



Dynamic Decision Making Laboratory

ISSUE 10

FALL 2018

Carnegie Mellon University

Annual Summary from Coty—Founding Director, DDMLab

Dear Friends and Collaborators:

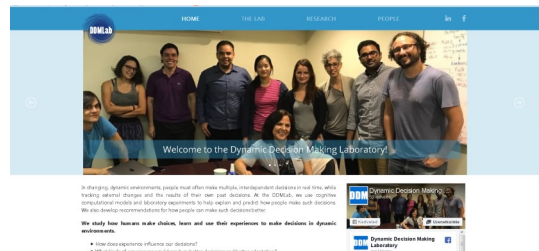
Another academic year has come to an end (2017-2018), and here we reflect on the research activities of the DDMLab during this year, while we start the new academic year (2018-2019). Thank you for letting us update you!

This past year we saw much movement in terms of lab members, travel, and grants. We are after all a *dynamic decision making* laboratory!

About grants, there were several submissions and some of the current grants have transformed in different ways. First, we are grateful for the support provided by the **Army Research Office (ARO)**, Network Sciences program. This grant has helped us in advancing our work on group and network learning, and on the escalation from individual learning models to group learning. Second, we have concluded a first year of **ARO's Multidisciplinary University Research Initiative (MURI)** program on Cyberdeception. This program, through our key collaborations with University of Southern California, University of Arizona, University of Texas at El Paso, and others, has advanced our ideas on signaling, behavioral and computational game theory, and cognitive modeling and their applications to cyber security. Third, we continue to have the support of the **National Science Foundation (NSF)** Decision Risk, and Management Science program. In our last year of this grant we are trying to wrap up a very successful program on the integration of descriptive and experiential decisions, through multiple manuscript submissions. Fourth, during last year we continued to be an integral part of the **Army Research Laboratories (ARL)**'s program on cybersecurity; the Collaborative Research Alliance (CRA). We led and continue to maintain an active research program on all the socio-cognitive aspects of cybersecurity for the CRA. Last, but not least, we are grateful for the support from the **Defense Advanced Research Projects Agency (DARPA)**, which through the SocialSim program has made possible the collaboration and interaction with our long-term collaborator Christian Lebiere in the Psychology Department as well as with new people in many other universities.

Many manuscripts that originated in past years, somehow managed to see the "light" this year (nothing wrong with that!). The new publications are largely centered on the theme of the socio-cognitive aspects of cybersecurity. Notably, our work on phishing and deception was popular this year. See a complete list of journal papers on our web page: www.cmu.edu/ddmlab.

By the way: we have a new, more modern and improved web site!!! Visit us!! Orsi Kovacs our incredible research associate and lab manager has done an amazing job!! I hope you will like it.



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In addition to our published journal articles, this year we also published several new manuscripts in conference proceedings, and we continue to attend multiple conferences (Cognitive Science, Human Factors, and others).

This year was particularly active with multiple conferences, key note lectures, and invitations to be part of multiple research initiatives. The academic year started with a fantastic visit to Denmark: in Odense, I gave a talk at the Danish Institute for Advanced Study (DIAS) and the University of Southern Denmark; in Aarhus, I gave another talk at the Interactive Minds Centre. Here is a picture of me with Carsten after Street Food dinner at Aarhus. I had a lot of fun in Denmark and I learned a lot from this visit. Thanks to Davide, Thorbjorn, Jacob, Carsten, and Oana. I loved Denmark!

Another highlight of this academic year was a fantastic workshop organized by my friend Mirta Galesic at the Santa Fe Institute. It was full of stimulating ideas in a very interdisciplinary and relaxed research environment.



A third highlight of this academic year was my visit to INSEAD for the Theoretical Organization Models (TOM) meeting.



This conference took place at the wonderful INSEAD campus of Fontainebleau, France. They gave me the honor of being a "Distinguished Speaker". It was great to see Jerker, Phanish, Hazhir, Chengwei, and Thorbjorn!

