Annual Report for Period: 09/2010 - 08/2011
Submitted on: 07/28/2011
Principal Investigator: Sayama, Hiroki .
Award ID: 0826711
Organization: SUNY Binghamton
Submitted By:
Sayama, Hiroki - Principal Investigator

Title:
Evolutionary Perspective on Collective Decision Making

Project Participants

Senior Personnel

Name: Sayama, Hiroki
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Laramee, Craig
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Dionne, Shelley
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Yammarino, Francis
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Schaffer, J. David
Worked for more than 160 Hours: No
Contribution to Project:

Post-doc

Graduate Student

Name: Bush, Benjamin
Worked for more than 160 Hours: Yes
Contribution to Project:
Ben has been working as a graduate research assistant in our lab. Originally hired in 2009 to work on this project, he is now funded from a different NSF award (NSF BCS-1027752). Although he is no longer funded by this project, his research is still relevant to this project and he has continued to collaborate with us. He worked with the PI's and to set up and run human-subject experiments, develop data collection software, and write a conference abstract. He is also working with PI's on developing computational models and conduct computer simulations.

Name: Hao, Chanyu
Worked for more than 160 Hours: Yes
Contribution to Project:
Chanyu has been working as a graduate research assistant for this project. She is funded from this NSF award. She helps the PI's set up and run human-subject experiments, conduct statistical analysis of experimental data, and write manuscripts.

Name: Serban, Andra

Worked for more than 160 Hours: No

Contribution to Project:

Andra joined the project and helped part of our experiments.

Name: Raway, Thomas

Worked for more than 160 Hours: No

Contribution to Project:

Tom joined this project in May 2010. He helps us develop experimental systems (software & hardware).

Name: Head, Hadassah

Worked for more than 160 Hours: Yes

Contribution to Project:

Hadassah has been working as a Research Assistant for this project. She is funded from this NSF award. She helps the PI's set-up and run human subject experiments, develop data collection software, and write manuscripts.

Name: Shirreffs, Kristie

Worked for more than 160 Hours: No

Contribution to Project:

Kristie joined the project and helped part of our experiments.

Name: Gupta, Alka

Worked for more than 160 Hours: No

Contribution to Project:

Alka joined the project and helped part of our experiments.

Name: Schmidt, Jeffrey

Worked for more than 160 Hours: No

Contribution to Project:

Jeff joined this project in May 2011. He is funded by the PI's other NSF award. He works with Ben Bush on the implementation of computational modeling and simulations.

Undergraduate Student

Name: Roygulchareon, Darlene

Worked for more than 160 Hours: No

Contribution to Project:

Undergraduate research assistant

Name: Garcia, Bridie

Worked for more than 160 Hours: No

Contribution to Project:

Undergraduate research assistant

Name: Domenick, Vincent

Worked for more than 160 Hours: No

Contribution to Project:

Experimental assistant (data encoder)

Name: Bush, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Experimental assistant (data encoder)

Name: Edmans, Andrew

Worked for more than 160 Hours: No

Contribution to Project:

Experimental assistant (data encoder)

Name: Paquette, Christopher
Worked for more than 160 Hours: No
Contribution to Project:
Experimental assistant (data encoder)

Name: Lugo, Matthew
Worked for more than 160 Hours: No
Contribution to Project:
Experimental assistant (data encoder)

Name: Levin, Natalie
Worked for more than 160 Hours: No
Contribution to Project:
Experimental assistant (data encoder)

Name: Orr, Kaitlyn
Worked for more than 160 Hours: No
Contribution to Project:
Kaitlyn joined the project and helped part of our experiments.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Hofstra University

We have recently started collaboration with Dr. Vincent Brown at Hofstra University. See the Activities for more details.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

This interdisciplinary research project aims to develop novel conceptual/computational models of the dynamics of collective human decision making by uniquely shifting the viewpoint from the dynamics of participants to the dynamics of ideas being discussed. We have proposed to redefine collective decision making as evolution of ecologies of ideas over a social network habitat, where populations of potential solutions evolve via continual applications of evolutionary operators such as reproduction, recombination, mutation, selection, and migration of solutions, each conducted by participating humans. The effects of various model assumptions on collective decision making have been investigated through computer simulations, and their results are being evaluated through experiments of team decision making with human subjects.

==

Activities in Year 2008-2009:

[Human-subject experiments]

We developed and conducted three 'Phase 1' small-scale in-class experiments with students to test the following hypotheses obtained from our preliminary computer simulations:

Hypothesis 1: Groups with more cohesive utility functions produce solutions of higher utility values.

Hypothesis 2: The balance between selective and creative attitudes within a group is crucial for determining the overall group performance.

Hypothesis 3: The availability of diverse evolutionary operators to the participants in discussion improves the quality of decision making.

Hypotheses 1 and 2 were already mentioned in our original proposal, while Hypothesis 3 was created based on Hypothesis 2 to be more specific and quantitative about the experimental parameters we wanted to study.

These experiments were conducted in Fall 2008 in the 'Evolutionary Product Design and Problem Solving' module of the course 'BE-461: Exploring Social Dynamics' offered to juniors and seniors in the Bioengineering and Management programs at Binghamton University. This course was developed with financial support from our other NSF grant (PI: Craig Laramee, Award #: 0737313). Specific experimental designs are described below.

======
Experiment 1: Product Name Design (for testing Hypothesis 1)

Twenty-three students were divided into six groups. The first three groups were made of students of the same gender, the same major, and in the same graduation year, which were expected to represent teams with more cohesive utility functions (Homogeneous condition). The other three groups were made so that the within-group difference of gender, major and year would be maximal as much as possible, which were expected to represent teams with less cohesive utility functions (Heterogeneous condition). These conditions were hidden from the students.

Each group was asked to collectively design an attractive name for a fictitious new cell phone imported from a foreign country. One member in each group was designated to take notes of all the candidate names discussed in the design process. The discussions were recorded. Once the team reached a consensus, they brought both their final decision and the whole list of discussed candidates back to the classroom. Their final decisions were projected to the screen in the classroom and then the students individually ranked the final decisions using PDAs connected to the CMC server. The peer evaluation was used to quantitatively assess the utilities of the final decisions made by each group. The length of the list of all the candidate names and the time till reaching a consensus were also measured as the characteristics of the decision making processes.

======
Experiment 2: Catch Phrase Design (for testing Hypothesis 2)

Twenty-three students were randomly divided into six groups. Each group was asked to discuss and come up with a list of inspiring catch phrases for promoting the sales of a fictitious new laptop computer. One member in each group was designated to take notes of all the candidate catch phrases discussed in the design process. The discussions were recorded.

