# Large-Scale Group Brainstorming and Deliberation Using Swarm Intelligence and Generative AI

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Abstract: Conversational Swarm Intelligence (CSI) is an GenAI-based method for enabling real-time conversational deliberations among networked human groups of potentially unlimited size. Based on the biological principle of Swarm Intelligence and modelled on the decision-making dynamics of fish schools, CSI has been shown in prior studies to enable thoughtful conversations among hundreds of real-time participants while amplifying group intelligence. It works by dividing a large population into a set of subgroups that are woven together by real-time AI agents called Conversational Surrogates. The present study focuses on the use of a CSI platform called Thinkscape to enable real-time brainstorming and prioritization among groups of 75 networked users. The study employed a variant of a common brainstorming intervention called an Alternative Use Task (AUT) and compared brainstorming using a CSI platform to a traditional text-chat environment. This comparison revealed that participants significantly preferred using CSI, reporting that it felt (i) more collaborative, (ii) more productive, and (iii) was better at surfacing quality answers. In addition, participants using CSI reported (iv) feeling more ownership and more buy-in in the top answers the group converged on and (v) reported feeling more heard as compared to a traditional chat environment. Overall, the results suggest that CSI is a promising GenAI-based method for brainstorming and prioritization at large scale.

## 1 INTRODUCTION

Humans are not the only species that deliberate in groups to reach decisions. Fish schools, bird flocks, and bee swarms are well known examples of natural groups that can reach rapid decisions to life-or-death issues, often converging upon the optimal solution. Biologists refer to this collaborative decision-making process as Swarm Intelligence (SI) and it enables many social organisms to make decisions that are significantly smarter than the individual members could achieve on their own (Krause, et. al, 2010).

Artificial Swarm Intelligence (ASI) is a novel technology developed in 2014 to enable networked human groups to converge on collaborative decisions by deliberating in systems modelled on biological swarms (Rosenberg, 2015). ASI has been shown to amplify the accuracy of group decisions across a wide range of applications, from financial forecasting and business prioritization to medical diagnosis (Askay, et. al., 2019. Rosenberg, 2016. Willcox et. Al., 2021).

While ASI has proven effective, initial versions required users to choose among a pre-defined set of options. This works well for narrow applications such as group prioritization, probabilistic forecasting and numerical estimation, but is not effective for solving complex problems that require groups to deliberate, brainstorm, prioritize and converge. To address this, a next-generation technology called Conversational Swarm Intelligence (CSI) was developed in 2023 that combines the principles of ASI with the power of large language models (Rosenberg, et al., 2023).

The goal of CSI is to enable large, networked human groups (25 to 500 people) to hold thoughtful

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conversational deliberations in real-time that rapidly converge on optimal solutions based on the combined knowledge, views, and opinions of the participants. To make this viable, researchers had to overcome several fundamental barriers related to basic human conversations. First and foremost, research shows that deliberative conversations are most effective in small groups of only 4 to 7 individuals and rapidly lose effectiveness with increasing size (Cooney, et. al., 2020). With additional members, all participants are afforded less and less airtime to express their views, and longer and longer wait times to respond to others. When a group reaches sizes larger than 10 to 12 people, it ceases to be a true deliberation and devolves into a series of monologues.

So how can a technology enable hundreds of people hold a productive real-time deliberation in which participants brainstorm solutions, build on the ideas of others, debate options and alternatives, and converge on solutions? To overcome this barrier, CSI takes its core inspiration from the decision-making dynamics of large fish schools. That is because large schools have thousands of members and provide an interesting analog to human organizations. Consider the image below which shows a large school facing three simultaneous threats that require a rapid and effective response:

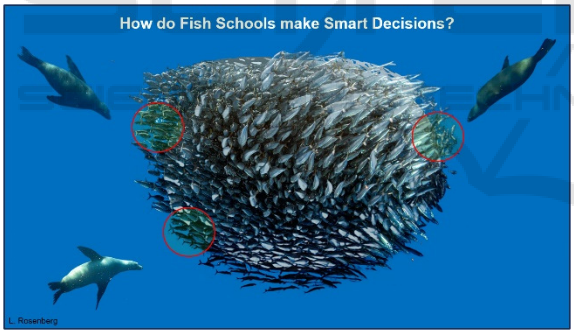


Figure 1: Fish School facing simultaneous threats.