Teaching was a good experience during the Spring 2018 Semester. I continue to try to find the best ways to teach the mix of concepts on decisions from experience, behavioral science with micro-worlds, cognitive modeling, and system dynam-

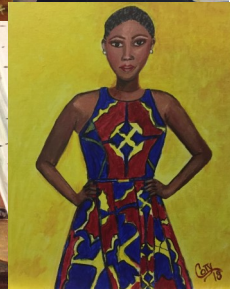
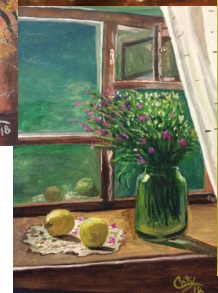
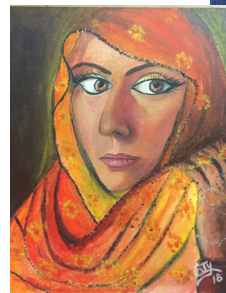
ics concepts and models all in one course, while making it practical and useful to the students. Not easy.

Finally, to end on a personal note, I continue to enjoy biking and painting on my weekends (when I can!).

These pictures show some of my favorite paintings from this year. I used water colors and acrylics. I haven't used oil for some time, I might try that again this year, or learn more of oil pastels, for a change.

I hope you enjoy this newsletter. Thank you so much for reading our update, and thank you so much for contributing to our efforts in so many ways!!

We look forward to a new year full of interesting research, surprises and new adventures. Let's all work to make this a better world.



2018

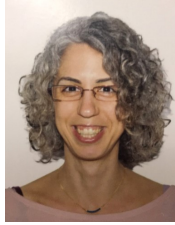
Coty

News From Our Members

Farewell



Dr. Prashanth Rajivan December 2015 - August 2018. Ph.D. in Applied Cognitive Science from Arizona State University, AZ. Dr. Rajivan took a faculty position at the Industrial and Systems Engineering Department at University of Washington, WA.



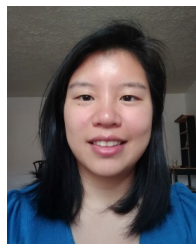
Dr. Efrat Aharonov, August 2016 - August 2018. Ph.D. in Psychology, Ben-Gurion University of Negev, Israel. Dr. Aharonov returned to Israel as a researcher in industry.



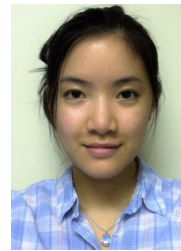
Sabina Sloman August 2017 - August 2018. B.A. in Economics at McGill University in Montreal, Québec. Sabina continues to work on her Ph.D. in the Social and Decision Sciences Department at Carnegie Mellon University.



Germán Lenin Dugarte Peña visited us from September to November 2017. He is a Ph.D. student in Computer Science and Technology at Carlos III University in Madrid.



Emily Ho visited us from August to November 2017. She is a Ph.D. student from Fordham University's Psychometrics and Quantitative Psychology program.



Nalyn Sriwatanakomen May 2016-July 2018. Nalyn concluded her work in the lab in order to focus on her application to graduate school.

Welcome New Members



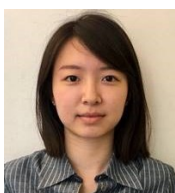
Palvi Aggarwal completed her Ph.D. in the area of cyber security at the Indian Institute of Technology Mandi, India. She joined the lab in September, and she is interested in exploring experiential decisions made by hackers and analysts in cyber-security games involving deception.



Korosh Mahmoodi completed his Ph.D. in Physics, University of North Texas, Center for Nonlinear Science. He joined the lab as a post-doctoral fellow this fall. His research interests are Artificial Intelligence, Computational Social Science and Complex Networks.



Kuldeep Singh, Ph.D. joined us this September as a visiting researcher. He completed his Ph.D. in Adhoc Network Security at Thapar University, India and his main research interests are network security and ad-hoc networks.



Qiao Shen is currently a sophomore double majoring in Psychology and in Economics and Statistics at Carnegie Mellon University. She joined the lab as a visiting student this fall.

Research Updates from Lab Members During 2017-2018



FROM PRASHANTH RAJIVAN

In the past year, I continued to work on multiple projects from previous years. I am particularly pleased to have published many of these efforts. Our data collection effort with the Mid-Atlantic Collegiate Cyber Defense Competition (MACCDC) in collaboration with Norbou Buchler at the Army Research Labs was published in the *Journal of Computers & Security*. In this paper, we discuss key team-level factors that determine the success of cybersecurity teams - Functional specialization within a team and an adaptive leadership approach to different security defense sub-tasks could be important predictors of overall performance.