Three different experimental conditions were created by providing the following additional information to selected groups:

Critical condition: 'Promote and maintain critical attitude throughout the discussion. Always play devil's advocate, trying to find ways for each catch phrase to be potentially problematic. Incremental improvement of existing ideas is the key to making a reliable solution. Completely new ideas will never be better than well-tested ideas.' (Two groups)

Creative condition: 'Promote and maintain creative attitude throughout the discussion. Always give positive feedback to someone who presented a new idea, trying to find good aspects in it. Crazy inspiration and idiosyncratic thinking is the key to breaking the barrier of stereotyped ideas. Incremental improvement of existing ideas will never work out.' (Two groups)

Control condition: No additional instruction was given. (Two groups)

The groups were initially asked to simply produce a list of catch phrases, but after 20 minutes of discussion, they were told to make a final decision and choose the best catch phrase out of the produced list. Once the team reached a decision, they brought both their final decision and the whole list of discussed candidates back to the classroom. Their final decisions were projected to the screen in the classroom and then the students individually ranked the final decisions using PDAs connected to the CMC server. The peer evaluation was used to quantitatively assess the utilities of the final decisions made by each group. The length of the list of all the candidate names was also measured as the characteristic of the discussion processes. In addition, the lineages of ideas during discussion were reconstructed as an evolutionary tree by transcribing the recordings, and their shapes were compared between conditions.

======
Experiment 3: Swarm Design with Interactive Evolutionary Methods (for testing Hypothesis 3)

Twenty-one students were randomly divided into seven groups. They were asked to collectively design, within 10 minutes, an 'interesting' pattern produced by a population of kinetically interacting agents simulated in a computer. For this experiment, we used Swarm Chemistry, a computational model of particle swarms with interactive evolutionary design interface created by the PI. The following four conditions were prepared and assigned randomly to each group:

Baseline condition: Neither mixing nor mutation operators were available.

Mixing condition: Only the operator for physical mixing of two swarms was available.

Mutation condition: Only the operator for genetic mutation of a swarm was available.

Mixing + mutation condition: Both the mixing and mutation operators were available.

The design process was repeated three times (each time group members were randomly shuffled) so that there were 3 x 7 = 21 final swarm designs produced during this experiment. Those final designs were projected to the screen in the classroom and then the students individually rated them in a 10-point scale using PDAs connected to the CMC server. The peer evaluation was used to quantitatively assess the quality of the final designs made in each condition.

======

The results of Experiment 3 were published as a conference paper and presented orally at the IEEE Symposium Series on Computational Intelligence in March 2009. The results of Experiments 1 and 2 were also quite promising, but the sample size was too small to reach statistically significant conclusions.

[Computational modeling and simulation]

We have summarized our preliminary results obtained from computer simulations in a paper and submitted it to a journal (Organizational Science). We are in the process of developing new agent-based computational simulation models that implement several model extensions discussed in our proposal, including the possibility of partial ideas and different domains of expertise, organizational network structure, and mental modeling capabilities of agents. Part of the results will be presented at the 2009 Academy of Management Annual Meeting in August 2009. Sayama, Dionne and Yammarino will attend this meeting to present latest simulation results. Another journal paper will be produced based on this conference paper.

==

Activities in Year 2009-2010:

[Computational modeling and simulation]

We have developed new agent-based computational simulation models that implement several new model extensions, including (1) possibility of partial ideas, (2) heterogeneous domains of expertise of participants, (3) dynamic changes of individual behavioral patterns, (4) complex social network structure involving many participants, (5) mental modeling capabilities of agents, and (6) mutual learning among agents. Extensions (1)-(4) were already mentioned in our original proposal, while (5) and (6) are new inclusions which we have realized quite important to consider for team decision making.

The results of Monte Carlo simulations using these models have been presented, or are going to be presented/published, at several venues: Complexity (journal article, model with (1), (3), (5), (6)), NetSci 2010 (conference presentation, model with (1), (2), (4), (5)), Leadership Quarterly (journal article, model with (1), (2), (4), (5), (6)), and INFORMS 2010 Annual Meeting (conference presentation, model with (1), (2), (4), (5), (6)). See the attached preprints for details of the computational models.

We are currently developing new simulation models that include long-term co-evolution of ideas and social ties/statuses of human participants in a social network context.

[Human-subject experiments]

We continued Experiment 1 'Product Name Design' and Experiment 2 'Catch Phrase Design' in Fall 2009. This time, we did so in a larger joint class of BE-461 'Exploring Social Dynamics' and MBA graduate course MGMT-508 'Organizational Behavior', to increase the sample size so as to reach statistically significant conclusions on Hypotheses 1 and 2. However, this attempt did not go successfully in this large class setting. The following problems were realized:

(a) Experiments were conducted simultaneously in a large classroom due to space limitation, which often caused avalanches of premature discussion wrap-ups when one of them finished.

(b) A strong personality or a language barrier within a group often dominated the whole group dynamics and made our framework emphasizing idea evolution inapplicable.

(c) Demographic diversity manipulated in Experiment 1 was not quite effective in controlling within-group heterogeneity.

To address issues (a) and (b) for the upcoming Fall 2010 experiments, we will prepare better controlled rooms for experiments and also form groups using demographic/psychological data collected from subjects.

In the meantime, in addressing issue (c), we noticed that having a superficial demographic diversity was not so relevant to realistic collective decision making, and that it would be more meaningful to examine the diversity in domains of expertise and the team development process. Therefore we have developed another experiment where within-group heterogeneity of knowledge and domains of expertise among participants is explicitly manipulated by providing different sets of vignettes to subjects. This experiment was based on the Phase 2 experiment plan we discussed in our original proposal. One difference from the original proposal was that we simplified the experimental design so that we can have enough number of group samples for each experimental condition (original design: 2x3, {homogeneous, heterogeneous} x {creative, critical, control} vs. new design: just two conditions, {homogeneous, heterogeneous}). The details of the experiment are described below.

======

Experiment 4: Liver Transplant Patient Ranking (for observing different team development dynamics between homogeneous and heterogeneous groups)

Four subjects are organized into a team. Each subject receives a separate vignette, which explains that the task of the team is to develop a priority ranking of five potential liver transplant patients. It also provides some background information about each of the five patients (e.g., family, financial status, career, etc.). In addition, each vignette describes the professional role assigned to the subject (physician, social worker, bioethicist, or hospital administrator), with expert knowledge specific to that role. In one experimental condition (homogeneity), all the four subjects in the team receive the same vignette for physicians. In another condition (heterogeneity), each subject in a team receives a different vignette. It is not disclosed to the subjects whether or not other team members have the same or different roles/vignettes. After all the subjects finished reading the vignettes, they are told to discuss freely to develop a priority ranking of the patients. There is no time limit imposed. Once the team reaches a decision, the subjects submit a final ranking to the experimenter and also write a summary report that provides the justification of their ranking. The subjects also take the Big-Five personality test before or after the experiments so that we can collect their personality data as well.

