Socio-Cultural Games for Training and Analysis

Barry G. Silverman[1], Gnana Bharathy[1], Michael Johns[1], Roy J. Eidelson[2], Tony E. Smith[1]
1- Electrical and Systems Engineering Dept.
2- Asch Center for EthnoPolitical Conflict
University of Pennsylvania, Philadelphia, PA 19104-6315
barryg@seas.upenn.edu
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This paper presents a theory for role playing simulation games intended to support analysts (and trainees) with generating and testing alternative competing hypotheses on how to influence world conflict situations. Simulated leaders and followers capable of playing these games are implemented in a cognitive modeling framework, called PMFserv, which covers value systems, personality and cultural factors, emotions, relationships, perception, stress/coping style and decision making. Of direct interest, as Section 1.1 explains, is codification and synthesis of best-of-breed social science models within PMFserv to improve the internal validity of the agent implementations. Sections 2 and 3 present this for leader profiling instruments and group membership decision-making, respectively. Section 4 then offers two real world case studies (The Third Crusade and SE Asia today) where the agent models are subjected to Turing and correspondence tests under each case study. The agent models are then used in a number of sensitivity and parameter elasticity studies. We observe the emergence of a 'civil rights' demand curve that correlates with real world data about when followers will shift from phases of peaceful to vigorous protest to insurgency against a leader. In sum, substantial effort on game realism, best-of-breed social science models, and agent validation efforts is essential if analysis and training tools are to help explore cultural issues and alternative ways to influence outcomes. Such exercises, in turn, are likely to improve the state of the science as well.

Keywords: Leaders and followers; spread of ideas; strategy games; personality and culture, agent-based simulation

1) Introduction and Purpose

Gaming and simulation of socio-cultural groups is a newly evolving field, motivated by the need to better understand how leaders and followers behave, what motivates them, how dangerous ideas spread, and how they might be influenced to cooperate, mitigate conflicts, and benefit the overall good. Green and Armstrong (2003) study the array of methods for forecasting conflict and show that predictions are significantly improved when subjects first participate in role playing games about the issues at stake. Hence, one aim of this research is to isolate the components needed for a generic role playing game to be used to rapidly mock up a class of conflicts commonly encountered in today's world. In other words, create a widely applicable game generator. Since it is often impossible to find humans to play all the roles of such games, or to play out all the possible scenarios, a second aim is to create plausible models of leaders and followers based first principles about what makes them tick and so they may play some of the roles in the game. If these cognitive agents are realistic, they can help trainees and analysts explore the range of their possible actions under varieties of conditions, thereby helping others to see more clearly how to influence them and elicit their cooperation. A related assumption based on evidence from video- and multi-player online-games, is that if the agents have sufficient realism, that should further motivate players (trainees) to be engaged and immersed in role playing games or online interactive scenarios. The benefits of these first two goals lie in forcing trainees and analysts to arrive at explanations of what is going on in a situation.

A 'catch-22' of these two goals is that, agent based simulation games will be more valuable the more they can be imbued with realistic leader and follower behaviors, while the social sciences that can reliably contribute to this undertaking are made up of many fragmented and narrow specialties, and few of their 'models' have computational implementations. The third aim of this research is thus to improve the science by synthesizing relevant first principles and best of breed social science models so they can be tested in agent-based games, and by that to cause the limitations of these models to be exposed and improved. What is known in diverse fields such as sociology and political science, psychological and cognitive modeling, anthropologic/culture modeling, epistemology and the spread of ideas, and personality profiling that might help one to construct more realistic models of groups, in general, and their leaders and followers, in particular? Can a game-based synthesis and implementation cause science improvement needs to be exposed and enhancements added to such models?