In the figure above, three predators approach the school, creating a complex life-or-death problem that requires a rapid and effective solution. Like many human organizations, all members of the school have limited information. As shown in Fig. 1, three small pockets of fish (e.g., the circled areas above) are each aware of a single predator approaching their location. At the same time, most fish in the school are unaware of any of the three predators. So how can this large organization in which all members have limited information, quickly find an optimal decision as to which direction the school should move?

Fish schools use a unique form of communication among neighboring individuals. Each fish has a specialized organ on the sides of their bodies called a lateral line that detects faint pressure and vibration changes in the water as the adjacent fish adjust their direction and speed. This enables small subgroups of neighbors to "deliberate" in real-time, establishing a local tug-o-war that converges on the direction that small subgroup of fish will go. And because each subgroup of neighboring fish overlaps other small subgroups, information quickly propagates across the full population.

This enables an emergent property that biologists call Swarm Intelligence, and it allows thousands of individuals, each with a limited view of the world around them, to rapidly converge on unified decisions that are critical for survival (Parish, et. al., 2002. Rosenberg, et. al., 2023). Fig. 2 below shows this information propagating across the school, leading to an efficient and effective collective decision.

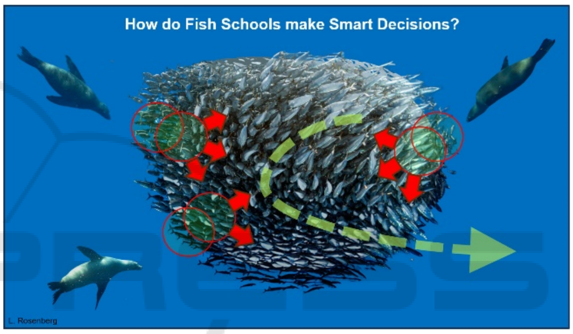


Figure 2. Swarm Intelligence enables optimized decisions.

CSI technology takes this natural process and emulates the dynamics by breaking large human groups into a network of overlapping subgroups, each with 4 to 7 members, as that size enables optimal conversational deliberation. Unfortunately, there is one more barrier that must be overcome – unlike fish, humans cannot participate effectively in overlapping subgroups (i.e. we did not evolve to participate multiple real-time conversations at once).

This is commonly called the Cocktail Party Problem – if you engage in a conversation with a small group at a party and get interested in what a neighboring group is discussing, you immediately lose focus on the original group (Bronkhorst, 2000). So how can hundreds of individuals hold a single conversation through overlapping subgroups?

To overcome this problem, CSI uses novel artificial agents called *"Conversational Surrogates"* that are powered by Large Language Models (LLMs) and enable the real-time overlap among deliberating groups (Rosenberg, 2023). Specifically, CSI breaks a large population into a series of parallel subgroups such that an LLM-powered surrogate agent is placed in each subgroup and tasked with observing the deliberation in that group, distilling the salient content, and passing critical ideas, insights, opinions and perspectives to other subgroups where that subgroup's local surrogate agent will express those points as a natural dialog within their ongoing conversation. With agents in all subgroups continuously observing insights and passing them to surrogate agents in other rooms, the full population is woven together into a single conversation in which ideas emerge and spread with high efficiency, along with arguments for and against those ideas. Using this novel architecture, 50, 500 or even 5,000 people can hold a real-time conversation in which they brainstorm ideas, debate alternatives, prioritize options and converge on solutions.


Figure 3: Conversational Swarm Intelligence Architecture.

An example CSI architecture is shown in Fig. 3 above in which a group of 98 people are divided into a network of 14 subgroups, each with 7 human users and one artificial agent. While the image implies that each subgroup can only pass information to two other subgroups in the network, the model employed in this study enabled insights to pass from any subgroup to any other subgroup (i.e., a fully connected network).

A unique matchmaking subsystem is used that that tracks (i) which groups have a new idea or insight that is ready to pass to others, (ii) which groups have not received insights for a threshold amount of time and are ready to receive another, and (iii) which of the available insights (across all sending groups) is most likely to maximally challenge each receiving group, based on what that group has discussed thus far.

In this way, CSI emulates the basic propagation of information within fish schools. but does so in a far more efficient manner. While schools and other biological swarms pass insights between neighboring members, CSI can pass insights between any local groups in the network. This makes CSI a "hyper-swarm" structure (Willcox, 2021) and it leverages this hyper-connectivity to challenge each local group with insights, opinions, and/or rationales that will most likely evoke the most meaningful responses.

