conducted, none of the pairs of experimental conditions showed statistically significant differences, yet the overall patterns were clear and consistent across the four sessions.

Data available at:

https://orb.binghamton.edu/systems_fac/13/

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