Dimensions of Leader-in-Context Models

Ceyhun Eksin (ceksin@seas.upenn.edu), Barry G. Silverman (BaSil@seas.upenn.edu), David Pietrocola (dpiet@seas.upenn.edu), Rui Kang (ruikang@seas.upenn.edu)
Ackoff Collaboratory for Advancement of the Systems Approach (ACASA),
Department of Electrical and Systems Engineering,
University of Pennsylvania, Philadelphia, PA 19107 USA

Abstract

In this study, we explore dimensions of comparison amongst complex agent-based models. Specifically, we look at holistic models of leaders-in-context. We focus our analysis on alternative models of the same phenomenon, that of the rise and fall of two corporations, respectively. The models were built by students with introductory training on the methodology and modeling framework. We extract dimensions and examine good vs. bad modeling behavior. We divide these dimensions into ones that are related to modeling leader context and ones that are related to leader profiling. We use these dimensions to address how to facilitate modeling alternative theories across a broad range of topics and how to compare resulting models.

Introduction

Studying the "traits of the great man" sitting atop a traditional organizational hierarchy is no longer sufficient to understand leadership. This approach like other schools of leadership study (e.g, cognitive, networks, cultural, etc.) tends to be singularly focused. Lichtenstein et al. (2006) and Avolio (2007) argue that leadership research today must be holistic and synthetic (see Silverman et al., 2007). Synthetic leadership theory underlines the necessity to integrate various theories on cognition, traits, and situational contingencies (e.g. context, culture, social networks, etc.) to provide a picture of the whole. This is what a leader encounters in the real world in the contexts he or she must manage. Hazy (2007) highlights the importance of hybrid computer modeling techniques to support experimentation on the holistic perspective. Hazy (2007) claims that hybrid models that include various techniques are likely to become abundant with increasing adoption of a holistic look at leadership. We feel that the most suitable approaches to a holistic perspective are socio-cognitive agent-based models where leader traits and affective reasoning in context are richly defined as endogenous parts of a complex system.

The reasons to model leaders are 1) to try and understand mechanisms that cause them to think under varying circumstances, and 2) once that is known and validated, to use these models to explore what-if possibilities, alternative courses of actions, and how to influence them.

In the social sciences, there are no set principles, no one-theory-fits-all situations. So ideally one wants to try different theories and factors. The modeling architecture must support this testing of theories allowing users to shift in different ideas and see if they better explain what is making leaders function as they do.

As a result, we want greater ability to plug theories and sub-models in and out of the framework. The holistic leader-in-context movement means that modelers must use a framework that covers many dimensions (cognitive, personality, cultural, socio-economic, etc.). How to model this breadth of topics while simultaneously permitting ease of trying different models is *one question* we explore here. In particular, this study examines how novice modelers (student trainees) can use a socio-cognitive architecture to plug in differing models of a leader-in-context.

The second author has developed a socio-cognitive modeling framework called PMFserv (Silverman et al., 2007) that provides a model of an agent's cognitive-affective state and reasoning abilities that is applied to profile the traits, cognitions, and social reasoning of agents alone and in groups. PMFServ utilizes cognitive appraisal theory where each agent goes through an observe, orient, decide, and act (OODA) loop (Boyd, 1995). For each agent, PMFserv operates its perception and runs its personality/value system to determine individual action decisions to carry out the resulting and emergent behaviors. The PMFserv framework also permits the modeling of groups, economic behavior, and socio-cultural factors. Hence, the framework is a reasonable candidate for analyzing leader behavior within varying contexts.

It is possible to build different versions of computational models when systems are complex. Yet, when these computational models are built, there are no existing common dimensions on which to evaluate them. A *second question* of interest is, "How can we compare models that claim to model the same phenomenon?" Recently, comparison amongst cognitive models has been studied by Lebiere et al. (2009) and John (2010). Lebiere et al. take on the task to compare cognitive models built by different individuals or teams that use different approaches. The hardest part of their approach is to come up with common grounds for comparison amongst different approaches. John explores the reduction in variation between novice modelers via guidance of CogTool (John, 2009). John first identifies common mistakes of modelers and then compares the variation between modelers with and without the tool support.