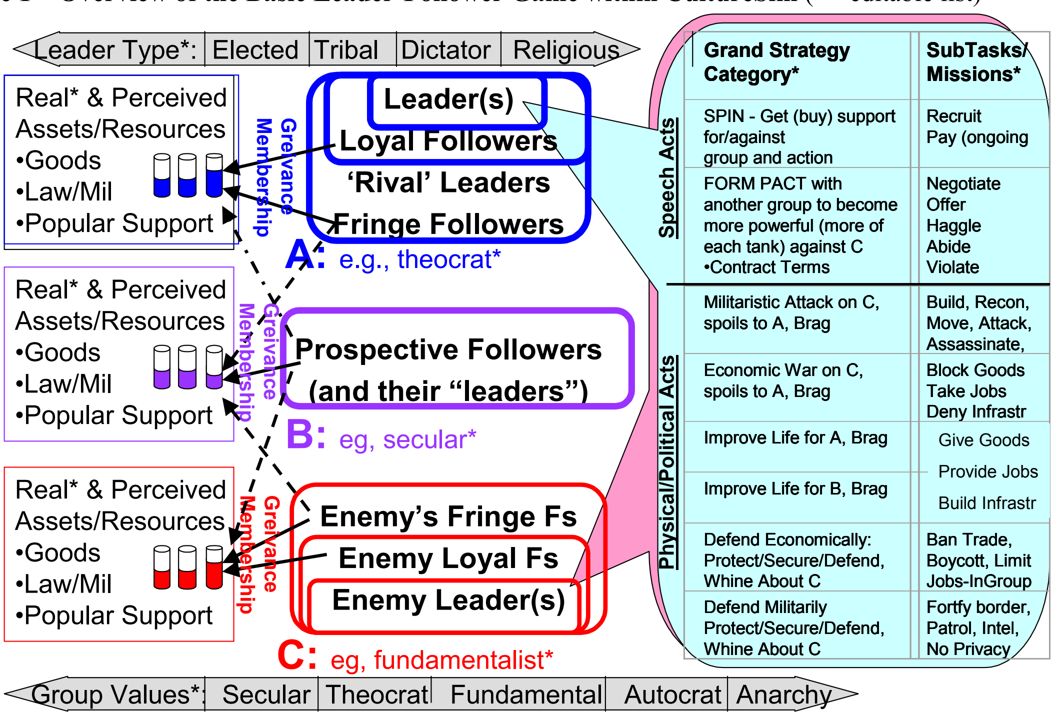
It is a human tendency to project our own value systems upon others and presume they want the same things we want (the mirror bias). Once we form such hypotheses, we tend to look only for confirming evidence and ignore disconfirming facts (the confirmation bias). Heuer (1999) points out that it is vital to break through these and related biases, and that methodical approaches such as realistic simulations, if well done, might help to elucidate and explore alternative competing hypotheses of agents' motivations, intentions and consequent behavior. Thus generation and testing of new hypotheses is a fourth aim, and another potential benefit of simulations.

We turn to a review of some of the literature in Section 1.2, after which Sections 2 and 3 examine best of breed approaches to modeling leaders and followers and how they interact in the game framework we have assembled. In Section 4, we summarize some of the games we have authored and analysis of the results. Finally, Section 5 discusses what has been learned in striving for the 4 aims, and a research agenda for improving the field of socio-cultural games and agent based leader-follower modeling and simulation. First, however, we pause to examine the basic socio-culture game of interest here.

1.1) Socio-Cultural Game Theory

How can an analyst or trainee devise policies that will influence groups for the collective good? And what must a socio-cultural game generator encompass? Figure 1, explained below, attempts to portray a fairly universal class of leader-follower game that groups often find themselves in and that are worthy of simulation studies. This could be for competing groups in a crowd, in an organization, in a region or nation, or even between nations. Analysts would need an appropriate suite of editors and a generator, to help them rapidly mock up such conflict scenarios and analyze what outcomes arise from different courses of action/policies.

Figure 1 – Overview of the Basic Leader-Follower Game within CultureSim (* - editable list)



Specifically, the socio-cultural game centers on agents who belong to one or more groups and their affinities to the norms, sacred values, and inter-relational practices (e.g., language, gestures, social rituals) of those groups. Specifically, let us suppose there are N groups in the region of interest, where each group has a leader archetype and two follower archetypes (loyalists & fringe members). We will say more about archetypes shortly, and there can certainly be multiple leaders and followers, but we stick in this discussion to the smallest subset that still allows one to consider beliefs and affinities of members and their migration to more or less radical positions. There is an editable list of norms/value systems from which each group's identity is drawn. The range across the base of Figure 1 shows an example of a political spectrum for such a list, but these could just as easily be different parties in a common political system, diverse clans of a tribe, different groups at a crowd event, and so on. Each entry on this list contains a set of properties and conditions that define the group, its practices, and entry/egress stipulations. The authority of the leader in each group is also indicated by a similarly edited list depicted illustratively across the top of Figure 1.