======

To collect the detailed data of decision making processes, we have developed a new real-time data collection tool (touch-screen PC combined with specially designed Java-based application). We place two trained observers/coders at two opposite sides around the subject team. A touch-screen PC with the data collection software is given to each observer. On the screen of the PC is displayed a matrix of buttons, whose rows represent speakers and columns represent topics. The observers independently watch the discussion process and keep pressing buttons as someone says something in the discussion. Each button-pressing event is logged in a local hard drive with time stamp data associated with it. This detailed information allows us to analyze various dynamical properties of the discussion.

We first had a pilot run of this new experiment in the larger joint class of BE-461 and MGMT-508 in Fall 2009, but due to issue (a) mentioned above, the results were not quite reliable. Therefore we set up a separate experimental room outside the classroom and recruited volunteer subjects from another (larger) undergraduate management class, MGMT-311 'Organizational Behavior' and ran a better controlled experiment in Spring 2010. The new data set appears much more promising, and we are currently in the process of analyzing the data.

Finally, we have developed and conducted another experiment for further testing of Hypothesis 2. Specifically, we continued using the interactive evolutionary design tool we had used in Experiment 3 (whose results were already published so we did not need to repeat the same experiment this year). One major extension implemented in the interactive evolutionary tool is the capability of recording a complete time-stamped log of every single evolutionary event that happened in the decision making process. This feature was described in our original proposal but has not been implemented until this year. Such a detailed log of evolutionary decision making processes allows us to reconstruct the genealogy of ideas over time and quantitatively analyze how exploration and exploitation occurred in human decision making. Moreover, we installed this software on the touch-screen PCs (mentioned above) and utilized them for the collaborative design experiment. This technology enhanced the students' participation, engagement and learning significantly, compared to the last year's experiment where students' own laptops were used. The procedure of the experiment carried out in BE-461 in Fall 2009 is as follows:

======
Experiment 5: Swarm Design with Interactive Evolutionary Methods II (for testing Hypothesis 2)

Twenty-two subjects were placed into 6 groups of 3 and 1 group of 4 students each. Each group was assigned to a station with a digital tabletop (i.e., touch-screen PC placed horizontally) running the revised interactive evolutionary design application. The students were then given a brief tutorial on how to use the application, including an overview of the various evolutionary operators available to them. Each group was then given 10 minutes to design an aesthetically pleasing swarm pattern, with no further guidance given. This phase of the experiment served as the experimental control.

Then the subjects were reshuffled into 7 new groups. Three groups were primed to be critical and risk-averse, with the following written instruction: 'Promote and maintain critical attitude throughout the design process. Incremental improvement of existing designs is the key to making a reliable solution. Completely new designs will never be better than well-tested ones.'

The other four groups were primed to be creative and adventurous, with the following written instruction: 'Promote and maintain creative attitude throughout the design process. Crazy inspiration and idiosyncratic thinking is the key to breaking the barrier of stereotyped designs. Incremental improvement of existing designs will never work out.'

Then the groups were once again given 10 minutes to design an aesthetically pleasing swarm pattern.

Finally, the above step was repeated one more time, with four 'critical' groups and three 'creative' groups.

The log files containing detailed information about all the evolutionary events were saved in a local hard drive of each PC and later collected for post-experimental analysis. One of the 'control' groups had a technical problem during the experiment, and therefore their data were excluded from the analysis. As a result, we collected data from 6 groups working under the 'control' condition, 7 under the 'creative' condition, and 7 under the 'critical' condition.

======

Part of the results of this experiment was included in a new journal article manuscript, which is currently under review in the IEEE Transactions on Evolutionary Computation. We are now analyzing topological properties of idea genealogies reconstructed from the log files and their differences between the three experimental conditions. We also plan to have each group's final product (swarm pattern) evaluated by third parties in order to assess the overall quality of their collective decision making.

==

Activities in Year 2010-2011:

[[Changes in personnel]]

One of the two graduate research assistants (Benjamin James Bush) began to be supported by using another NSF grant of the main PI (Award #: BCS-1027752) as of August 2010. Consequently, we hired a new graduate research assistant, Hadassah J. Head, a graduate student in Systems Science of the Thomas J. Watson School of Engineering and Applied Science, starting in August 2010. In recruiting, we made extra efforts in reaching out to underrepresented groups, which was successful as we were able to hire a female student for this position.

To secure the financial support for the graduate research assistants until August 2012, we filed a request for one-year no-cost extension of this project. The request was approved by Binghamton University and then by the NSF.

Also, we welcomed to our research group a visiting scholar, Dr. Jin Akaishi, from Kumamoto National College of Technology, Japan, from April 2010 to March 2011. His stay was fully funded by Japanese government. He participated in various aspects of our project, and he also worked on his own new project that uses web search engines to collect historical information about social networks and collective sentiments of human society. This work is quite relevant to and useful for our project as well.

Finally, we have recently started collaborating with Dr. Vincent Brown at Hofstra University, a leading scholar on individual and group brainstorming and human creativity. We will offer him the technical tools we developed for our electronic brainstorming experiment (explained later), and he will offer us advice on possible ways to improve the system and to better analyze the experimental data. Dr. Brown is the PI of another NSF HSD grant (BCS-#0729470). We hope this collaboration will turn to be a fruitful outcome of synergistic activities between multiple HSD-funded projects.

[[Computational modeling and simulation]]

[Idea & social network co-evolution] We have finished implementing a new computational model of the co-evolution of ideas and social ties/statuses of human participants in a social network context. This model aims to fulfill the objectives 5.1-(d) 'Complex social network structure involving many participants' and (e) 'Co-evolution of ideas and participants' in our original proposal.

The model considers multiple ideas residing within each individual, real-valued directed social links between individuals, and heterogeneous behavior distributions. Individual agents divide their time into three distinct actions: thinking about and reconciling one's own ideas ('think'), disseminating ideas to others ('talk'), and listening to ideas from one's peers ('listen'). Each individual is host to a local population of ideas, some of which are fixed, while others can be replaced as a result of social interaction. Individuals evaluate ideas based on their local idea population, and these evaluations are used to update the (directed) link weights whenever ideas are exchanged. Using this model, we simulate the co-evolution of ideas and the social network itself. We then calculate the distribution of network centrality over the space of all possible individual behaviors, as well as the probability for each individual to be the origin of the ideas being discussed in the society.

Preliminary results of this simulation was reported at the Eighth International Conference on Complex Systems (ICCS 2011; see Publications and the attached pre-/reprints). We are currently running more systematic parameter sweep simulations using this model. We plan to write a manuscript on the results by the end of 2011, which will be submitted to IEEE Transactions on Systems, Man and Cybernetics or other appropriate journal.

