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Jonathan Gratch, Stacy Marsella and Peter Carnevale

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The objective of this proposal was to promote the use of computational models as a tool for enhancing understanding of human social dynamics, specifically the relationship between emotion, cognition and behavior, and on computationally modeling the consequences of emotion for decision-making in social contexts. Accomplishments can be grouped into three interrelated efforts. First, the project extended and validated computational models of intra-personal processes: specifically, research examined how an individual's emotions are impacted by structure of tasks and how task events unfold over time. Second, research enhanced fundamental understanding of inter-personal emotional processes: specifically, how emotional signals (e.g., facial expressions) generated by one individual might impact the beliefs, feelings, and decisions of another. This work introduced reverse appraisal theory as a mechanism to explain such social effects. Finally, the research produced insights into relationship between situational appraisals and expressed emotion: specifically, studies examined if there was a stable relationship between what participants actually

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Final Technical Report

MODELING AND EVALUATING EMOTIONS IMPACT ON COGNITION

Technical Point of Contact: Jonathan Gratch, 310-440-0306, gratch@ict.usc.edu

Date: July 1, 2013

Project Goals: The objective of this proposal wass to promote the use of computational models as a tool for enhancing our understanding of human social dynamics. This proposal facilitated an interdisciplinary collaboration between computer science and social science research, addressing the relationship between emotion, cognition and behavior, specifically focusing on computationally modeling the consequences of emotion for decision-making in social contexts and the role of culture in moderating these effects. The effort advanced our paradigm of model-driven experimentation (using computational models of human behavior to generate predictions that can be validated through human experimentation). The findings demonstrate the generality of the approach by extending prior empirical findings to several domains of human social interaction and assess the universality of proposed cognitive models by contrasting the behavior across several experimental tasks and demographic groups.

Primary Accomplishments and experimental findings: The research performed as part of this grant served to advance to use of computational models of human emotional processes and innovated the use of such models to study human social emotional processes. Accomplishments can be grouped into three interrelated efforts. First, the project extended and validated computational models of intra-personal processes: specifically, research examined how an individual's emotions are impacted by structure of tasks using appraisal theories of emotions as a theoretical basis for both model development and hypothesis generation. Second, research examined the inter-personal emotional processes: specifically, how emotional signals (e.g., facial expressions) generated by one individual might impact the beliefs, feelings, and decisions of another. This work pioneered the use of virtual confederates, driven by the computational model, to unpack interpersonal emotional processes. Finally, a third thrust examined the relationship between situational appraisals and expressed emotion: specifically, studies examined if there was a stable relationship between what participants actually showed on their faces and manipulations of aspects of tasks that impact participant's appraisals. This research advanced the use of computer vision techniques to explore psychological problems.

- Intra-personal processes: This work primarily focused on how emotions differentially arise within an individual based on the structure of their interactions with environment and specifically on modeling the temporal dynamics of emotion processes. These were

examined through a series of experimental tasks. Studies examined how structural aspects of a situation, predicted by appraisal theory, can influence emotional responses and subsequent decision making. An especial focus of this work was examining how different sequences of emotional events might impact people's choice of different strategies to cope with emotion. Work followed a "model-driven experimentation" paradigm, wherein models were used to simulate situations and generate specific temporally predictions about felt emotion and coping responses that were subsequently tested in laboratory experiments. The work is described in detail in several publications by Gratch and Marsella and by Gratch and Mao (listed below)

- Interpersonal processes. The expression of emotion can influence the decisions of other social partners and a major focus of the grant was to test the conjecture that appraisal theory serves as an effective explanatory framework for predicting these influences. A major and novel contribution of the grant was the development of *reverse appraisal theory.* This theory claims that people interpret expressions of emotion in the context of co-occurring events to reverse-engineer how the expressor is appraising the situation. These reverse-engineered appraisals then provide a basis for inferring the other party's goals. Thus, reverse-appraisal theory proposes a specific mediation model for how people make mental-state judgments from emotional information in social situations. This mediation models was tested and verified through a series of studies led by de Melo and served as the basis of his dissertation on this topic. The details are described in the publications below

- Emotional expression: Appraisal theory argues that patterns of appraisals are reflected in observable behavior such as facial expressions of emotion. As part of the goal of this effort was to demonstrate that displays of emotion driven by the intra-personal model impact human decisions (i.e., reverse appraisal), this work sought to verify that emotional displays seen 'in nature' actuall reflect appraisal processes. This conjecture was examined in one line of research that placed people in experimental tasks where appraisals could be manipulated and facial displays measured by automatic video-based methods. The conjecture was supported. Details can be found in the article by Gratch, Cheng, Marsella and Boberg listed below.