In this study, we take a different approach. We establish dimensions for comparison of a certain type of holistic leader models built by novice modelers (students) using a common framework, i.e. PMFserv's existing socio-cognitive appraisal framework. Specifically, the framework allows modelers to define: 1) Context, i.e. how leaders perceive the world; 2) Decision making behavior, i.e. how leaders process information flowing in and determine actions accordingly; and 3) World behavior, i.e. how the world gets affected by these individual actions. In this study, we define world behavior beforehand and restrict modelers to focus on the first two parts to replicate a given scenario. Next, we specify dimensions of comparison in leader-in-context models by identifying the differences amongst models. Unlike John (2010), there are no errors in modeling but there is good or bad modeling. Finally, we use these dimensions to specify desired features for models of leader-in-context.

The next section summarizes the PMFserv framework focusing on cognitive appraisal theory. The methodology section describes the dimensions of comparison and outlines the good and bad practices of leader-in-context modeling. The subsequent section describes the specifics of the scenario and task given to modelers. The results section analyzes the differences amongst the models based on the dimensions explored. The last section concludes with discussion and related future work.

Cognitive Appraisal within PMFServ

The Performance Moderator Function Server (PMFserv) was designed by Silverman et al. (2006) as a modular system and socio-cognitive modeling framework for implementing and evaluating performance moderator functions (PMFs). PMFserv operates what is sometimes known as an observe, orient, decide, and act (OODA) loop. PMFserv agents utilize cognitive appraisal theory to help them cope with these contexts. This involves a perception system, a values system, an emotion model and a decision module.

Perception Module

Perception of agents and objects around each agent determine the context. The perception is based on "affordances" (Cornwell, 2003) which is a form of distributing perceptions so that an agent's knowledge of the world is marked up onto the perceived objects, instead of the perceiving agents. Each entity in the world, agents, objects, groups, organizations etc., applies perception rules to determine how it should be perceived by each perceiving agent. Hence, each agent can perceive the same entity differently based on these rules. For example, a bike might afford the actions 'ride', or 'walk alongside' to an agent if it knows how to ride a bike but it might only afford the 'walk alongside' action to another agent that does not know how to ride a bike. In this case, the mark-up rules that reveal actions depend on properties of the perceiving agent. An example of a company that is marked up for such perceptions is given in Figure 1. Each gray box represents one way the company can be perceived. Each element of the grid is called a perceptual type (p-type). These p-types are not mutually exclusive.

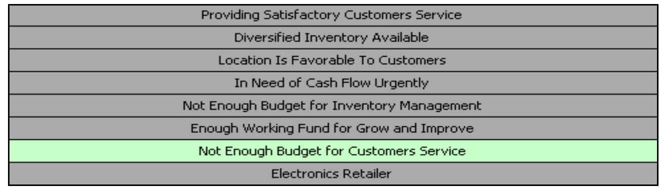

Figure 1: Company P-types

Modelers establish appropriate context via rules on a p-type. For example, a CEO might see that 'Not Enough Budget for Customer Service' is active and be afforded actions 'Decrease Customer Service' or 'Fire employees' whereas this context is not valid for a customer agent. Hence, p-type rules might require that the perceiving agent works at the company or that it is the CEO of the particular company. The set of active p-types determine the actions afforded to perceiving agents. We define the parameters that affect the p-type rules as input parameters.

Activations and Value System

An afforded action provides activations to those taking that action. These activations are fixed and irrespective of the agent that is afforded the action. Agents assess the activations of each action against their values system to compute the utility of taking that action. By comparing utility of all alternative actions, agents complete the primary appraisal, i.e. how alternative contexts affect their personal well-being, emotions etc. They then select the action that maximizes their utility.