The vast majority of conflicts throughout history ultimately center around the control of resources available to a group and its members. The resources of each group are illustrated along the left side of Figure 1 and are summarized for brevity into three tanks that serve as barometers of the health of that aspect of the group's assets – (1) political goods available to the members (jobs, money, foodstuffs, training, healthcare etc.); (2) rule of law applied in the group as well as level and type of security available to impose will on other groups; and (3) popularity and support for the leadership as voted by its members. Querying a tank in a culture game will return current tank level and the history of transactions or flows of resources (in/out), who committed that transaction, when, and why (purpose of transactional event).

To start a game, there are initial alignments coded manually, though these will evolve dynamically as play unfolds. Specifically, each group leader, in turn, examines the group alignments and notices Loyal Ingroup (A), Resistant Outgroup (C), and those "undecideds" in middle (B) who might be turned into allies. Also, if there are other groups, they are examined to determine how they might be enlisted to help influence or defend against the out-group and whatever alliance it may have formed. Followers' actions are to support their leader's choices or to migrate toward another group they believe better serves their personal value system. Actions available to Leader of A are listed in the table on the right side of Figure 1 as either speech acts (spin/motivate, threaten, form pact, brag) or more physical/political acts. Of the latter, there are 6 categories of strategic actions. The middle two tend to be used most heavily by stable, peaceful groups for internal growth and development. The upper two are economic and militaristic enterprises and campaigns taken against other groups, while the lower two categories of actions are defensive ones intended to barricade, block, stymie the inroads of would-be attackers. The right hand column of the action table lists examples of specific actions under each of these categories – the exact list will shift depending on whether the game is for a population, organizational, or small group scenario. In any case, these actions require the spending of resources in the tanks, with proceeds going to fill other tanks. Thus the culture game is also a resource allocation problem. Leaders who choose successful policies will remain in power, provide benefits for their followers, and ward off attackers. Analysts and trainees interacting with this game will have similar constraints to their policies and action choices.

1.2) LeaderSim Game World

The model presented in Figure 1 is a theory of role playing socio-cultural games that guides various implementations we have attempted to date. It provides a point of departure for delineating the 5Ps of any scenario – i.e., people (roles, relationships), plot, place, processes (campaigns, actions, speech acts), and player pedagogy. We have authored implementations of this theory that run inside of other people's videogame engines such as a Mogadishu Black Hawk Down recreation inside Unreal Engine (vanLent et al. 2004, Silverman et al. 2006b), or an Iraqi food relief scenario inside of the BigWorld Engine (MacDonald et. al, 2006). Such 3-D animated worlds are useful for training of street scenes, however, the graphics become an unnecessary burden when trying to analyze and understand what lies behind such conflicts.

The lead author spent much of 2004 assembling a paper-based version of Figure 1 as a role playing diplomacy game and play-testing it with analysts: Silverman, Rees et al (2005). The goal of the game is to help players to experience what the actual leaders are going through, and thereby to broaden and deepen their understanding, help with idea generation, and sensitize them to nuances of influencing leaders in a given scenario. The mechanics of the game place the player at the center of the action and play involves setting objectives, figuring out campaigns, forming alliances when convenient, backstabbing when necessary. This is in the genre of the Diplomacy or Risk board games, though unlike Diplomacy, its rapidly reconfigurable to any world conflict scenario.