[Reconstructing the evolution of social networks and sentiments] The new computational model reported above has illustrated the importance of considering dynamic changes of social networks and collective ideas in human society. From an experimental viewpoint, however, there is a fundamental lack of technical tools to obtain such social data in reality. Fortunately, we had a visiting scholar, Dr. Jin Akaishi, for Year 2010-2011, who worked on a new project to fill in this gap. Dr. Akaishi developed a computational tool to automatically collect Google search 'hits' for every pair of keywords given in a text file. By adding carefully designed keywords to specify a particular time point, one can obtain a rough estimate of how closely associated two keywords were in a specific year, for example.

We applied this technique to reconstruct the temporal evolution of a social network from 2005 to 2009 of 93 individuals who are important in the US economy. The results were reported at the Fifth International ICST Conference on Bio-Inspired Models of Network, Information, and Computing Systems (BIONETICS 2010; see Publications and the attached pre-/reprints). We are currently expanding the scope of this data collection method to social sentiments and other information that captures the average state of collective ideas in our society.

[[Human-subject experiments]]

[Experiment 2] We continued Experiment 2 'Catch Phrase Design' again in Fall 2010. In so doing, we went back to a smaller subject population size (22 students in BE-461 'Exploring Social Dynamics') because of the problems we had in the experiment in Fall 2009. We used seven separate rooms for group discussion so that groups did not interfere with each other. We also made sure that all the subjects were English native speakers. These experimental settings were the same as those of Fall 2008, so the data of 2008 and 2010 were merged together for post-experimental analysis.

There was one fundamental change in the design of Experiment 2 in Fall 2010: We conducted a group evaluation of product quality by a large number of third parties---students in MGMT-311, an undergraduate management course on organizational behavior that had more than 120 enrollments. The catch phrases created in Fall 2008 and Fall 2010 were mixed and projected in a randomized order on a screen of a large lecture hall, and then the students of MGMT-311 rated the quality of each product on a 0-10 scale individually and independently. This change made a major improvement of the experiment because separating designers and evaluators would significantly improve the objectiveness and reliability of the evaluation results.

In the meantime, Experiment 1 'Product Name Design' was not repeated in Year 2010-2011, because it became apparent over the last two years that the experimental manipulation of demographic diversity in Experiment 1 was not as effective as originally thought. Experiment 1 was instead replaced by Experiments 4 and 6 (described later).

[Experiment 5] We also repeated Experiment 5 'Swarm Design with Interactive Evolutionary Methods II' in Year 2010-2011. Also for this experiment, designers and evaluators were separated for the first time. We recruited volunteer subjects from Bioengineering sophomores and conducted the swarm design experiment outside classes, using the interactive computational tools we developed before. The results of this experiment were then evaluated by the students of BE-461. The same evaluators also rated the results of 2009 so that the sample size would be large enough to reach statistically significant results.

[Experiment 6 (new)] Furthermore, we ran a modified version of Experiment 4 'Liver Transplant Patient Ranking' by adding another experimental condition to supplement the homogeneous and heterogeneous condition: a condition called 'instructions/no instructions' in which participants are instructed to (a) score/rank liver transplant patients before discussing the problem or rank order with the group (i.e., an individual ranking provided prior to any group ranking discussion), or (b) instructed as a group to provide a ranking, leaving off the instructions to first rank patients as an individual before discussing as a group. The revised experimental design is as follows:

======

Experiment 6: Modified Liver Transplant Patient Ranking (for observing different team development dynamics between homogeneous and heterogeneous groups)

Subjects were recruited from a large undergraduate 'Organizational Behavior' class in Fall 2010, and the experiment took place in experimental rooms housed in the Center for Leadership Studies. Subjects were assigned to four person groups, and groups were randomly assigned to either the 'instruction' or 'no instruction' condition, and then within that condition, randomly assigned to the homogeneous or heterogeneous condition. Groups were not instructed that they were in either condition.

The experiment proceeded as follows: Groups in the 'instruction' condition were provided vignettes that were either the same (homogeneity, or all participants have same information and are physicians) or unique (heterogeneity, or all participants had different information as a physician, social worker, hospital administrator or bioethicist). Groups in this 'instruction' condition were then provided a task sheet asking them to examine the background of five patients and individually determine the rank order of the five patients before discussing the problem with any other group member. Once all group members finished their individual ranking, the group was instructed to discuss the task and determine a rank order that the entire group could support. Once the groups reached a decision, they were asked to provide a written summary sheet outlining their ranking justification to the experimenter. There was no time limit imposed. The subjects also provided personality data in the form of a Big-Five personality test (NEO-FFI) following the experiment.

Similarly, groups in the 'no instruction' condition were provided vignettes that were either the same (homogeneity, or all participants have same information and are physicians) or unique (heterogeneity, or all participants had different information as a physician, social worker, hospital administrator or bioethicist). However, groups in this 'no instruction' condition were instructed to discuss the task and determine a rank order that the entire group could support. Once the groups reached a decision, they were asked to provide a written summary sheet outlining their ranking justification to the experimenter. There was no time limit imposed. The subjects also provided personality data in the form of a Big-Five personality test following the experiment.

======

Changes in experimental condition (adding 'instruction/no instruction') were designed to explore a group discussion process in more detail, especially when subjects enter a group discussion with preconceived notions of preferences for outcomes (i.e., individual rank order of how the outcome should be). This change was implemented after a review of Experiment 4 revealed some group subject members did not often contribute to the group discussion, and agreed to whatever more vocal members of the group decided. As such, we continued to explore dominance issues in the group (the 'no instruction' condition which replicated the environment surrounding Experiment 4) but included an individual preference element (i.e., 'instruction') into the discussion to see what effect this may have on participation and idea generation within the group exercise.

Additionally, we made slight changes in the vignette surrounding the bioethicist's information so that the subject playing the role as a bioethicist will have a clear guideline for discussion regarding 'payment for organs' issues. The prior bioethicist vignette provided two short readings on controversy surrounding famous or wealthy people who were able to 'leapfrog' the national/state organ transplant lists to be moved to the top of the list as a priority, and briefly noted the bioethicist's support of the national/state organ transplant lists. The new vignette for the bioethicist tabled key information from the articles and provided a clear statement that the bioethicist thought 'payment for organs' was morally wrong. This change in the bioethicist's vignette was implemented after a review of Experiment 4 revealed ethics issues were rarely discussed among groups. Moreover, anecdotally subjects in the bioethicist role often stated they had no relevant information to contribute, despite the fact that one patient in the rank order problem was offering a significant donation to the hospital in exchange for a transplant. As such, a clearer guidelines were provided to spark group discussion surrounding a key topic considered central to the exercise objective (i.e., introduce/discuss ethical issues in medicine/science/business).