For this to work, PMFserv requires every agent to have goals, standards, and preferences (GSP) trees filled out. GSP trees are multi-attribute value structures where each tree node is weighted with Bayesian importance weights. Within a simulation, each agent has the same tree structure, i.e. nodes are the same but the weights differ among agents. The assignment of node weights determines the traits of a certain agent. Figure 2 provides an example of a simple GSP tree structure for a company CEO.

In order to determine a specific agent's importance weights, modelers utilize differential diagnosis (Bharathy, 2006) and analytical hierarchy process (AHP). This provides a systematic and valid methodology for assessing the weight of each node to effectively

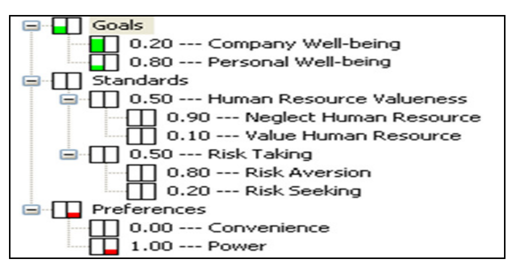

Figure 2: An example GSP tree

profile the agents and settings of interest. Using differential diagnosis, modelers collect and assess relevant evidence to attribute behavior. In this process, each hypothesis corresponds to a node in the GSP tree, i.e. behavior or traits. The output is organized in tabular form called an 'evidence table' with additional attributes such as reliability, frequency of occurrence, and relevance. Evidence tables allow one to consider all competing hypotheses at once and rank them accordingly by assigning confirmation scores to each hypothesis. Figure 3 provides a shortened example of an evidence table. The table shows that the first evidence relates to the nodes 'Risk Aversion' and 'Risk Seeking'. From the evidence table, the weights are estimated through the AHP process by pair-wise comparison of their confidence index.

	Standards					
Evidence (Ei) ✓ = Evidence supports, or can be made to support, the hypothesis x = Evidence rejects the hypothesis	Reliability (Ri)	Relevance Or (Diagnostic Value)	H1: Risking Aversion	H2: Risk Seeking	H3: Value Human Resource	H4: Negalect Human Resource
Circuit City did not change business mode since 1990s.	1	1	✓	x		
Circuit City laid off 3400 top salesmen in 2007.	1	1			x	✓
Circuit City had problems with inventory management.	0.9	1				
Circuit City CEO Schoonover received $1.4 million in salary and bonuses in fiscal 2006,	1	1				

Figure 3: Evidence Table

Emotion model

This is the module that calculates how each agent is likely to feel from taking an action based on arousals, i.e. combining activations and values system (GSP tree). Each afforded action has an activation mapping on the GSP trees. The activation mapping is a collection of success/failure levels on a set of GSP nodes. For a simple example, an activation mapping on the values system (in Figure 2) of the action 'Decrease Customer Service' is given in Figure 4. It shows that the result activates two nodes positively, 'personal well-being' and 'neglect human resource', and one node negatively, 'company well-being'. The set of emotions that each agent generates from taking an action is determined by the sum of their activations weighted by node weights. Thus an importance-weighted values system results in differing emotions being generated within the same context by different personalities. For mathematical underpinnings of the implemented model, see Silverman et al. (2006).

Actions	Results	Node	Op	Success Level	Op	Failure Level
Decrease customer service	100% - Decrease customer service	Company Well-being	=	0	+	0.1000
		Neglect Human Resource	+	0.1000	=	0
		Personal Well-bing	+	0.1000	=	0

Figure 4: Activation mapping for action 'Decrease Customer Service'

Decision Module

The decision model receives information from the value-driven emotion model and implements utility theory to select actions. A decision in PMFserv is a choice made by an agent when choosing between alternative afforded actions. A decision-making algorithm runs to select the decision with the highest subjective expected utility. Subjective expected utility (SEU) for each decision is determined by appraising all possible emotions that will be generated if the decision is taken by that agent. The decision taken is called an action. An action may generate effects on the environment – actor, target and other entities – based on its result. These result effects are called action bindings. We will refer to parameters that these action bindings affect as output parameters. Figure 5 gives an example of an action binding for the action 'Decrease customer service'. The output parameters are 'capital' and 'customerServiceQuality' of the target of the action.