Staff supported under grant: The following personal were supported under the period of performance of the grant

- Faculty:
    - Jonathan Gratch (CS, Psychology)
    - Stacy Marsella (CS, Psychology)
    - Peter Carnevale (Business, Psychology, Communications)
    - Morteza Dehghani (CS, Psychology)
- Graduate Research Assistants
    - Lin Cheng
    - Celso de Melo
    - Nintin Gupta
    - Jonathan Ito

- Visiting student researchers
    - Dimitrios Antos (Harvard)
    - Joana Campos (INESC-ID Portugal)
    - Jennifer Talevich (USC)
    - Wim Van der Ham (Twente, the Netherlands)
- Research Staff
    - Jamison Moore
    - Brooke Stankovic
    - Jill Boberg
    - JinqQiao Fu
    - Angela Nazarian
    - Lia Oganesyan
- External (unfunded) collaborators
    - Steven Read (USC Psychology)
    - Barbara Grosz (Harvard, CS)
    - Wenji Mao (Chinese Academy of Sciences, Automation)
    - Woontack Woo (GIST Korea, CS)

Grant related publications:

- de Melo, Carnevale, Gratch. Humans vs. Computers: The Effect of Perceived Agency on People's Decision Making. Under review
- Rainer Reisenzein, Eva Hudlicka, Mehdi Dastani, Jonathan Gratch, Koen Hindriks, Emiliano Lorini, and John-Jules Meyer. Computational Modeling of Emotion: Towards Improving the Inter- and Intradisciplinary Exchange. *IEEE Transactions on Affective Computing*, (in press)
- Jonathan Gratch, Lin Cheng, Stacy Marsella and Jill Boberg. Felt emotion and social context determine the intensity of smiles in a competitive video game. *10th IEEE International Conference on Automatic Face and Gesture Recognition.* Shanghai, China, April 2013
- Wenji Mao and Jonathan Gratch. Modeling Social Causality and Responsibility Judgment in Multi-Agent Interactions: Extended abstract. *23rd International Joint Conference on Artificial Inteligence*. Beijing, China, Aug, 2013
- de Melo, C., Gratch, J., Carnevale, P. (2013).The effect of agency on the impact of emotion expressions on people's decision making. Paper to be presented at the International Conference of Affective Computing and Intelligent Interaction (ACII).
- de Melo, C., Carnevale, P., & Gratch, J. (2013). People's biased decisions to trust and cooperate with agents that express emotions. Paper presented at the Trust Workshop at the Autonomous Agents and Multiagent Systems (AAMAS) Conference.
- de Melo, C., Carnevale, P., & Gratch, J. (2013). Agent or avatar? Using virtual confederates in conflict management research. Paper to be presented at the Annual Meeting of the Academy of Management (AOM).
- de Melo, C., Carnevale, P., & Gratch, J. (2013). Reading people's minds from emotion expressions in social decision making. Paper to be presented at the Annual Meeting of the International Association for Conflict Management (IACM).