Although the prior developed real-time data collection tool was used again in this experiment, to increase the efficacy of rater agreement, we purchased a digital video recording camera to tape group sessions. This enabled coders to revisit the areas of disagreement and resolve disagreements on ratings.

Moreover, we trained two new coders (students blind to hypotheses) and used these two coders to code every group session, further enhancing our initial agreement scores among raters. Prior, we used upwards of eight people that may or may not have worked with their coding partner in prior group sessions and may or may not have attended the same coder training class. This new method (same two coders) saw significant improvement in initial rater agreement and coding dispute resolution rates.

[Experiment 7 (new)] Finally, we created a new experiment that evaluates computer-based communication and decision support systems for improving the quality of the brainstorming experience and assist groups in efficient use of problem solving time. Specifically, we developed an electronic group brainstorming program based on a Human Based Genetic Algorithm (HBGA) and idea network (a genealogy of ideas generated in the brainstorming). We are exploring the effects of different algorithmic parameters, particularly selection strategies in suggesting candidate ideas to the user, on the standard measures of brainstorming. The standard measures are quantity, quality, and creativity of ideas generated. The selection strategies examined are random selection of ideas ('random') and selection of ideas far apart on the idea network ('network-informed'). This experiment aims to see if there is any statistical difference between these two conditions. Details of the experimental design is described below.

======
Experiment 7: Computer-Assisted Collective Brainstorming

Subjects were recruited from students taking MGMT-311: Organizational Behavior. A total of 120 students participated. They were separated into groups of four. Each group participated in several electronic brainstorming tasks in a controlled room where four computers were set up at four corners of the room, facing outward so that the subjects would have no visual contacts. Each experiment involved a three electronic brainstorming task session and an online Big-Five personality survey. First, participants independently worked on Guilford's Alternative Uses Task to assess their individual creativity. Then they did two brainstorming sessions as a collective. There was no direct oral or online communication allowed between subjects during the experiment. The first task was to generate marketing catch phrases for a laptop (same as in Experiment 2), while the second was to generate marketing catch phrases for a new pizza restaurant. In each of the two sessions, either 'random' or 'network-informed' selection mechanism was used for idea suggestion, which was hidden from the subjects. The overall experimental design was 2 x 2 x 2 (laptop vs. pizza; random vs. network-informed; and first session vs. second session). All the idea generation events were recorded electronically in the central server that coordinated the whole collective brainstorming processes.

======

We are currently working on several manuscripts on the results of these experiments above, most of which will be finished and submitted to journals or conferences by the end of 2011.

[[Dissemination of results]]

Now that the project is nearing its completion, we have been very active in disseminating its research outcomes. Most notably, the main PI has been invited to two keynote talks at academic conferences. Below is a list of recent dissemination activities (also see the attached pre-/reprints):

* Three journal publications (see Publications).

* The NSF Human and Social Dynamics 2010 Grantees Conference
  (September 27-28, 2010, Arlington, VA)
  - Presented a poster on the overall progress of the project.

* The 2010 Computational Social Science Society Conference
  (November 5-6, 2010, Tempe, AZ)
  - Presented two talks: one on the overall project with emphasis on Experiments 1, 2, 3 & 5, and the other on computational simulation models.

* INFORMS 2010 Annual Meeting
  (November 7-10, 2010, Austin, TX)
  - Presented a talk on computational simulation models.

* The Fifth International ICST Conference on Bio-Inspired Models of Network, Information, and Computing Systems (BIONETICS 2010) (December 1-3, 2010, Boston, MA)
  - Presented a talk on a technique to reconstruct social networks using web search engines.

* The Japanese Society for Evolutionary Computation Symposium 2010 (December 18-19, 2010, Fukuoka, Japan)
  - Presented a KEYNOTE TALK on the overall project with emphasis on Experiments 1, 2, 3 & 5.

* Research description for NSF Highlight
  - Wrote a summary of research aims and outcomes for NSF Highlight (not selected for publication).

* The Eighth International Conference on Complex Systems (ICCS 2011) (June 26-July 1, 2011, Quincy, MA)
  - Presented two talks: one on the computer-supported collective brain storming system, and the other on the new computer simulation model of co-evolution of ideas, individual behaviors and social network topologies.

* Fourth International Workshop on Guided Self-Organization (GSO-2011) (September 8-10, 2011, Hatfield, UK)
  - Will present a KEYNOTE TALK on the overall project with emphasis on Experiments 3 & 5.

Findings:

Findings in Year 2008-2009:

In the results of Experiment 1, a statistically significant difference was detected between Homogeneous and Heterogeneous conditions in terms of the ranking of final decisions (i.e., decisions made in Homogeneous condition was better than those in Heterogeneous). It was also observed, though without statistical significance, that groups in Homogeneous condition produced fewer candidate names and converged in a consensus faster than those in Heterogeneous condition.

In the results of Experiment 2, a statistically significant difference was detected between Creative and Critical conditions in terms of the ranking of final decisions (i.e., decisions made in Creative condition was better than those in Critical). Comparison of genealogies of ideas also revealed visually that the evolutionary trees in Creative condition grew faster and produced more branches than those in Critical.

In the results of Experiment 3, a statistically significant difference was detected between Baseline and Mutation, Baseline and Mixing + Mutation, and Mixing and Mixing + Mutation (i.e., the availability of more evolutionary operators makes the results better). It was also observed that each of the Mixing and Mutation operators contributed nearly independently to the improvement of the design quality.

These experimental results are all in agreement with our preliminary results produced by computer simulations, supporting our evolutionary perspective on collective decision making.

==

Findings in Year 2009-2010:

Through computer simulations with one of our new agent-based models, we have found that, as the agents' memory capacity increases, a group reaches superficial consensus more easily, but the shared mental model of the problem develops only within a limited area of the problem space because incorporating knowledge from others into one's own knowledge quickly creates local agreement on where relevant solutions are, leaving other potentially useful solutions beyond the scope of discussion. In other words, the more the participants can remember about others' opinions, the more likely it may be for the group to get stuck exploring only limited sets of possibilities. This could be understood as a form of 'groupthink'. A journal article summarizing these findings is accepted for publication in an interdisciplinary journal 'Complexity'.

Using another agent-based model with social network structure, we have found that the high network connectivity generally promotes mental model convergence. In the meantime, the team performance improvement is achieved in well connected networks only when members have both heterogeneous domains of expertise and strong mutual interest. In all other conditions, the high connectivity causes the worst degradation of team performance through team development processes, while star-shaped centralized networks are the best to minimize such team degradation. A journal article summarizing these findings is accepted for publication in 'Leadership Quarterly'.