Result Effects (Action Bindings)

Standard Action Binding | Custom Action Binding | Custom Perception Binding

	Target	Property	Operation	Variable Type	Value
1	target	capital	+	Number	1
2	target	customerServiceQuality	+	Number	-1
3					

Figure 5: Action Binding rule table

Methodology

In this section, we introduce the dimensions of comparison amongst the models. These dimensions also highlight good versus bad modeling behavior. We divide the dimensions of comparison into two major clusters: 1) Dimensions related to modeling leader-context interactions, i.e. how context, afforded actions, leader responses and its effects on the world are modeled, and 2) Dimensions related to modeling leader personality, i.e. how agent value systems are constructed.

Dimensions Related to Modeling Leader-Context Interactions

These are the dimensions that provide feedback on how conditions that lead to leader actions (p-types and afforded actions) and effects of leaders actions on the world are modeled. It is possible to further divide these dimensions into two: context richness and action-result balance.

Context Richness It refers to the depth of the model with respect to leader perception. Within the PMFserv framework, context is determined by p-types. If one wants to have finer levels of granularity in perception modeling, it is necessary to increase the number of p-types. This will enable one to pin down the reasons for events in finer detail. However, increasing only the number of p-types is not always sufficient. Number of input parameters that affect the perception rules often needs to be correlated with number of p-types. If number of affecting parameters is much smaller than number of p-types then there is a strong indication of overloading parameters with multiple meanings which in return means p-types are not clearly defined. This will often require accurate estimation of these parameters. In short, the context which affords actions to agents should be clearly defined so that agents consider the correct set of actions at the right set of circumstances.

Action-Result balance It refers to the relations between actions and parameters that are affected by the results of those actions. One must consider all aspects of taking that action when one is defining an action's effects on the world. Often, results of actions come with trade-offs. The modeler has to reflect these trade-offs via output parameters.

Dimensions Related to Modeling Leader Traits

While the previous cluster of dimensions may reflect on how leaders perceive and how their actions affect the world, it is really the personality that determines how leaders vary from one another within the same context. The dimensions in this section refer to assessment of leader personality models.

Quality and Quantity of Evidence Organizing information from otherwise diverse or amalgamated sources is critical to the success of the modeling activities. Although differential diagnosis and AHP process minimizes subjectivity and biases within the process, the validity of results depend on the quality and number of pieces of evidence. Quality of evidence refers to the relevance and reliability of evidence. A modeler should try to obtain reliable evidence that is relevant to the story. Additionally, one would want to increase the number of pieces of quality evidence attributed to each node.

Coverage in Tree to Activation Mapping Activation mappings on GSP trees are used for emotion calculations which in return get used in decision-making. If a node does not get covered by an activation mapping from any of the actions then that node will be idle throughout the simulation. In other words, it will not have any effect on the decision-making calculations. Modelers need to make sure that each node gets mapped to an activation by at least one action.

Sensitivity Analysis If change in a parameter value causes significant changes to the main outcome of the model then it means that the model is sensitive to that parameter. This would require that parameter to be estimated with higher precision. The behavior of a validated cognitive model should ideally be fairly robust with respect to tweaking changes on a single personality trait. Within the PMFserv framework, sensitivity to a node indicates that for certain key actions, activation mappings affect mainly that node. The modeler has to be aware of this sensitivity and carefully use techniques discussed in the previous section and try to find additional evidence for more accurate determination of node weights.