- de Melo, C., Carnevale, P., & Gratch, J. (2012). The effect of virtual agent's emotion displays and appraisals on people's decision making in negotiation. To appear in Proceedings of The 12th International Conference on Intelligent Virtual Agents (IVA'12). pdf
- de Melo, C., Carnevale, P., Read, S., & Gratch, J. (2012). Reverse appraisal: The importance of appraisals for the effect of emotion displays on people's decision-making in a social dilemma. In Proceedings of The 34th Annual Meeting of the Cognitive Science Society (CogSci'12).
- de Melo, C., Carnevale, P., Gratch, J. (2012). The impact of emotion displays in embodied agents on emergence of cooperation with people. Presence: Teleoperators and Virtual Environments Journal 20(5), 449-465.
- de Melo, C., Carnevale, P., Read, S., Antos, D., & Gratch, J. (2012). Bayesian model of the social effects of emotion in decision-making in multiagent systems. To appear in Proceedings of Autonomous Agents and Multiagent Systems (AAMAS'12).
- de Melo, C. (2012). The interpersonal effect of emotion in decision-making and social dilemmas. Ph.D Dissertation. Computer Science Department, University of Southern California.
- Choi, A., de Melo, C., Woo, W., & Gratch, J. (2012). Affective engagement to emotional facial expressions of embodied social agents in a decision-making game. Computer Animation and Virtual Worlds, 23, 3-4, 331-342.
- de Melo, C., Carnevale, P., Read, S.,& Gratch, J. (2012). Reverse appraisal: Appraisals mediate the effect of emotion displays in decision-making in a social dilemma. Poster presented at the Emotion SPSP Pre-Conference Meeting.
- Mao, Wenji, and Jonathan Gratch. (2012). "Modeling social causality and responsibility judgment in multi-agent interactions." *Journal of Artificial Intelligence Research v*44(1), 223-273.
- Morteza Dehghani, Jonathan Gratch, Peter Carnevale. (2012). Interpersonal effects of emotions in morally-charged negotiations. *Proceedings of the 34th Annual Meeting of the Cognitive Science Society.* Sapporo, Japan.
- William Kennedy, Frank Ritter, Christian Lebiere, Jonathan Gratch and Richard Young. (2012). ICCM Symposium on Cognitive Modeling of Processes "Beyond Rational." International Conference on Cognitive Modeling. Berlin, Germany.
- Peter Carnevale, Yoo Kyong Kim, Celso de Melo, Morteza Dehghani, Jonathan Gratch (2011). These Are Ours: The Effects of Ownership and Groups on Property Negotiation. *International Association of Conflict Management*de Melo, C., Carnevale, P., Antos, D., & Gratch, J. (2011). A computer model of the interpersonal effect of emotion displayed in a social dilemma. In Proceedings of Affective Computing and Intelligent Interaction (ACII'11).
- Antos, D., de Melo, C., Gratch, J., & Grosz, B. (2011) The influence of emotion expression on perceptions of trustworthiness in negotiation. In Proceedings of the 25th Conference on Artificial Intelligence (AAAI'11).

Grant related invited talks:

- Keynote speaker, Workshop on Empathic and Emotional Agents at the International Conference on Autonomous Agents and Multiagent Systems, Valencia, Spain, June 2012
- Invited Panelist, International Conference on Cognitive Modeling, Berlin, April 2012
- Invited Speaker, Northwestern University Cognitive Science Seminar Series, Chicago, IL November 2011
- Invited Panelist, International Conference on Affective Computing and Intelligent Interaction, Memphis, TN, October 2011
- Keynote speaker, Workshop on Standards in Emotion Modeling, Lorentz Center, Leiden. August 2011
- Keynote speaker, IEEE International Conference on Automatic Face and Gesture Recognition, Santa Barbara, March 2011

Abstract

The objective of this proposal was to promote the use of computational models as a tool for enhancing understanding of human social dynamics, specifically the relationship between emotion, cognition and behavior, and on computationally modeling the consequences of emotion for decision-making in social contexts. Accomplishments can be grouped into three interrelated efforts. First, the project extended and validated computational models of intra-personal processes: specifically, research examined how an individual's emotions are impacted by structure of tasks and how task events unfold over time. Second, research enhanced fundamental understanding of inter-personal emotional processes: specifically, how emotional signals (e.g., facial expressions) generated by one individual might impact the beliefs, feelings, and decisions of another. This work introduced reverse appraisal theory as a mechanism to explain such social effects. Finally, the research produced insights into relationship between situational appraisals and expressed emotion: specifically, studies examined if there was a stable relationship between what participants actually showed on their faces and manipulations of aspects of tasks that impact participant's appraisals. This project led to one PhD dissertation.