By facilitating large, networked populations to debate complex issues in real-time, CSI enables individuals with a wide range of knowledge, wisdom, and insights to collaboratively deliberate on broad, open-ended problems. And because every assertion expressed by every participant is identified and stored in a real-time taxonomy database by the CSI system, the system can immediately produce detailed forensic reports that reveal how each decision was reached, including a complete assessment of every idea raised, the reasons that support and reject each ideas, and impact each idea or reason had on others to sway the group towards a maximally supported solution.

In addition, CSI solves common biasing problems that drive deliberating groups to non-optimal answers. For example, groups can be overly impacted by individuals with strong personalities, with high rank within an organization, or who express ideas very early in a deliberation. This is mitigated by the CSI structure because points raised by a strong personality, a high-ranking individual, or an early talker in the deliberation only impact a small local subgroup. For those points to gain traction across the full population, they must stand on their own merits: either discussed organically in multiple subgroups or passed into subgroups by surrogate agents. Ideas that are passed into a group and significantly impact that group are more likely to pass to other groups, thus enabling strong insights to propagate quickly.

The effectiveness of CSI has been researched in a handful of recent studies. In one study conducted at Carnegie Mellon in 2023, groups of 48 participants were tasked with debating the future impact of AI on jobs using a CSI platform called Thinkscape™. The participants using CSI contributed 51% more content ($p<0.001$) compared to those using standard centralized chat. In addition, CSI showed 37% less difference in contribution between the most vocal and least vocal users, indicating that CSI fosters more balanced deliberations. (Rosenberg, et. al., 2023).

In another recent study, groups of 35 individuals were tasked with taking a standardized IQ test, either as individuals on a survey, as a "crowd" by taking the aggregation of surveys, or as a conversational swarm inside the CSI-powered Thinkscape platform. The groups of randomly selected participants using CSI averaged a collective of score 128 on the IQ test when working together in conversational swarms, greatly outperforming both the average individual participant (IQ 100, $p<0.001$) and outperforming traditional statistical aggregation across groupings of 35 individual tests (IQ 115, $p<0.01$). In addition, the score of 128 IQ achieved by the average CSI group placed its performance in the 97$^{th}$ percentile of individual IQ test takers, achieving "gifted" status by most metrics (Rosenberg, et. al. 2024).

While prior studies have shown that large groups using CSI (i) increase conversational participation, (ii) foster more balanced dialog among participants, and amplify collective intelligence compared to traditional methods, no prior study has explored the ability of large groups to brainstorm collaboratively and converge on a set of prioritized solutions in real-time. The following study aimed to test brainstorming among groups of approximately 75 individuals and assess their comparative perceptions of brainstorming with CSI versus brainstorming within a single large group in a traditional online chat platform.

## 2 BRAINSTORMING STUDY

To assess if large networked human groups can hold real-time brainstorming conversations using a CSI structure and converge on a small set of maximally supported solutions, two sets of approximately 75 people (sourced from a commercial sample provider) were assembled in the text-based Thinkscape platform and tasked with a collaborative brainstorming problem. As a baseline, the same groups we also assembled in a single large text-based chatroom of similar real-time functionality to Discord, Slack, Google Chat, Microsoft Teams and other commercial room-based chat environments.

The brainstorming task used was a modified version of a typical Alternative Use Task (AUT) that is given to assess creative abilities in individuals and/or groups (Habib, et. al, 2024; Guilford, 1967). In this case, two alternative use tasks were devised – a first task which asked groups to imagine they work for a large company that has been stuck with a significant inventory of traffic cones. Their task is to come up with as many alternative uses of traffic cones as possible (unrelated to traffic) that could be viable products sold the fictional company and to identify the best ideas among the proposed alternatives. The second task was structured the same way, but the item that the fictional company had in inventory were toilet plungers.

The protocol for the first group of 75 individuals was to first brainstorm the traffic cone AUT task first in a single large chat room and then brainstorm the toilet plunger AUT task in a CSI structure in which the 75 individuals were broken up into approximately 15 subgroups of 5 individuals, each sub-group including one AI agent (i.e., conversational surrogate) that participated in the local conversation by sharing ideas received from other subgroups. The second group of 75 performed the same protocol, but brainstormed traffic cones first in the CSI structure, then brainstormed toilet plungers second in a standard large chat room structure. At the conclusion of the intervention, both groups were given a survey in which they were asked a set of subjective judgment questions to compare each brainstorming experience, the single large room versus the CSI structure.