Task and Scenario

After approximately 25 hours of framework and methodology training, students were given strict guidelines to come up with a working model that replicates a given scenario as one part of their coursework requirement. The class consisted of junior and senior Systems Science and Engineering (SSE) students with the exception of one Economics major. Most students are also completing a double major or a minor degree in our business school. Students were given two weeks to complete their assignment and they had support from experienced model builders. The students worked in groups of four or five. They were given a benchmark model that required certain tasks to be completed to fully function. Each individual had to model an agent by picking a theory of behavior and reflect this theory onto a values system for their agent. The set of agents to model were given to them. Team members had to decide on which agent each student would model. Each group had to come up with important parameters, contexts, afforded actions, activations and results of taking those actions for the set of agents. The benchmark model contained a set of rules that govern the dynamics of the world and groups were fully aware of how the world would function. Lastly, they were required to replicate scenario outputs within their model.

Specifically, students were given the story of Circuit City (CC) going bankrupt and Best Buy (BB) excelling. They were given a news article that overviews the story. Additionally, they were encouraged to do their own research on the story and their specific agents. The minimum required set of agents included Circuit City CEO, Best Buy CEO, and two or three (depending on group size) types of consumers. Further, two companies were modeled and placed under the control of the respective CEO. Each student focused on profiling a single agent. The decisions of consumers were predefined within the world dynamics as 'Shop from Best Buy' or 'Shop from Circuit City'. The teams were required to maintain these two actions and were not allowed to add new actions for the consumers. CEO agents did not have any predefined actions, thus the teams had to work on all parts of the OODA loop for those agents.

Results

This section provides examples of dimensions discussed in the methodology section from student models. We provide a summary of the models in Table 1. Out of the eight teams, six teams were able to create a model that replicated the desired output behavior, i.e. CC's fall and BB's rise. Two teams (Model_5 and Model_8) were not able to complete their model within the given time frame. In Table 1, we provide a collection of p-types from each model (except Model_3) that afford actions only to CEOs (BB CEO or CC CEO). P-type rules, action binding code, and a portion of the p-types have been omitted due to space restrictions.

The first set of examples relate to context richness. Teams had a hard time balancing affordances, actions and activations to create meaningful context. In Model_4, CEO gets afforded actions such as 'Acquire New

Business' and 'Expand to Prime Locations' via the p-type 'Business Expansion Possible'. These actions have no clear context because they get afforded to the CEO all the time. In fact, in Model_4, CEO gets afforded all the actions (listed in Table 1) at all times, i.e. the only requirement is for the agent to be CEO of that company. In Model_6, CEO agents are afforded the actions 'Increase customer service' and 'Increase number of new products' as long as companies have positive capital. Similarly in Model_2, p-types 'BB Customer Service Savings Available', 'BB Improvement', 'BB Price' are all active if parameter 'customerServiceQuality' is greater than zero. In other words, the CEO does not distinguish between these p-types. Additionally, Model_3 uses the parameter set 'Inventory' and 'capital' to define five different p-types indicating possible overloading. However, this group used different values of 'Inventory' and 'Capital' as thresholds to trigger these five p-types. Unlike the previous examples this kind of rule format is acceptable to define varying context but not desired as it relies on fine tuning of these parameters. Finally, we refer to Model_7 as an example model that defines context appropriately. Model_7 uses differing combinations of input parameters to define various contexts.

A majority of the modelers were able to capture the trade-offs of actions inside the action bindings. One obvious violation was in Model_6. 'Decrease number of new products' only has an effect on the parameter 'amount of products'. One would imagine that this action would have direct and immediate positive effect on the 'capital' of the company. As an example, in Model_4 the action 'Expand to Prime Locations' increases 'Accessibility Rating' but at the same time it hurts company's 'capital'.