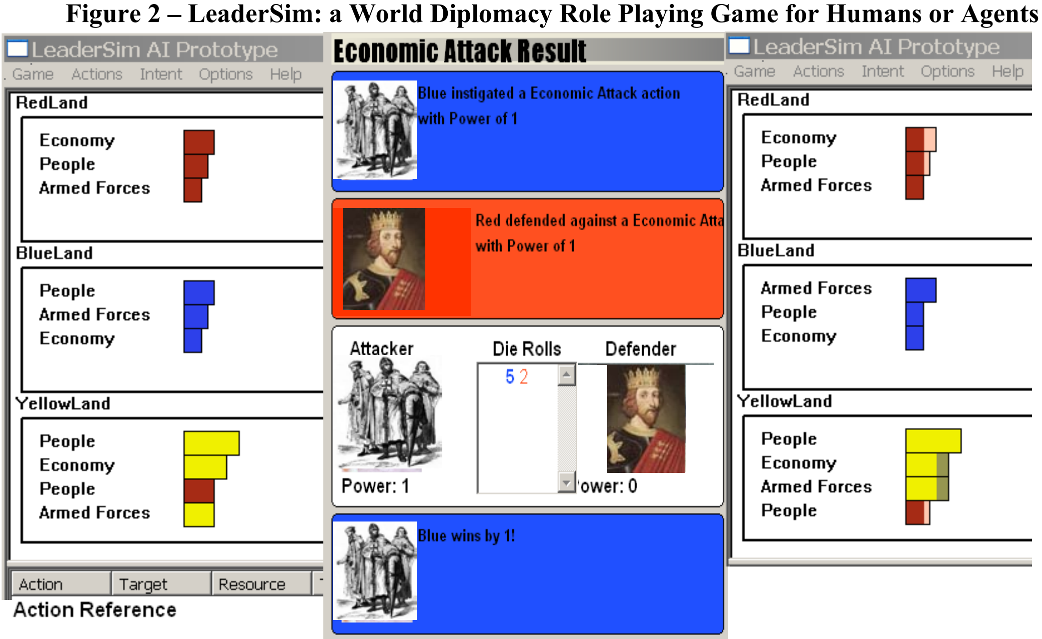
After completing the mechanics and play-testing, three implementations of the game were created: (1) a software prototype called LeaderSim (or Lsim) that keeps world scenarios and action sets to the simplest possible so that we can easily build and test all of the core ideas of the theory; (2) a scaled up version called Athena's Prism that has been delivered as a fully functioning computer game in mid 2005, though AI opponent features are continually being added; and (3) a streamlined version of the paper-based game has been turned into a board game called BigWig© to appear at toy stores in early 2007 and aimed at being played to conclusion within an hour (it is thus intended to serve as an intro to the diplomatic strategy genre for new players).

The computer implementation of the full game (Athena's Prism) has been developed as a distributed multi-player game architecture. The operations concept, is that this could be played by one human on one PC with all the others simulated by artificial intelligence (AI), or all leaders could be human players at remote stations (no AI), or any combination in between of humans and AI, including all AI. The current implementation of Athena also includes a robust scenario and leader editor module, and a game artist worked on the graphics of all the user and player interfaces. It is not our purpose here, and there is insufficient space, to review these many screens and features, and the interested reader is referred to Silverman, Rees, et al. (2005) for those details. Describing primarily Lsim here (with some mention of the scaleup in Athena) will suffice for all the purposes of this writeup.

In the Lsim game, we consider a world made up of at most 3 abstract territories, each of which has a constituency with up to 3 resources categories. The three lands must be named Redland, Blueland, and Yellowland, though actual leaders and groups can be assigned to these lands through editors. The left side of Figure 2 shows all 3 lands (constituencies) each with 3 sets of resources. Each leader/player gets to own a constituency which may or may not be shared with other leaders in the same territory. Constituencies are marked up according to identity theory with the features and expectations of the leader's constituency (e.g., actions and leaders that the constituency favors or opposes). Athena includes resources such as people, economy, military, media, authority, mass communication channels, emissaries, zealots, WMDs, black markets, military, etc. to constitute the constituency. Lsim limits these to the first 3 resources on the list.

In both Athena and Lsim, resource levels are represented by tokens (bingo chips, shown as histograms in Figure 2) that may be used to pay for various actions one wishes to perform in the world. This resource-action-token representation provides an extremely concise, yet flexible and powerful way of describing scenarios and for carrying out game strategies. Adopting this formalism has allowed us to elicit and represent much of the complexity of situations that are difficult for experts even to verbalize. It is only necessary to get the relative levels of the tokens correct to capture the nature of socio-cultural, resource allocation conflicts between groups. Figure 2 depicts a region filled with two relatively smaller groups (Redland, Blueland) and larger group Yellowland. In some runs, students have set these up to be Richard Lionheart, Guy, and Saladin of the Third Crusade, but it is easy to alter this.