For clarity, when using CSI, each participant was only able to converse with the other 4 members of their subgroup and with a local AI agent. The agents did not introduce any AI generated ideas or opinions into local conversations – they only passed and received conversational ideas and opinions from other subgroups (every 30 to 60 seconds). This weaved the set of 15 subgroups into a single unified conversion in which individuals could build on ideas raised in other subgroups and express their support or opposition to ideas from in subgroups. A time limit of 12 minutes was provided for each brainstorm task.

## 3 DATA AND ANALYSIS

Each of the two groups of 75 participants took part in a 30-minute session in which they performed two AUT brainstorms for 12 minutes each (one using CSI and one in a traditional chat room) and then individually completed a subjective feedback survey to compare the two experiences. The questions asked on the survey were as follows:

- Which method felt more productive?
- Which method made you feel more heard?
- Which method felt more collaborative?
- Which method was surfaced better answers?
- Which method made you feel more buy-in?
- Which method made you feel more ownership?
- Which method did you prefer overall?

The only substantive difference between the two groups of participants was that Group 1 brainstormed in a standard chat room first, then used CSI, while the participants of Groups 2 brainstormed using CSI first and then used the standard chat room. This was to mitigate ordering effects on the subjective feedback.

In total we collected 147 surveys, each comparing brainstorming and prioritization using a CSI structure versus a traditional chat room. In the CSI structure, the 75 individuals brainstormed by being divided into 15 subgroups of 5 people, each subgroup including an AI agent that participated in their local conversation to link all the subgroups together. In the standard chat room structure, all 75 people were able to see the ideas of everyone else and respond to the full group.

The results were highly conclusive, showing that a significant majority of the 147 survey-responding participants preferred the CSI structure to the standard chat room structure in all seven questions asked. To assess if these results were statistically significant, a one-proportion z-test was performed on each question in the surveys to test if the results showed statistically significant evidence that more people preferred one method over the other. Because multiple statistical tests were run, we used a Bonferroni adjustment to determine significance at the 1% alpha level and needed to observe a p-value<0.01/7=0.0014 for each of the 7 questions tested. This level of significance was observed in each of the seven questions, meaning we can conclude with 99% confidence that participants preferred the CSI platform (Thinkscape) for brainstorming and prioritization as compared to traditional text chat.

## 4 RESULTS

The segmented bar chart in Figure 4 below shows the proportion of survey respondents that preferred either Thinkscape or Standard Chat when answering each of the feedback questions.

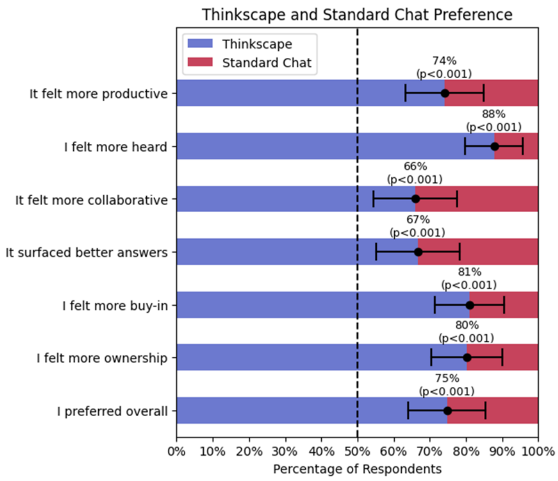


Figure 4. Subjective Feedback Results with Error Bars.

We can see in Fig. 4 that a significant majority of participants preferred Thinkscape with respect to all seven of the feedback questions, the support ranging between 66% and 88%, with 75% of respondents preferring Thinkscape overall. Each question in Figure 4 also shows error-bars reflecting a 99% Bonferroni-adjusted confidence interval estimating the true proportion of all participants who would prefer Thinkscape over a Standard Chat. None of the confidence intervals overlap the 50% dotted line, demonstrating statistical significance in our findings that Thinkscape is the preferred method.

## 5 CONCLUSIONS

The results of this study are promising, showing that groups of 75 individuals can successfully brainstorm ideas and prioritize options in real-time using a text-based CSI platform. The results further show that participants significantly preferred the CSI structure (which used AI agents to connect conversations in real-time across many small subgroups) over the traditional flat structure of a single chatroom.

In particular, they found the CSI structure to be more productive, more collaborative, and more effective at surfacing quality answers. In addition, over 80% of participants in the study reported feeling *"more heard"* during each deliberation and came away feeling *"more ownership"* and *"more buy-in"* with respect to the resulting answers than they did in a traditional real-time chat environment.