In order to construct the GSP structure for their agents of interest, students were asked to collect evidence that could help to profile their agents. The number of evidence that students organized ranged from 8 to 25. Students were encouraged but not required to use reliability or relevance scores for their evidence tables. Most of the students utilized a low-medium-high scale and rated their evidence as medium or highly reliable. On the average, a team had 11 nodes for Goals, Standards, and Preferences. Hence, there was an average of 33 nodes in total on average. This meant that roughly 33 hypotheses existed within an evidence table. Students cross-compare these hypotheses with each piece of evidence. Furthermore, students were able to provide evidence for each node. Given the limited time the modelers had, we consider this an acceptable effort.

Each individual had to incorporate a theory and justify how their theory reflects on the values system (GSP structure and node weights) of their agents. Students utilized theories such as individual theory, marketing theory, Maslow's theory on the hierarchy of needs, economic buyer theory, utility theory, agency theory, consumer behavior theory, etc. GSP node names (hypotheses) were formed by these theories. Each team came up with a common GSP structure but each individual had to incorporate a different theory for their agent. The key here was to look at whether that theory was confirmed for their individual agent via pieces of evidence. The majority were able to justify that their individual theory applied to their agent.

As a final requirement for their coursework, students were required to come up with an if-then hypothesis based on a change in personality trait of the agents that each person was responsible for modeling. An example if-then hypothesis is: "If 'Save Money' node weight of CC CEO is reduced then CC would remain in business for a longer time." In short, students related a macro-level metric to a change in micro-level values. Out of the 12 students who modeled either CC or BB CEO for their teams, only four (only one of them was BB CEO) reported that their model was sensitive to the changes that were made on the GSP trait they analyzed. All reported that the change in behavior was in parallel with their initial expectations, i.e. their if-then statement. The rest reported that their model is relatively insensitive to their parameter changes and the hypothesis is disconfirmed.

Concluding Remarks

This study placed a benchmark model of two firms, CC and BB, in the hands of student trainees and challenged them to research and build alternative models of leaders in context. The leaders they built had to account for the cognitive and personality variables that may have caused the decline of CC and the success of BB. Further, these leader models had to operate in a holistic environment and cope with many types of networks and social dynamics that are spawned at run time: ego-networks, economic networks, transaction networks, and so on.

Six teams successfully completed the assignment. They researched alternative theories and built differing models of leaders-in-context. Thus they illustrate answers to question number one – can users build and plug-in alternative models covering the breadth of socio-cognitive dimensions dictated by the modern leader-in-context theory. Their results also address the answer to the second question and give us ample fodder to begin to understand how to compare different models of the same phenomenon.

We explored dimensions for comparison of leader-in-context models. The first set of dimensions concentrated desired features on modeling parts of the OODA loop and the second set concentrated on leader personality modeling and its effects on the model. We extracted these dimensions from working student models by focusing on differences between models. We realize that this variability between models is likely to reduce when models are built by experienced modelers. A future research direction is to analyze whether these dimensions remain salient and sufficient for assessment of expert models.

Table 1: Summary of student models (Input parameters, p-types, afforded actions, and output parameters)