In the results of Experiment 5, a statistically significant difference in frequencies of evolutionary operator usage was detected between 'critical' and 'creative/control' conditions. Namely, groups instructed to be critical and risk-averse tended to focus more on mutation, while groups instructed to be creative and adventurous focused more on mixing. There was no statistical difference found between 'creative' and 'control' conditions. These findings are very interesting as they relate human behavior in decision making directly with evolutionary concepts. A journal article that includes this finding was written and submitted to IEEE Transactions on Evolutionary Computation.

==

Findings in Year 2010-2011:

[[Computational modeling and simulation]]

[Idea & social network co-evolution] Preliminary computer simulations with the new model of idea-social network co-evolution have shown that individuals with greater propensity to 'think' (than the other 'talk' and 'listen' behavioral choices) tend to acquire lower centrality in a social network. In other words, it helps to talk and listen a lot if one wants to be central in the social network. This effect disappears when all the ideas in each individual are fixed (i.e., hard-wired or genetically determined, with no possibility of learning).

The result above was rather shocking, yet reasonable in some sense, presenting the dilemma often observed in human organizations that good decision makers may not always occupy central positions in the society. Our model may be able to illustrate in what conditions this situation could be reversed.

We are currently revising the codes for data analysis to calculate the probability for each individual to be the origin of the ideas being discussed in the society. This will enable us to see if thinkers are the source of most ideas being discussed even if they are not central to the social network.

[Reconstructing the evolution of social networks and sentiments] Temporal changes in network topology and node centrality measures observed in the reconstructed social network of 93 important figures in the US economy reflected several real-world events, such as shifts of power/influence and temporary formation of strong relationships. These results demonstrate the potential of our web search engine-based method for examining changes that have occurred in real-world social networks.

[[Human-subject experiments]]

[Experiment 2] The average rating score of ideas generated in the Creative condition was significantly greater ($p < .05$) than in the Critical condition. There was no significant difference detected between the Creative and Control conditions. Also, the average number of ideas generated in the Creative condition was significantly greater ($p < .05$) than either Control or Creative condition. This indicates that collective human decision making works optimally when no additional instruction is given, in the sense that it can produce as good solutions as when instructed to be creative, yet without producing so many useless candidate solutions.

These results, combined with the results of Experiment 5 of Year 2009-2010 (above), leads us to develop an interesting explanation of what have been observed in the series of our experiments: Behaviors of people working in groups are most diverse when no explicit instructions are given, leading to best decision outcomes. Instructing teams to be either creative or critical may result in loss of behavioral diversity and therefore less efficient or less productive discussion. These results can be understood evolutionarily: With greater behavioral diversity, ideas take more different paths to reach better solutions on a fitness landscape made by team members.

[Experiment 5] Preliminary results of the analysis of idea genealogy topologies have shown that the Creative condition produced more ideas with shorter 'lifespans' (i.e., length of time period from the idea's birth to death in discussion) than the other two conditions, though we have not reached a statistically significant level on those at this point. Visual observation suggests that idea genealogies in the Creative conditions were longer/deeper with many short-loving branches than those in the other two conditions. We are yet to develop and conduct more rigorous mathematical analysis of topological differences of the idea genealogies. We also need to combine the results of Year 2009-2010 and 2010-2011 to increase the sample size. We will continue analysis over Summer 2011.

[Experiment 6 (new)] Preliminary data analyses have been conducted for Experiment 6. Two coders coded all experiments and used video recordings of sessions to resolve disagreements in coding. As such, agreement rates between the two coders (regarding topics of discussion among all four subjects) exceeded 95% for all groups.

ETHICS. Regarding changes to the bioethicist vignette to increase discussion surrounding ethics, preliminary analyses indicate ethics-based topics were discussed only 3% more than in the prior experiment (Experiment 4). However, the rank order (of patients to receive a liver transplant) saw a decrease in rank order position for the patient that was offering a quid pro quo to the hospital. In Experiment 4 the patient that wanted to donate money to the hospital in exchange for a liver transplant received an average rank of 3rd position, where position #1 means 'first to receive transplant' and position #5 means 'last to receive transplant.' In the current experiment (Experiment 6), the 'quid pro quo' patient saw a decrease in average rank to 4th position, even though the topic of ethics only increased in discussion by 3%.

Future analyses will focus on examination of theoretical and behavioral ethical frameworks as a means of understanding why subjects viewed certain ethical transgressions such as bribery different than individual personal failings (such as divorce, loss of custody of children). Anecdotally, personal failings were considered more significant transgressions than bribery. Moreover, although groups generally used age as key decision point for ranking, the patient consistently ranked last in both Experiments 4 and 6 was the second youngest patient. This patient, although in his 30s, had been twice divorced, and did not have custody of his children, which was a frequent justification provided by all groups for the last-place ranking of this patient.

We plan to examine the ethical topics surrounding discussions of patients, and plan to examine if an international sample pool voted differently on issues such as bribery than did non-international students. Again, cultural and demographic issues (such as gender) will be considered when examining discussion contribution, topics raised, time to decision and rank order. Analyses on these potential demographic differences commence summer 2011.

PRE-DECISION DISCUSSION CONDITION. Preliminary analyses examined potential fundamental differences in discussion topics, time to decision and/or rank order between the two conditions (individual rank order preceding group rank order versus group rank order only). Groups instructed to make individual decisions prior to group discussion made decisions faster than did the groups without such instruction. In general, heterogeneous expertise groups had longer discussion time than did homogeneous groups. This effect was more significant when individual team members held diverse pre-discussion preferences.

GENDER. Other statistical analyses on the results of Experiments 4 and 6 derived the following observations regarding the effects of gender: (a) The ratio of males to females in a team is positively related to decision efficiency and gender of the discussion leader - the more females in a team, the more likely a female dominates the discussion, but has no impact on decision choice. (b) People and relationships related topics are primary ones regardless of group gender configuration, their respective shares of total conversations for all gender groups being very similar. (c) The share of women's discussions of work and money has increased considerably over time, being higher than the share of all-male and mixed gender groups. These latter groups dominate the discussion in terms of the social issues topics approached. Overall, conversations are significantly affected by specific expertise related information.

Analyses on these potential conditional differences continues through summer 2011.

[Experiment 7 (new)] The idea network generated with the network-informed selection strategy had a more 'flat' topology with a more homogeneous degree distribution than the one with the random selection strategy. Also, the semantic distances between ideas generated by the network-informed strategy were moderately greater than those by the random one ($p < .1$).