Also, our book chapter summarizing work on human factors in cybersecurity was published in the book titled *Human Factors and Ergonomics for the Gulf Cooperation Council: Processes, Technologies, and Practices*.

Our work on the phishing project has resulted in two publications - one in the *Frontiers of Psychology* and the other in the *Journal of Computers in Human Behavior*. Through these papers, we show that certain kinds of deception strategies are more likely to persuade end-users to respond. We have also gained insights into adversarial personalities that lead to higher divergent thinking when writing phishing emails and insights into end-user personalities that are susceptible to phishing attacks. We were also able to publish our work on Adversarial Machine Learning in the Cognitive Science Society conference this year. In the paper, titled "Human Decisions on Targeted and Non-Targeted Adversarial Samples", we take the first step into what can be an important innovation in cognitive science: we analyzed human's judgments and decisions when confronted with targeted (inputs constructed to make a ML model purposely misclassify an input as something else) and non-targeted (a noisy

perturbed input that tries to trick the ML model) adversarial samples. Our findings suggest that non-targeted samples interfered more with human perception and categorization decisions than targeted samples. We are currently working on additional experiments to extend this work. Finally, my collaboration with Efrat and Ido Erev is reaching the final publication stage. We will soon be publishing our work in the *Journal of Computers in Human Behavior*. In summary, the past year was very busy, educational, exciting, collaborative and productive. Although, this is my last year in DDMLab, I am excited to start a new position as a Research Professor at University of Washington in Seattle! I will greatly miss all my fellow DDMLabers.

FROM EFRAT AHARONOV-MAJAR

During the past year, I worked on protective decisions in the cybersecurity domain. We submitted one paper on the effect of temporal patterns of security failures on engagement in data backups (Ben-Asher, Aharonov-Majar, and Gonzalez). We wrote two more papers in collaboration with Prashanth Rajivan concerning repeated security updates. One of the papers addresses the effect of update cost and experience on the timing of installing security updates (Rajivan, Aharonov-Majar, Gonzalez, and Erev). The second research project addressed the impact of cost variability pre-experience choice on implementing security updates early on. In a third project, we collaborated with researchers from the Army Research Laboratory and from UTEP on human learning in a 2-person deception game, using principles from game theory and decisions from experience models (Gutierrez, et al.).

Research Updates Continued

In a second research venue, I worked on extending models of decisions from experience to social networks. We continued to explore platforms and methodologies for running online group experiments. Currently, we are writing two papers. One examines the effect of payoff variability on groups' decision making and compare it to individual decisions under payoff variability (Aharonov-Majar, Gonzalez, Erev, & Morrison). The second research examines decisions in a social dilemma, exploring the effect of feedback and order on decisions to contribute or make monetary requests from a joint pool (Aharonov-Majar, Budescu, & Gonzalez). I enjoyed working on all the different projects. I am writing this blurb as I complete two years in the lab, and leaving this "home away from home" to seek new adventures.

FROM CRISTOBAL DE LA MAZA GUZMAN

In the past year, I finished my dissertation titled "Preference learning for policy analysis". In policy analysis, individual preferences are used to measure welfare across the population. Nonetheless, individuals are heterogeneous in both what they want or their preference content, and whether they know what they want or their preference structure. Prior work typically restricts preference heterogeneity analysis to differences in preference content. My dissertation explores the intersection of public policy analysis with preference heterogeneity along these two dimensions. We present a general framework for analyzing and discovering preference content and structure from choice data. Our framework extends welfare measurement to fully account for preference heterogeneity and can help to better understand the welfare impacts of new policies for sub-populations. As heterogeneity in preference can be related to judgment structure, we first study how heterogeneity in preference content is related to heuristic judgment. We establish the relationship between judgment and choice for cumulative flood risks. Second, we propose a model that can directly determine differences in both preference content and structure for individual decision makers empirically using graph matching methods. Finally, we measure heterogeneity in preference content across sub-populations. We develop and test a method to uncover relevant sub-populations in a choice model automatically using machine learning tools. We illustrate the approach discovering relevant socioeconomic covariates in a recent and real decision facing the Chilean government about the environmental impacts of electricity generation. Our framework can help to design policy interventions tailored to the heterogeneous preferences of the public.

