Annual Report for Period: 09/2009 - 08/2010
Submitted on: 06/02/2010
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 for this project. He is funded from this NSF award. He helps the PI's develop computational models, conduct computer simulations, set up and run human-subject experiments, develop data collection software, and write manuscripts.

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 will help us develop experimental systems (software & hardware).

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)

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

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.

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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.

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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.

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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.

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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.

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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.

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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.

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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-5 personality test before or after the experiments so that we can collect their personality data as well.
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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:

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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.

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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.

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.

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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.

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 two graduate research assistants for this project, Chanyu Hao from China and Benjamin Bush from California, who started in Fall 2009. They are both from underrepresented groups (Hao is 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 enrolled in the Ph.D. program in Systems Science at Binghamton University, and Sayama supervises his work. Both 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 plan to file 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.

In addition, we have two other graduate students participating in this project, Andra Serban (Management) and Thomas Raway (Biomedical Engineering). They are financially supported by their respective Schools. Dionne and Sayama supervise Serban and Raway's Ph.D. work, respectively. Serban helps part of our human subject experiments and data analysis. Raway helps software development for experiments.

Moreover, the experiments we conducted in class produced educational benefits on students who participated in them. The experimental results were analyzed and fed back to the students, either immediately or in the following week, so that they could understand the effects of experimental variables on the outcomes of collective decision making. The positive educational impact of those experiments was observed in the student 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.

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. , vol. , (2010). Accepted,

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. , vol. , (2010). Accepted,

Benjamin James Bush and Hiroki Sayama, "Hyperinteractive evolutionary computation", IEEE Transactions on Evolutionary Computation, p. , vol. , (2010). Submitted,

Hiroki Sayama, Shelley D. Dionne, and Francis J. Yammarino, "Evolutionary perspective on group decision making", TBD, p. , vol. , (2010). 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. , (2010). 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

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:

We are currently in the process of publishing a technical journal article that will disclose the details of the product. Once the article is published, the software will be released publicly on the PI's website under free software licenses.

Product Type:

Software (or netware)

Product Description:

We have developed a Java-based application that provides a simple, intuitive interface for real-time data collection from a team discussion. This software is used on a touch-screen PC by an observer of the experiment, who can record who said what 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 the first year of this project support our preliminary results obtained in computer simulations, which greatly enhances the validity of our model 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.

In the second year of the project, we further expand our conceptual models so that we include more complex problems spaces, heterogeneous domains of expertise among team members, social network structures of teams, and the effects of long-term learning. These model extensions make our framework more directly applicable to real-world collective decision making settings. Our findings from computer simulation models 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 one journal paper on this topic.

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 and received very positive responses.

Contributions to Human Resource Development:

With support from this NSF award, we are training two graduate students (Benjamin Bush and Chanyu Hao). They are both from underrepresented groups (Hispanic and female). 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 Experiment 5 (Liver Transplant Patient Ranking Experiment) 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:

Organizational Partners

Any Conference