Annual Report for Period: 09/2008 - 08/2009
Submitted on: 06/01/2009
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

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

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)

23 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)

23 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)

21 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, based on which we plan to write a journal paper as well in the near future. The results of Experiments 1 and 2 were also quite promising, but the sample size was too small to reach statistically significant conclusions. We will conduct the same set of experiments in Fall 2009 to collect more data and improve statistical significance of the results. Moreover, we are currently designing the 'Phase 2' large-scale experiments, which will take place in Fall 2009 as well.

These experiments produced educational effects 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 and also in the fact that many students designed and conducted similar experiments for their final research projects.

On the computational modeling side of the project, 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.

Findings:

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.

Training and Development:

Through participation in this 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.

So far we have not been able to hire graduate research assistants for this project, because the date when the fund became available (September 8, 2008) was too late to hire ones for FY 2008-2009. Over the past year, we searched, nationally as well as internationally, for good candidates for those positions, and have recently selected Chanyu Hao from China and Benjamin Bush from California as our graduate research assistants starting 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 will enroll in the Ph.D. program in Management at Binghamton University, and Dionne will supervise her work. Bush will enroll in the Ph.D. program in Systems Science at Binghamton University, and Sayama will supervise his work. Hao already arrived at Binghamton in Spring 2009 and has taken a graduate course on computational modeling taught by Sayama.

Because we could not hire them in the first year, 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.

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

Books or Other One-time Publications

Shelley D. Dionne, Hiroki Sayama, and Francis J. Yammarino, "Evolutionary perspective on group decision making: A within- and between-groups simulation", (2009). manuscript submitted to journal, Submitted
Bibliography: Submitted to Organizational Science

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, Accepted
Bibliography: Proceedings of the 2009 Annual Meeting of the Academy of Management, forthcoming

Web/Internet Site

Other Specific Products

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.

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.

Contributions to Human Resource Development:

Not applicable, as we have not hired any graduate research assistants yet.

Contributions to Resources for Research and Education:

N/A

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 Journal

Any Web/Internet Site

Any Product

Any Conference