The system is still preliminary with much room for improvement in algorithms, implementation and interface design. We will continue improving the system and continue experiments to increase the sample size for the analysis. In particular, one limitation of the current system is that it relies on the human subject to rate the relatedness between existing ideas and a newly generated idea. We are working on automating this rating process by using natural language processing tools, which is expected to improve the speed and quality of the brainstorming process significantly.

Training and Development:

Through participation in this interdisciplinary project, Sayama (PI) has acquired skills and experience that are essential to designing and conducting experiments with students in class. Dionne (co-PI) has learned knowledge about quantitative modeling and technical skills for computational modeling through this project.

We have hired three graduate research assistants for this project so far: Chanyu Hao from China, Benjamin Bush from California, and Hadassah Head from New York. They are all from underrepresented groups (Hao and Head are female, and Bush is Hispanic), satisfying our original intention to achieve broader impacts. Hao enrolled in the Ph.D. program in Management at Binghamton University, and Dionne supervises her work. Bush and Head enrolled in the Ph.D. and M.Sc. program in Systems Science at Binghamton University, respectively, and Sayama supervises their work. All of these students took a graduate course on computational modeling taught by Sayama.

Because we could not hire graduate students in the first year of the project, we filed a one-year no-cost extension so that we will be able to continue to hire them for three consecutive years until Spring 2012 using this grant. The request was approved by Binghamton University and NSF.

In addition, two new students participated in the project, specifically in the role of data coders for Experiment 6. Graduate research assistant Chanyu Hao developed a coder training program based on information and feedback received from Experiment 4. The improved coder training program was an intensive two week program, with each coder training for 8 hours each week. Coders were trained together, and trained on coding methodology, coding technology, and resolution of disagreement techniques. Trainer Hao observed/conducted the entire training program. The continuity provided by a single trainer, combined with an enhanced, intensive training program provided greatly improved initial agreement rates and a clear, developed procedure for dispute resolution. Moreover, the availability of the video to review disputes was significant in the ability of coders to review and discuss justifications for ratings during coding disputes. The video also enabled Hao to mediate coding disputes when necessary (although rarely employed).

We have several other graduate students participating in this project: Andra Serban (Management), Alka Gupta (Management), Thomas Raway (Systems Science) and Jeffrey Schmidt (Systems Science). They are financially supported by other funding sources. Dionne and Sayama supervise their Ph.D. work. Serban and Gupta help part of our human subject experiments and data analysis. Raway and Schmidt help software development for experiments and computer simulations.

Moreover, the experiments we conducted in class produced educational benefits on students who participated in them. From the Thomas J. Watson School of Engineering and Applied Science, about 25~50 students participated in the experiments each year and received feedback from PI Sayama (class instructor) at the conclusion of the experiments. Students learned how evolutionary concepts can be applied to better understand collective product design other decision making processes. From the School of Management, approximately 150 undergraduate students participated in the experiments each year and received feedback from PI Dionne (class instructor) at the conclusion of the experiments. Students better understand the impact of homogeneity and heterogeneity on decision making, and group processes surrounding decision making. Both topics fit into course content on group/team development and collective decision making. Positive educational impact of experimental participation was noted on course satisfaction survey results.

Outreach Activities:

This research project has been publicized through several print media exposures, including: BU discover-e (Binghamton University Research News), 2009 Binghamton University Research Magazine, Binghamton University Alumni Magazine, and BU Pipe Dream (student paper at the University). The project was also featured in a couple of online news sources.

We also wrote an NSF Research Highlight article in response to the request from the NSF HSD program (attached to this report), which was unfortunately not selected for final publication.

Journal Publications

Hiroki Sayama, Dene Farrell, and Shelley D. Dionne, "The effects of mental model formation on group decision making: An agent-based simulation", Complexity, p. 49, vol. 16, (2011). Published,

Shelley D. Dionne, Hiroki Sayama, Chanyu Hao, and Benjamin Bush, "The role of leadership in shared mental model convergence and team performance improvement: An agent-based computational model", Leadership Quarterly, p. 1035, vol. 21, (2010). Published,

Benjamin James Bush and Hiroki Sayama, "Hyperinteractive evolutionary computation", IEEE Transactions on Evolutionary Computation, p. 424, vol. 15, (2011). Published, 10.1109/TEVC.2010.2096539

Hiroki Sayama, Shelley D. Dionne, and Francis J. Yammarino, "Evolutionary perspective on group decision making", TBD, p. , vol. , (2011). in revision,

Shelley D. Dionne, Hiroki Sayama, and Francis J. Yammarino, "An examination of team emergent processes, mental models, and problem representation with agent-based modeling", TBD, p. , vol. , (2011). in preparation,

Books or Other One-time Publications

Hiroki Sayama, Shelley Dionne, Craig Laramee, and David Sloan Wilson, "Enhancing the architecture of interactive evolutionary design for exploring heterogeneous particle swarm dynamics: An in-class experiment", (2009). Book, Published
Bibliography: Proceedings of the Second IEEE Symposium on Artificial Life (IEEE-CI-ALife '09), Nashville, TN, IEEE, pp.85-91

Shelley D. Dionne, Hiroki Sayama, and Francis J. Yammarino, "An examination of team emergent processes, mental models, and decision making with agent-based modeling", (2009). Book, Conference presentation
Bibliography: Proceedings of the 2009 Annual Meeting of the Academy of Management

Hiroki Sayama, Shelley D. Dionne, Chanyu Hao, and Benjamin J. Bush, "Shared mental model formation on social networks", (2010). Conference presentation, Conference presentation
Bibliography: NetSci 2010: International School and Conference on Network Science, May 10-14, 2010, Boston, MA.

Hiroki Sayama, "Evolutionary perspective on collective decision making and product design: An experimental approach", (2009). Invited talk, Invited talk
Bibliography: Science Friday, June 5, 2009, Icosystem, Cambridge, MA.

Hiroki Sayama, Shelley D. Dionne, Chanyu Hao, and Benjamin J. Bush, "Shared mental model formation and mutual learning on social networks", (2010). Conference presentation, Conference presentation
Bibliography: INFORMS 2010 Annual Meeting

Hiroki Sayama, "Understanding and improving collective decision making", (2010). Invited talk, Invited talk
Bibliography: invited talk at Kresge Center for Nursing Research, Binghamton University, Binghamton, NY, March 16, 2010

Jin Akaishi, Hiroki Sayama, Shelley D. Dionne, Xiujian Chen, Alka Gupta, Chanyu Hao, Andra Serban, Benjamin James Bush, Hadassah J. Head, and Francis J. Yammarino, "Reconstructing history of social network evolution using web search engines", (2010). Conference proceedings, Published
Bibliography: Proceedings of the 5th International ICST Conference on Bio-Inspired Models of Network, Information, and Computing Systems (BIONETICS 2010), Boston, MA, December 1-3, 2010, Springe

Hiroki Sayama, Shelley Dionne, Craig Laramee, David Schaffer and Francis Yammarino, "Evolutionary perspective on collective decision making: Computer simulations and human-subject experiments", (2010). Conference presentation, Conference presentation
Bibliography: Presented at The 2010 Computational Social Science Society Conference, November 5-6, 2010, Tempe, AZ.

