

Dynamic Decision Making Laboratory

Carnegie Mellon University

A Note from Coty

2013-2014 was a busy academic year full of new challenges.

We started the academic year with the lab's participation in a new large research consortium, the Cyber-Security Collaborative Research Alliance (CRA), involving academia, industry, and government: <http://www.hss.cmu.edu/pressreleases/pressreleases/ddml.html>

This CRA brings together a group of researchers to develop fundamental theories and models of cyber-security phenomena, including aspects of human attackers, defenders, and end users. Our lab plays an important role in building models of human behavior and decision making in the context of cyber-security. Our knowledge and years of research in decision making in dynamic tasks will be integrated into operational models of cyber-security. We aim to provide the basic science of human decision making in this context so that in the future, new cognitive-aware algorithms and models can be developed to maintain the safety of our cyber-space. This is a collaborative effort with many colleagues at CMU (Lorrie Cranor, Lujio Bauer, Nicholas Christin) and outside of the university.

Several of our ongoing research grants got renewed, including our grant from the Army Research Office on Cyber-Situation Awareness; the National Science Foundation grant on the Decisions from Experience phenomena with Instance-Based Learning models; the Qatar National Research Fund grant in collaboration with Professor Iliano Cervesato (CMU-Qatar) to study inferential processing and decisions in relational data sets; and a grant from the Army Research Laboratories, the Network Science-Collaborative Technologies Alliance (NS-CTA), to study trust and scalable recommendation and information sources.

As a result of the new CRA, we opened a search for a new post-doctoral fellow. Frederic Moisan, Ph.D. in Computer Science and Economics, from the University of Toulouse, Toulouse, France, joined our team in February 2014. This year was also the last year for several of our post-doctoral fellows, including Noam Ben-Asher (Ben-Gurion University, Israel), Katja Mehlhorn (University of Groningen, Netherlands), and Shikhar Kumar (Arizona State University). Katja has a position at University of Groningen, Noam accepted a research position at the Army Research Laboratory, and Shikhar accepted a position back at Arizona State University. As a result, we were also joined by Nathan Ashby, from Universitat Erfurt and Max Planck Institute in Erfurt, Germany in April 2014.

We also have new visitors from many parts of the world: Sukrit Gupta (PEC University of Technology, India), Angela Wu (Sun Yat-Sen University, China), Robert ten Brincke (ETH, Switzerland), and Hassen Ghabiri (ENSI, University of Manouba, Tunisia). All members of the lab have contributed in many ways to the research progress with new ideas, analyses, papers, and presentations in conferences and in laboratory meetings. Thanks to all!

I invite you to browse our new publications and new collaborations. During this year, we have made considerable progress in our understanding of the search process and the use of experience in dynamic situations. We have also made progress toward extending our Instance-Based Learning Model of individuals to social dilemmas and multi-person, group decision making.

Many workshops and conferences have contributed to developing interesting new ideas this year. But of special note is the "Learning, Bounded Rationality, and Decisions" workshop in Israel, which brought an amazing group of researchers

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interested in learning and bounded rationality for talks, conversations, and fun. Here is a photo of me visiting Sharoni Shafir's "bee lab" on our way to the Dead Sea (photo credit: John Sterman).

Finally, I would like to take the opportunity to thank all of you, the close friends of the DDMLab from all over the world, who have contributed to our ideas and development in many ways. We are looking forward to making 2014-2015 another successful and productive academic year with your help and support!

Coty Gonzalez
 Founding Director, Dynamic Decision Making Laboratory



News From Our Members

Congratulations to **Shikhar Kumar**, who started as a Post-Doctoral Fellow in the School of Government and Public Policy at the University of Arizona Tucson; **Katja Mehlhorn**, who is teaching at the Department of Artificial Intelligence at the University of Groningen in the Netherlands; and **Noam Ben-Asher**, who started as a researcher at the Army Research Laboratory. We'd like to thank them all for their contribution and to wish them the best in their future endeavors.

Welcome to **Frederic Moisan** and **Nathan Ashby**, our newest Post-Doctoral Fellows this year. Fred joined us from the [University of Toulouse](#), where he earned his Ph.D. in Computer in computer science and economics. His current research interests include combining game theory with logic, behavioral experiments, cognitive modeling, and simulation to study the underlying principles of human rationality and cooperation in complex social interactions.

Nathan joined us from the [University of Essex](#) in April of 2014. In 2010, he joined the Max Planck Institute for Research on Collective Goods as a research fellow. He subsequently earned his Ph.D. in 2012, with his thesis focusing on the role of attention and memory in valuation judgments and choice behavior.

This year, we were joined by four visiting scholars from abroad.