Figure 2 – LeaderSim: a World Diplomacy Role Playing Game for Humans or Agents



Action Reference

Hostile Actions

Name	Funded by	Targets	Defended by
Conventional Attack	Armed Forces	Armed Forces, People	Armed Forces
Economic Attack	Economy	Economy, People	Economy
Asymmetric Attack	People	Armed Forces, Economy, People	Armed Forces, People

Non-Hostile Actions

- Manage Domestic Affairs: Renew any five resource units
- Move: Transfer units of one resource into another
- Give Foreign Aid: Spend resources to allow another player to renew resources

As the base of Figure 2 also shows, there are a set of 3 hostile and 3 non-hostile actions in Lsim. In all there are nearly 100 possible actions in the current version of Athena. Each action has rules which identify action applicability, costs, and constraints (e.g., use x economy tokens to pay for amassing and mobilizing the military, or 'tap' an emissary token to pay for making a state visit). The rules govern the spending (tapping) and replenishment (untapping) of tokens (it's a zero sum game), how to grow your assets and expand around the globe, how your actions affect other players, ways to defend against attacks, what may be done during communiqués or summits, how espionage works, the carrots or benefits you can offer other leaders, and so on. A graphical action wizard helps step human players through these rules whenever they take a turn. Despite there only being 100 possible actions, the choice set rapidly explodes to intractability when one considers the array of possible targets, multiple ways one can pay for any given action, and the various levels one can choose to do an action at. Hence, we restrict our attention in this article to Lsim's limited action set. Also, we omit description of the dialog and spying screens and assets.

In general, when humans play the game, they rapidly evolve a portfolio of strategies that they tend to pursue asynchronously and in parallel, where a strategy is a high level goal that might be implemented by any of a number of alternative actions. An 'action' is defined as a sequence of low level moves governed by the rules of the game. There are only a few moves (e.g., tap/untap tokens, re-assign tokens to resources, etc.). This portfolio or strategy-action-move hierarchies tend to reflect the culture and personality of the leader in a scenario as they attempt to navigate the 'game' against the other players. As one example of this, the middle of Figure 2 depicts a turn where Redland (Richard) is attacked economically by his supposed ally (Guy, the Latin King of Jersalem). The game engine handles the 'dice rolling' once both sides have picked a level of attack and defense, respectively, and in the bottom middle and then the right side of Figure 2, one can see that Guy successfully weakened Richard's campaign and made him more dependent on his host (Guy), though certainly not more sanguine about the alliance.

For the AI to be able to replace a human player and to assemble and manage a portfolio in a way as to reasonably emulate a world leader, a number of components are required in the mind of the agent as shown as the next few subsections amplify. In particular, Performance Moderator Function Server (PMFserv) is a human behavior modeling framework that manages an agent's perceptions, stress and coping style, personality and culture, social relationships, and emotional reactions and affective reasoning about the world: Silverman et al.(2002a,b, 2005, 2006a,b). Before we turn to a more detailed examination of how this works, we first briefly overview the literature on computational agent approaches.

1.3) Computational Theories of Agents

To our knowledge there are no other agent based (or other) approaches that come close to embracing the breadth and depth in Figure 1, though there are a number of contributions to various slices of that picture. Here we mention a few of these in order to illustrate the range of issues one must model to implement Figure 1. We begin with theories and implementations that are computer based and then proceed to the behaviorally inspired ones.

Game Theory - As a first sub-community, game theory itself offers some useful notions, though for the most part it is a rich theory only for simple games and is incapable of handling the details of Figure 1. For example, Woolridge & Dunne (2004) examine the computational complexity of qualitative coalitional games and show that finding optima is O(NP-complete) for most questions one would like answered. This means of course, that for formalisms such as POMDPs, that the game is computationally intractable except via approximations. As an aside, Simari & Parsons (2004) ran an experiment comparing the convergence rates of (1) approximations and relaxations of prescriptive approaches (i.e., POMDP) and (2) "descriptive approaches" based on how humans tend to make decisions. In small games the prescriptive approximations do better, but as games grow larger and more complex the descriptive approach is preferred and will provide closer convergence and faster performance. This finding is certainly relevant to the current investigation, and is compatible with the approaches pursued here.