Hiroki Sayama, Shelley Dionne, Chanyu Hao and Benjamin Bush, "Shared mental model formation and mutual learning on social networks", (2010). Conference presentation, Conference presentation
Bibliography: Presented at The 2010 Computational Social Science Society Conference, November 5-6, 2010, Tempe, AZ.

Hiroki Sayama, "Evolutionary perspective on collective decision making: Evolutionary computation as computational models/tools for social science research", (2010). Conference keynote talk, Conference keynote talk
Bibliography: Presented as the keynote talk at The Japanese Society for Evolutionary Computation Symposium 2010, December 18-19, 2010, Fukuoka, Japan.

Hiroki Sayama, Shelley D. Dionne, Craig Laramee, J. David Schaffer, and Francis J. Yammarino, "Evolutionary perspective on collective decision making", (2010). Conference presentation, Conference presentation
Bibliography: Presented as a poster at The NSF Human and Social Dynamics 2010 Grantees Conference, Arlington, VA, September 27-28, 2010.

Benjamin James Bush, Jeffrey Schmidt, and Hiroki Sayama, "Behavior and centrality in idea exchanging adaptive social networks", (2011). Book, Published
Editor(s): Sayama, H., Minai, A. A., Braha, D. and Bar-Yam, Y. eds.
Collection: Unifying Themes in Complex Systems Volume VIII: Proceedings of the Eighth International Conference on Complex Systems
Bibliography: New England Complex Systems Institute Series on Complexity (NECSI Knowledge Press, 2011), pp.437-438

Hadassah J. Head, Benjamin James Bush, Alka Gupta, Hiroki Sayama, and Shelley D. Dionne, "Network-informed idea selection strategies for electronic brainstorming", (2011). Book, Published
Editor(s): Sayama, H., Minai, A. A., Braha, D. and Bar-Yam, Y. eds.
Collection: Unifying Themes in Complex Systems Volume VIII: Proceedings of the Eighth International Conference on Complex Systems
Bibliography: New England Complex Systems Institute Series on Complexity (NECSI Knowledge Press, 2011), pp.731-733

Hiroki Sayama, "Guiding designs of self-organizing swarms: Interactive and automated approaches
", (2011). Conference keynote talk, Conference keynote talk
Bibliography: To be presented as a keynote talk at the Fourth International Workshop on Guided Self-Organization (GSO 2011), September 8-10, 2011, Hatfield, UK.

Web/Internet Site

URL(s):
http://coco.binghamton.edu/NSF-HSD.html
http://bingweb.binghamton.edu/~sayama/SwarmChemistry/

Description:
First one: Project website
Second one: Swarm Chemistry website (computational model used for some of our experiments)

Other Specific Products

Product Type:

Software (or netware)

Product Description:
We have developed several Java applications that enable interactive evolutionary design of particle swarm patterns as well as data collection and visualization of idea evolution processes. These applications are combined with horizontal touch-screen PCs to facilitate collaborative work among group members.

Sharing Information:
The software is now publicly available on the PI's website.

Product Type:

Software (or netware)

Product Description:
We have developed several versions of Java-based applications that provide a simple, intuitive interface for real-time data collection from a

team discussion. These software applications are used on a touch-screen PC by an observer of the experiment, who can record (1) speakers and topics and (2) what kind of non-verbal cues were shown in the discussion, by pressing buttons on the touch screen.

Sharing Information:

Currently we don't plan to disseminate this software with others, as it is configured for our experiments and not for general use.

Contributions

Contributions within Discipline:

The key findings obtained in this project support our framework that uses evolutionary principles to describe collective decision making. As discussed in our proposal, this research will bring conceptual as well as technical breakthroughs for human and social dynamics studies by shifting the viewpoint from human individuals to discussed ideas and by integrating evolutionary principles and methodologies into the modeling of their dynamics. This will help generate many relevant hypotheses about the dynamics of collective decision making and will therefore bear a significant intellectual impact that will lead to a theoretical advancement from a traditional, individually-focused psychological or social science paradigm to a more dynamic, multilevel, evolutionary paradigm for collective social processes.

Our models have been expanded significantly over the course of the project so that we can include more complex problems spaces, heterogeneous domains of expertise among team members, social network structures of teams, effects of long-term learning, and the co-evolution of social networks and ideas. These model extensions make our framework more directly applicable to real-world collective decision making settings. Our findings provide operationalized, mechanistic explanations of why some teams outperform others and how effective teams are made up and organized.

Contributions to Other Disciplines:

The technical tools developed for and the experimental results obtained in Experiment 3 (Swarm Design) are highly relevant to the field of computational intelligence, especially interactive evolutionary computation (IEC). Our results demonstrate the importance of IEC architecture design and the multiple evolutionary operators for the improvement of evolutionary design. We have coined the term 'Hyperinteractive Evolutionary Computation (HIEC)' for our new IEC framework, and have written and published one journal paper on this topic.

The above contribution was well demonstrated by the fact that the PI was invited as a keynote speaker to The Japanese Society for Evolutionary Computation Symposium 2010 (December 18-19, 2010, Fukuoka, Japan), where he presented an overview of this project and illustrated the potentials of evolutionary computation as computational models/tools for social science research, which was received very positively by computer scientists and engineers.

Our recent computational simulation model of shared mental model formation considers social network structure of a team, which presents a new line of research of recently emerging Network Science. We presented our modeling work at NetSci 2010, CSSS 2010 and INFORMS 2010 and received very positive responses.

Contributions to Human Resource Development:

With support from this NSF award, we are training three graduate students (Benjamin Bush, Chanyu Hao and Hadassah Head). They are all from underrepresented groups (Hispanic and females). We hope that they will eventually contribute to various STEM and organizational/management science fields, and also better represent in academia the groups they belong to.

We also had several undergraduate experimental assistants participate in our experiments, which has contributed to the development of their research and management skills.

Contributions to Resources for Research and Education:

We plan to develop an online database that disseminates the raw data of team discussion processes obtained in Experiments 4/6 (Liver Transplant Patient Ranking Experiments) so that other researchers can examine and explore our experimental results.

Contributions Beyond Science and Engineering:

Our framework and results will help enhance, improve and gain insights to our understanding of managerial decision making and its effectiveness. This will be a major contribution of our project to the public welfare since organizational management has been a significant challenge in today's complex society.

Conference Proceedings

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Conference