FROM PEGAH FAKHARI

I joined the lab less than a year ago, but in this period, I was able to work on three different projects. In the first project, the DEED project, I investigated how people combine information from experience and description to make their final choices. I found that choice ecology and more specifically estimated/ or perceived variance is the key to determine how people are more likely to choose certain kind of options which could generate DE-gap. In the variance framework, we can explain the results from Glockner's study on reduced, certain and non-reduced gambles.

The second project is on the rock-scissors-paper game. Unlike the prisoners' dilemma, the RSP game is a competitive game where players do not cooperate with each other. A player should generate a random (like) behavior and learn about any existing pattern in the other player's behavior. So, two tasks should be addressed: detecting and generating random behavior. I showed that an IBL model (unlike the Bayesian updating model) with hyperbolic discounting function is able to account for the data dynamically.

In the third project, I designed multiple experiments to investigate how confident people are in sampling paradigms and decision from experience. The first goal is to test whether the stopping criteria in the sampling paradigm relates to how confident participants are in their estimations. Our second goal is to examine whether forced vs. free sampling has a different effect on confidence rating. Finally, our third mission is to study the effect of sampling policy on participants' choice and confidence rates. We are in the final stage of implementing the code and will start collecting data soon.

FROM DAVID HAGMANN

I have spent the past year at the University of Pennsylvania on a Doc.Mobility fellowship from the Swiss National Science Foundation. My main project (with Alex Rees-Jones) looked at whether people are avoiding information related to income taxes and whether that undermines the effectiveness of tax incentives. We find, in a lab experiment, that people are indeed avoiding information about the taxes we impose on them as part of the experiment -- and that this leads them to donate less to charity than when we make transparent what the incentives are. In a second project with Katy Milkman and Angela Duckworth, I look at whether providing participants with more frequent performance feedback on test questions can lead

Research Updates Continued

them to stop answering questions sooner. Online learning platforms and programs could provide learners with immediate feedback, which previous work suggests helps students learn. However, in an earlier project with Coty (and lab alumnus Jason Harman), we found that immediate feedback can lead to less exploration in risky choice: people are discouraged by unfavorable outcomes. This is the beginning of an effort to extend the work into the domain of education, where students often can choose how much to practice, and other performance tasks (e.g. exercising). I am excited to return to Pittsburgh and to the lab in the Fall to finish my dissertation.

FROM DON MORRISON

Much of my work this past year has been building web based experiments for use in a variety of projects by Coty, Efrat, Pegah and Nalyn, for use over MTurk. These have largely been built on top of socket.io and node.js. This has several advantages over the older HTTP-focused way we have built web deployed experiments in the past: the results are much more like a desktop application, giving a better user experience; and we get immediate, explicit notification of when a user closes their browser or loses the network connection. For multiple player experiments, we have been using a larger framework, nodeGame, that is built on top of socket.io and node.js, and is the work of Stefano Ballietti, who recently joined Microsoft Research from Northeastern University, and which supplies several facilities addressing the many difficulties multiple, coordinating participants present in web based applications.

I have also continued to build models for a variety of projects in our Python based IBL framework, PyIBL: pyibl.ddmlab.com.

FROM ERIN MCCORMICK

This past year I have continued to work on my dissertation, which has two components. The first investigates human adaptation to continuous, gradual, exogenous changes in the probabilities and payoff values of choice outcomes in decisions from experience (work that is part of a manuscript with Coty and Sam Cheyette, former lab member and current graduate student at University of Rochester). We find that a previously neglected factor in dynamic choice environments (the direction or trend of change) influences the success of adapting in such dynamic environments, in conditions of both partial and full feedback about out-

comes. The second part of my dissertation proposes to investigate how decision makers adapt to time constraints on their decision process (work advised by Coty and Stephen Broomell, another faculty member in the Social and Decision Sciences). This project seeks to systematically test whether certain changes in the decision process should and do allow decision makers to adapt to constraints on how long they have to make their decisions, and is anticipated to have implications for testing theories of time-constrained decision making and predicting how decision processes change under time constraints.