Communicative and Plan Recognizing Agents - A related game-agent sub-community involves straddling the artificial intelligence and epistemological literatures in what is at times called nested intentionality modeling. In this type of approach one finds theories and implementations of agents attempting to move beyond just observing agents' actions to also include the modeling of intentionality of the other agents in the game (supporting Need 4): e.g., see Dennett (1986). This is a nascent community, although some progress has resulted from the earliest days where it was claimed that the problem was NP-complete: Kautz & Allen (1986). Some researchers have advanced the field via formal methods such as POMDP, Distributed Bayesian Networks, etc. such that their plan recognizers tend to operate in polynomial space: Geib (2004). However, these tend to be for rather simple problems, such as 2 player games with minimal action choices. Other researchers have pushed the complexity to the O(linear) level primarily by focusing on descriptive heuristics relevant to the domain in which they work, rather than trying to apply complex, principled formalisms: e.g., see Kaminka & Avrahami (2004). It is this latter type of paradigm that we pursue in our own intention modeling. The large agent communication literature also provides useful methods for speech act performative manipulation, inter-agent communication, and negotiation management that we omit from the current discussion, but which benefits and informs our work as well.

Strategic RPG Videogames - For the most part, AI in videogames is devoted to the use of finite state machines for low-level functions such as navigating, path finding, and personal combat tactics. A small portion of this community focuses on what might be called "Leader AI" mostly for strategy games, but also role playing games and a few massive multiplayer online games. Most often these games have the player try to run a country or constituency in some historical era or in a fantasy or futuristic alien world. For example, the Civilization series of games, the Empire Earth games, Alpha Centauri, Rise of Nations, Galatic Civilizations, SimCountry, and so on. The leader AIs tend to be the opponent leaders and they fairly uniformly rely on simple rules buried in scripts to govern the branching of agent behaviors. The AI is there mostly to entertain the player, and rules are kept simple and pre-scripted, often with an easy to beat opponent for new players and a harder level to challenge better players (accomplished by making the AI omniscient). These AIs tend to be difficult to communicate with except in simple ways, are hard to make alliances with at anything but the highest levels, are incapable of carrying out coordinated efforts, and often are inconsistent: e.g., see Woodcock (2002). The bottom line for the videogame community is that it does not pay to invest in leader or follower AI beyond the minimum needed to engage the player (buyer), and there are many instances where this simple approach suffices to create enjoyable play and sufficient drama for entertainment purposes, keeping players engaged for many hours. That is a feat that none of the other communities can lay claim to, and if one is interested in player learning (as we are here), one cannot ignore this capability. However, even the videogame community realizes (e.g., see Kojima, 2004) that players continually demand better and greater entertainments, and significantly improved leader AI is an eventuality they must eventually reckon with if they are to provide dynamic (non-scripted), innovative gameplay as is offered in the approach described here. All the issues mentioned above also lead us to the need to have our own game generator – composability for rapid mock up of real world socio-cultural conflict scenarios, playing against realistic leader-follower agents, and flexibility to use for analytical purposes. This does not preclude use of existing game environments, and as will be mentioned at key points in this article, we have plugged our agent-based human behavior simulator (PMFserv) in to drive agents in other game worlds – e.g., Unreal Engine, BigWorld, JSAF, etc.

Human Behavior Models - An important learning objective of our research program is to directly model and explore the underlying behaviors and motivations of leaders and followers. For these purposes, we turn to a final agent sub-community -- that of the human behavior modelers. Unlike game AI, human modeling need not focus on navigating and battling around spaces, but instead invests in detailed modeling and simulation of individual agent's decision and cognitive processes, and worries about accuracy and validity of the resulting behaviors. This community eschews the rationalistic-normative paradigm of game theory, and instead often embraces an array of descriptive, naturalistic, or heuristic approaches to modeling human cognition and reasoning: e.g., see Pew & Mavor (1998). As cited above, descriptive/cognitive approaches: (1) hold a better chance of converging in coalition games; (2) are more tractable for plan recognition/intentionality modeling; (3) offer improved mechanisms for the perception and reasoning about aspects of other agent behavior such as trust, relationships, and group membership choices; and (4) hold the promise to help agents move beyond surface features and explain their choices and behaviors. Despite these arguments for richer human behavior models, the human behavior modeling community does not hold a well-developed approach to all these issues. There are some widely used cognitive models (e.g., SOAR, ACT-R) that tend to be quite adept at logical processes of reasoning and learning but which ignore many other components of behavior and cognition. In contrast, PMFserv complements such models of cognition with a wide range of implemented best-of-breed human performance moderator functions (PMFs) such as: for physiologic impacts (e.g., exertion, fatigue, injuries, stimulants, noise); for sources of stress like event stress or time pressure; and with models of emotion and affect to modulate expected utility formulations and to help account for cultural, personality, and motivational factors that impact upon leader-follower relations, Silverman (2005). PMFserv also manages social relationship parameters and thus macro-behavior (e.g., in collectives or crowds of PMFserv agents) emerges from individuals' interactions and micro-decisions. As a result, PMFserv is the agent framework adopted for our leader-follower AI. The human behavior modeling community is relatively new to the idea of modeling individual differences drawn from validated personality/culture models and instruments. That is the portion of PMFserv we focus on here, as the next two sections explain for leaders and followers, respectively.