Future studies into CSI should test collaborative brainstorming and prioritization among significantly larger groups to validate usage among hundreds or thousands of simultaneous participants. Considering that the average Fortune 1000 company has over 30,000 employees, the ability to engage large groups in real-time discussions, brainstorms, evaluations, debates, assessments and prioritizations could be a powerful collaborative method for solving problems, planning projects, forecasting outcomes, assessing risks, capturing employee feedback, and fostering the cross-pollination of ideas across large companies. In addition, CSI could be useful for promoting buy-in and fostering feelings of ownership within large and complex project teams.

Future studies should also test the value of CSI in voice-chat and videoconferencing environments. In addition, future studies should explore the value of CSI in vertical applications that could benefit from group deliberation at massive scale. Examples of such applications include citizen assemblies, deliberative civic engagement, deliberative democracy, big science, decentralized autonomous organizations (DAOs), political forecasting, and market research. And finally, future studies of CSI should test its potential in enabling Collective Superintelligence to be achieved among large, networked groups.

## REFERENCES


Askay, D., Metcalf, L., Rosenberg, L., Willcox, G. (2019) “Enhancing Group Social Perceptiveness through a Swarm-based Decision-Making Platform.” Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS-52), IEEE.

Blair, Clancy & Gamson, David & Thorne, Steven & Baker, David. (2005). Rising Mean IQ: Cognitive Demand of Mathematics Education for Young Children, Population Exposure to Formal Schooling, and the Neurobiology of the Prefrontal Cortex. Intelligence. 33. 93-106. 10.1016/j.intell.2004.07.008.

Bronkhorst, Adelbert W. (2000). "The Cocktail Party Phenomenon: A Review on Speech Intelligibility in Multiple-Talker Conditions". Acta Acustica United with Acustica. 86: 117–128. Retrieved 2020-11-16.

Cooney, G., et. al. (2023) "The Many Minds Problem: Disclosure in Dyadic vs. Group Conversation." Special Issue on Privacy and Disclosure, Online and in Social Interactions edited by L. John, D. Tamir, M. Slepian. Current Opinion in Psychology 31 (February 2020): 22–27.

Habib S, Vogel T, Anli X, Thorne E. How does generative artificial intelligence impact student creativity?. Journal of Creativity. 2024 Apr 1;34(1):100072.

Guilford, J. P. (1967). *The Nature of Human Intelligence.* McGraw-Hill.

Krause, J., Ruxton, G.D., & Krause, S. (2010). Swarm intelligence in animals and humans. Trends in ecology & evolution, 25 1, 28-34

Parrish, J. K., Viscido, S. and Grünbaum, D. (2002) “Self-Organized Fish Schools: An Examination of Emergent Properties.” Biological Bulletin 202, no. 3: 296–305

Rosenberg, L. (2015) “Human Swarms, a real-time method for collective intelligence.” Proceedings of the European Conference on Artificial Life, pp. 658-659

Rosenberg, L. (2016). Artificial Swarm Intelligence vs human experts. 2016 International Joint Conference on Neural Networks (IJCNN), 2547-2551.

Rosenberg, L., Willcox, G., Schumann, H. and Mani, G. (2023) “Conversational Swarm Intelligence (CSI) Enhances Groupwise Deliberation.” 7th International Joint Conference on Advances in Computational Intelligence (IJCACI 2023). Oct 14, 2023. New Delhi. https://doi.org/10.1007/978-981-97-0180-3_1

Rosenberg, L., Schumann, H., Dishop, C., Willcox, G., Woolley, A. and Mani, G. (2024). Conversational Swarms of Humans and AI Agents enable Hybrid Collaborative Decision-making. IEEE UEMCON 2024. DOI: 10.1109/UEMCON62879.2024.10754763

Rosenberg, L., Willcox, G., Schumann, H. and Mani, G. (2024). Towards Collective Superintelligence: Amplifying Group IQ Using Conversational Swarms. In Proceedings of the 26th International Conference on Enterprise Information Systems - Volume 1: ICEIS; ISBN 978-989-758-692-7; SciTePress, pages 759-766. DOI: 10.5220/0012687500003690

Willcox, G., Rosenberg, L., Domnauer, C. and Schumann, H., 2021, October. Hyperswarms: a new architecture for amplifying collective intelligence. In *2021 IEEE 12th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)* (pp. 0858-0864). IEEE.