Sukrit Gupta was an undergraduate student in the Department of Computer Science at [PEC University of Technology](#), India. He spent five months doing a research internship at the lab. We wish him the best of luck in future endeavors.

Angela Wu is an undergraduate student from [Sun Yat-Sen University](#) in Guangzhou, China who is pursuing her bachelor's degree in Information Security. She is spending three months lending the lab some of her programming expertise and gaining more research experience.

Robert H. W. ten Brincke is a Ph.D. candidate from the Chair of Decision Theory and Behavioral Game Theory at [ETH Zurich](#), Switzerland. His current research focuses on individual risky decision making as well as risky decision making in competition (e.g. game theory) and draws on formal mathematical modeling and laboratory experiments.

Hassen Ghabiri is an Assistant Professor at [ENSI](#) (University of Manouba) in Tunis, Tunisia. He will be spending his one-year tenure as a Fullbright Scholar visiting with Carnegie Mellon.

Congratulations to Coty and Mike, who were two of the authors on a paper that received the **Best Paper Award** at this year's *IEEE Conference on Cognitive Methods in Situation Awareness and Decision Support*.



Group photo, Noam's farewell lunch, August 2014

New Research

Below is a summary of research highlights during 2013-2014:

From Frederic Moisan

An ongoing project consists of investigating how people can effectively defend themselves when faced with a malign opponent that is motivated to maximize profit at the cost of others. We conduct experiments involving a very simple security game that is rather difficult to play optimally. While we primarily observe that people do not behave according to classical economic theories but instead largely rely on their own experience, the main purpose of this study is to provide us with more insights into people's main weaknesses in these situations and how they could learn to protect themselves more efficiently.

In another line of research, we have initiated collaboration with researchers from ETH Zurich to study the existing relationship between individual differences and the dynamics of cooperation within dyadic interactions. For this purpose, we combine the concept of *Social Value Orientation* (SVO) with the use of a well-known game theoretic paradigm: the iterated Prisoner's Dilemma. Our general goal is to investigate what combinations of (different) SVOs within a pair of individuals can promote/hinder the emergence of cooperation within that pair. In

the context of this project, we also aim at developing our own experimental platform to run web-based experiments that involve real-time interactions between multiple human participants.

From Jason Harman

The past year has been very exciting with several projects culminating in high impact publications and presentations. Three projects are most notable: **1)** In December, I received a small grant from the PNC Center for Financial Services Innovation at Tepper to study risk taking in retirement savings decisions. The grant allowed me to hire a programmer and run exciting new experiments in a more applied context. More importantly, the grant has allowed a burgeoning relationship between PNC and the DDMLab. As a result of our collaboration, I was asked to develop and perform educational videos for PNC's educational website, [Achievement Sessions](#). The videos should go live in November. **2)** An ongoing collaboration between our lab and faculty at the University of Calgary Hayskayne's School of Business has resulted in three manuscripts, the first of which should be in press soon at the *Journal of Operations Management*, one of the top journals in management. **3)** Our collaboration with John O'Donovan and Tarek Abdelzaher has extended IBL to the domain of recommendation systems with a paper accepted to the Proceedings of ACM RecSys 2014.

New Research (Cont'd)

From Nathan Ashby

I just started in the lab this April, but have hit the ground running. So far Prof. Gonzalez and I have conducted three lines of research that are either already under review or in preparation. In our first set of studies, we examined the effects of variability in experience on adaptation to changes in the choice environment. Our second set of studies explored the influence of descriptive information on the amount of exploration and the type of exploration strategy employed. While our most recent investigated the effects of increasing the number of options to choose from on the preference construction process and the influence of individual differences in cognitive abilities (e.g., working-memory) and approach (e.g., sensation seeking and risk attitudes). The common goal underlying each of our investigations is to gain a greater understanding of the basic cognitive processes involved in learning from experience. We plan to expand this work in the coming year, while additionally trying to construct a more general model of decision making which can predict both experiential and descriptive choice.

From Mike Yu

Over the past year we've expanded our research focus on trust in several different directions. Extending our previous research with Muniba Saleem, we've investigated how trust evolves over multiple plays of the Trust Game with different partners, finding changes in trusting behavior that reflect how players perceive the game rather than how they perceive their partner. Using a similar design as that study, we're currently investigating whether inducing trusting behavior in the earlier rounds of the trust game can get first movers to adapt more quickly than asking players to make their own choices.

Branching off into other directions, we've developed a working model of IBL in R that is currently being used to test how different inputs into the base IBL model can return different results — with a particular focus on what inputs may lead to behavior more consistent with human cooperation in a number of different games (including Diner's Dilemma and Prisoner's Dilemma). We're investigating changes in when and how often the model receives feedback, as well as how utility is parsed before entering the IBL model. Finally, in collaboration with UCSB, ARL, and SA Technology, we've been working on several projects that investigate the intersection of user interfaces, situation awareness, and trust.