Models	Input Parameters	P-Types that afford actions to CEOs	Afforded Actions	Output Parameters
Model_2	customerServiceQuality	BB Customer Service Savings Available	1. Decrease customer service	capital, customerServiceQuality
	customerServiceQuality	BB Improvement	1. Increase customer service	capital, customerServiceQuality
	customerServiceQuality	BB Price	1. Reduce Price	Price
Model_4		Business Expansion Possible	1. Acquire New Business 2. Expand to Prime Locations	capital, product Range capital, accessibilityRating
		Employee Quality	1. Allow Flexible Scheduling 2. Train Employees	capital, customerServiceQuality capital, customerServiceQuality
		Marketing Improvements Possible	1. Implement Centrizing	capital, customerServiceQuality, brandImage
		Payroll Increases Possible	1. Increase Top Management Salaries	capital, productRange, brandImage
		Payroll Savings Possible	1. Decrease Salesman Salaries	capital, customerServiceQuality, brandImage, accessibilityRating
Model_6	Capital	Improvements available	1. Increase customer service	capital, customerServiceQuality
	amountOfProducts	Not spending money on new products	1. Decrease number of new products	amountOfProducts
	Capital	Products available	1. Increase number of new products	amountOfProducts
Model_7	location	Liquidate Stores	1. Close 100 Stores	capital, location
	location, capital	Locations Available	1. Open 100 New Stores	capital, location
	newTechnology, capital	New Technology Available	1. Invest in New Technology	capital, newTechnology
	promotions, capital	Promotion Available	1. Hold Promotion	capital, promotions
	brandNames	Savings Available by Canceling Partnership	1. Cancel Partnership	capital, brandNames
	promotions	Savings Available by Cancelling Promotion	1. Cancel Promotion	capital, promotions
	websiteQuality	Web Savings Available	1. Decrease Online Presence	capital, websiteQuality
	websiteQuality, capital	Website Improvement Available	1. Improve Online Presence	capital, websiteQuality

Model comparison is fairly straightforward in traditional mathematical models that are tractable. However, cognitive agent-based models are hard to compare because each model includes a diverse library of models that have different assumptions and perspectives. This is the main reason why knowledge produced by different complex social models does not accumulate. In fact, every modeler prefers to start from scratch to build their own model which they can build confidence in. Furthermore, even under strict guidelines, modelers still come up with a whole variety of models.

Throughout the paper, we use dimensions instead of metrics of comparison to distinguish the fact that these dimensions of comparison are not quantified. In the future, we hope to be able to quantify these dimensions into metrics for assessment of socio-cognitive leader models.

References

Avolio, B. J. (2007). Promoting More Integrative Strategies for LeadershipTheory-Building. *American Psychologist, 62,* 25-33.

Bharathy, G. (2006). *Agent based Human Behavior Modeling: A Knowledge Engineering based Systems Methodology for Integrating Social Science Frameworks for Modeling agents with Cognition, Personality & Culture*. dissertation, U. of Pennsylvania.

Boyd, J. (1995). *The Essence of Winning and Losing*.

Cornwell, J., O'Brien, K., Silverman, B.G., Toth, J.(2003). Affordance Theory for Improving the Rapid Generation, Composability, and Reusability of Synthetic Agents and Objects. *12th Conf on BRIMS,* SISO.

Hazy, J. K. (2007). Computer models of leadership: Foundation for a new discipline or meaningless diversion? *The Leadership Quarterly, 18,* 391-410.

Lebiere, C., Gonzalez, C., Dutt, V., & Warwick W. (2009) Predicting cognitive performance in openended dynamic tasks a modeling comparison challenge. In A. Howes, D. Peebles, R. Cooper (Eds.), *9th ICCM, Manchester, UK.*

John, B. E. (2009). *CogTool user guide version 1.1.*, Carnegie Mellon University, Pittsburgh, PA.

John, B. E. (2010). Reducing the Variability between Novice Modelers: Results of a Tool for Human Performance Modeling Produced through Human-Centered Design, *BRIMS, Charleston, SC*

Lichtenstein, B. B., & Uhl-Bien, M., & Marion, R. (2006). Complexity Leadership Theory: An interactive perspective on leading in complex adaptive systems. *Emergence: Complexity and Organization,* 8, 2–12.

Silverman, B., G., Johns, M., Cornwell, J., & O'Brien, K. (2006). Human Behavior Models for Agents in Simulators and Games: Part I – Enabling Science with PMFserv, *Presence, 15,* 139-162.

Silverman, B. G., Bharathy, G., K., Nye, B.,Eidelson, R. (2007). Modeling Factions for 'Effects Based Operations': Part I – Leader and Follower Behaviors. *Journal of Computational & Mathematical Organization Theory, 13*, 379-406.