FROM SABINA SLOMAN

This year, I worked with Coty to try to better understand how people learn and problem solve in networked environments. We have been analyzing experimental data collected and published by Mason et al. (2008) in which participants attempted to maximize payoffs in environments that vary in complexity and connectedness. We presented our work at a workshop on social learning at the Santa Fe Institute. We are currently working with Robert Goldstone from Indiana University to see what this data can tell us about how the difficulty of a problem and degree of exposure to information from others affect how and whether people choose to explore a problem space or exploit known solutions.

FROM ORSI KOVACS

I started as a lab manager last November and in the past year, I worked mainly on the lab's and Coty's personal website design and implementation along with my lab managerial responsibilities.

I also worked on the cyber-deception project in collaboration with Coty, Christian Lebiere, Don Morrison and Nancy Cooke from Arizona State University. A version of the liar's dice game is under development to investigate how different deception strategies affect human decision making in a simulated online environment. I implemented a simple deception binary choice game in Qualtrics with which Coty and I are planning to explore how cognitive biases influence human's decision making and interact with different deceptive signaling strategies.

Adventures During 2017-2018



During my visit to University of Heidelberg, Psychology Department with Joachim Funke and Helen Fischer



System Dynamics conference, Iceland



Farewell party for Efrat and Prashanth



Recent Publications

In the past year, eight journal articles and book chapters authored by members of the DDMLab and our collaborators were published, including pieces in journals such as the *International Journal of Human-Computer Studies*, *Journal of Economic Psychology*, *Computers in Human Behavior*, *Computers and Security*, *Frontiers in Psychology* and the *Journal of Behavioral Decision Making*.

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

Some Recent Publications in Conference Proceedings (available upon request):

- Gutierrez, M., Kiekintveld, C., Aharonov, E., & Gonzalez, C. (2018). Human Learning in the Multi-Armed Bandit with Independent Support. First International Workshop on AI and Computational Psychology: Theories, Algorithms and Applications. July 14-15, 2018, Stockholm, Sweden.
- Harding, S M., Rajivan, P., Bertenthal, B. I., & Gonzalez, C. (2018). Human Decisions on Targeted and Non-Targeted Adversarial Samples. *40th Annual Meeting of the Cognitive Science Society (CogSci 2018)*. July 25-28, 2018, Madison, WI.
- De La Maza, C., Davis, A., Gonzalez, C. & Azevedo, I. (2018). A graph-based model to discover preference structure from choice data. *40th Annual Meeting of the Cognitive Science Society (CogSci 2018)*. July 25-28, 2018, Madison, WI.
- Cranford, E A., Lebiere, C., Gonzalez, C., Cooney, S., Vayanos, P., & Tambe, M. (2018). Learning about Cyber Deception through Simulations: Predictions of Human Decision Making with Deceptive Signals in Stackelberg Security Games. *40th Annual Meeting of the Cognitive Science Society (CogSci 2018)*. July 25-28, 2018, Madison, WI.

Some of the Invited Talks

- 2018 August 7. *Stock & Flow Failure: Correlation Heuristic and Valence Effects*. Plenary talk. 36th International Conference of the System Dynamics Society, Reykjavik, Iceland, August 6-10, 2018
- 2018 June 29-30. *Scaling up models of individual learning to organizational learning*. Key Note lecture. Theoretical Organization Models (TOM) conference. INSEAD Fontainebleau, France.
- 2018 May 24. *CyberDeception*. Security & Human Behavior Workshop. Carnegie Mellon University, Pittsburgh, PA.
- 2018 May 7. *Human Decisions on Targeted and Non-Targeted Adversarial Samples*. 2nd. ARO/IARPA Workshop on Adversarial Learning. University of Maryland, College Park, MD.
- 2018 April 16. *Scaling up models of decisions from experience: From individuals to networks*. Workshop on Integrating Different Perspectives on Social Learning. Santa Fe Institute. Santa Fe, NM.
- 2017 October 30. *The Psychology of Deception in the Cyber World*. First International Workshop on "Cyber Deception and Defenses", Dallas, Texas.
- 2017 September 22. *Adaptation to Change*. Science At Home. Department of Physics and Astronomy. Aarhus University, Aarhus, Denmark.
- 2017 September 20. *Adaptation to Change*. Danish Institute for Advanced Study (D-IAS), University of Southern Denmark. Odense, Denmark.



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2018 NEWSLETTER!

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