From Don Morrison

We are creating PyIBL, a library of reusable Python code to quickly and easily create Instance-Based Learning models. Details, including documentation and instructions for downloading and installing the latest version, are available at <http://pyibl.ddmlab.com>.

From Pingtao Yi

We are examining the issue of “wisdom of crowds.” It is of particular interest to investigate how far humans can go in exploiting the wisdom of crowds.

We developed a novel aggregator to process the averaging of group estimates, which is far different from existing classical aggregators. Based on both simulation analyses and empirical data, it has been verified that the new method can often reach incredible levels of tracking or even capturing the real truth. This program is in process. We will release the full study report in the near future.

From Eric Qi

Collaborating with Coty, we are now exploring what are the key factors of decision making in people's understanding of system dynamics, i.e., stock and flow structure. After a cross-national experiment with American and Chinese participants, we find that mathematical skills and familiarity with context domain are correlated with people's performance in stock and flow tasks. Moving forward, we are investigating the role of visual perception and seeking to bridge the divide between decision making ability under system dynamics and problem solving ability in real life.

From Angela Wu

Inspired by past research in CyberSA decision making, we are trying to build a complete model with loss evaluation to simulate the learning and decision-making process of a security analyst. We have built an initial computational model based on IBLT to analyze cyber-attacks at both instance- and scenario-level, and provide knowledge and feedback with synthetic loss evaluation. Moving forward, we will continue to improve the model and investigate how an analyst can learn faster and make better choices in specific cyber situations.

Recent Publications

In the past year, three articles authored by members of the DDMLab and our collaborators were published in the *Journal of Behavioral Decision Making* and the *Journal of Economic Psychology*. An additional four journal articles and a book chapter are currently in press.

For a full list of publications, please see the publications page on the lab's website at <http://www.hss.cmu.edu/departments/sds/ddmlab/papers.html>.

Conference Proceedings

Here are some papers that appeared in conference proceedings recently:

- Ben-Asher, N., Rajivan, P., Cooke, N., & Gonzalez, C. (2014). Studying the dynamics of cyber-war through instance-based learning and multi-agent modeling. Presented at the 4th Annual Midwest Cognitive Science Conference. May 31, 2014. Wright State University. OH.
- Lejarraga, T., Lejarraga, J., & Gonzalez, C. (2014). Decisions from experience: How groups and individuals adapt to change. Presented at the 74th Annual Meeting of the Academy of Management. August 4, 2014. Philadelphia, PA.
- Onal, E., Schaffer, J., O'Donovan, J., Marusich, L., Yu, M. S., Gonzalez, C., & Höllerer, T. (2014). Decision-making in abstract trust games: A user interface perspective. In *Proceedings of the 2014 IEEE International Inter-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support (CogSIMA)* (pp. 21-27). IEEE.
- Onal, E., Schaffer, J., Schaffer, J., O'Donovan, J., Marusich, L., Yu, M. S., Gonzalez, C., & Höllerer, T. (2014). Trust and consequences: A visual perspective. In R. Shumaker & S. Lackey (Eds.), *Virtual, augmented and mixed reality: Designing and developing virtual and augmented environments* (pp. 203-214). Heidelberg: Springer International.

Presentations & Invited Talks

Coty gave the following workshops and invited talks during 2013-2014:

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| September 18, 2014 | <i>Decision making in dynamic systems</i> . International Workshop on Decision Making and Recommender Systems 2014. Bozen-Bolzano, Italy. |
| June 23, 2014 | <i>Human decision making in a cyber world: Some research challenges</i> . 13th Annual Workshop on the Economics of Information Security. Pennsylvania State University |
| April 23, 2014 | <i>Human decision making in cyberspace</i> . NSF SaTC CyberSpace 2015 Workshop (Cyber 2025); Panel on Social, Behavioral, and Economic S&T. Washington, DC. |
| March 14, 2014 | <i>CyberWar Game: A paradigm for understanding new behavioral challenges for Cyber War</i> . Workshop on Cyber Warfare: Building the Scientific Foundation. George Mason University, Fairfax, VA. |
| February 21, 2014 | <i>Unification and simplification dilemma of cognitive architectures</i> . Workshop on Problem Solving and Dynamic Decision Making (EPSDDM). University of Essen, Essen, Germany. |
| February 20, 2014 | <i>Dynamic decision making: Learning processes and cognitive challenges</i> . Workshop on Problem Solving and Dynamic Decision Making (EPSDDM). University of Essen, Essen, Germany. |
| January 25, 2014 | <i>Dynamic decision making: Learning processes and cognitive challenges</i> . Learning, bounded rationality and decisions. Three related workshops and a winter school. Israel. |