2) Theories on the Personality and Values of Leaders

An important source of ideas for the modeling of leaders comes from the field of political psychology. While these are not implemented or operationalized agent models, they can be a source for creating agent frameworks with greater degrees of realism. In terms of leader theories that might impact the leader-follower game (Aim 2), Chemers (1997) indicates that while the leadership literature often appears fragmented and contradictory, it can be summarized in terms of four dominant theories of leadership: Leader Trait Theory, Transaction Theory, Transformational Leader Theory, and Situational Contingency Theory. These leadership theories seek to stipulate the most effective leadership style and behaviors that a leader must perform well in order to be effective in a given situation. Our current LeaderSim agents include implementations of some portions of the situational, transformational and transactional features as will be outlined shortly. However, these theories ignore leader to leader relations, plus they tend to be normative and prescriptive. From our viewpoint, we need to embellish this with a theory that focuses upon inter-leader dynamics and that permits us to model leaders as they are (not as a prescription would prefer). As a result, we turn now to a descriptive theory of leader style, one that is measurable and can be fully implemented in our agent-based framework.

After two decades of studying over 122 national leaders including presidents, prime minister, kings, and dictators, Hermann (1999), has uncovered a set of leadership styles that appear to influence how leaders interact with constituents, advisers, or other leaders. Knowledge about how leaders react to constraints, process information, and are motivated to deal with their political environment provides us with data on their leadership style. Hermann determined that the traits in Table 1 are particularly useful in assessing leadership style.

In Hermann's profiling method, each trait is assessed through content analysis of leaders' interview responses as well as or other secondary sources of information. Hermann's research also has developed methods to assess leadership at a distance, based mostly on the public statements of leaders. While both prepared speeches and statements from interviews are considered, the latter is given preference for its spontaneity. The data is collected from diverse sources, usually as many as 50 interviews, analyzed or content coded, and then a profile can be developed. These are then compared with the baseline scores developed for the database of leader scores. Hermann (1999) has developed mean scores on each of the seven traits. A leader is considered to have high score on a trait, if he or she is one standard deviation above the average score for all leaders on that trait.

Table 1 – The Seven Traits of the Hermann Leadership Style Profile

<table>
<tr><td>1. Belief that one can control what happens</td><td rowspan="2">Combination of the two attributes (1) and (2) determines whether the leader will challenge or respect the constraints.</td></tr>
<tr><td>2. Need for power/influence</td></tr>
<tr><td>3. Concept complexity (IQ)</td><td rowspan="2">Combination of the two attributes (3) and (4) determines how open a leader will be to information.</td></tr>
<tr><td>4. Self-confidence</td></tr>
<tr><td>5. Task Vs Relationship Focus</td><td>a continuum between two poles:
o Moving the group toward completion of a task, and
o Maintaining group spirit and morale (building relationships).</td></tr>
<tr><td>6. An individual's general distrust or suspiciousness of others</td><td rowspan="2">The leader's outlook about the world and problems largely determines the confrontational attitude of the country, likelihood of taking initiatives and engaging in sanctions. The extent of their in-group bias and general distrust of others is driven by:
o perceived threats or problems in the world, or
o perceived opportunities to form cooperative relationships.</td></tr>
<tr><td>7. The intensity with which a person holds an in-group bias.</td></tr>
</table>

In our LeaderSim personality model, we adopt Hermann's traits (Table 1) with the following changes:

- simplified traits 3 and 4 by using Openness-to-Information directly rather than as a combination of conceptual complexity and self confidence.
- After discussions with Sticha et al. (2001), we added one further trait, namely Protocol Focus vs. Substance Focus as a continuum to describe the leader's penchant for protocols (e.g., state visits or speech acts such as religious blessings) as opposed to taking any concrete actions.

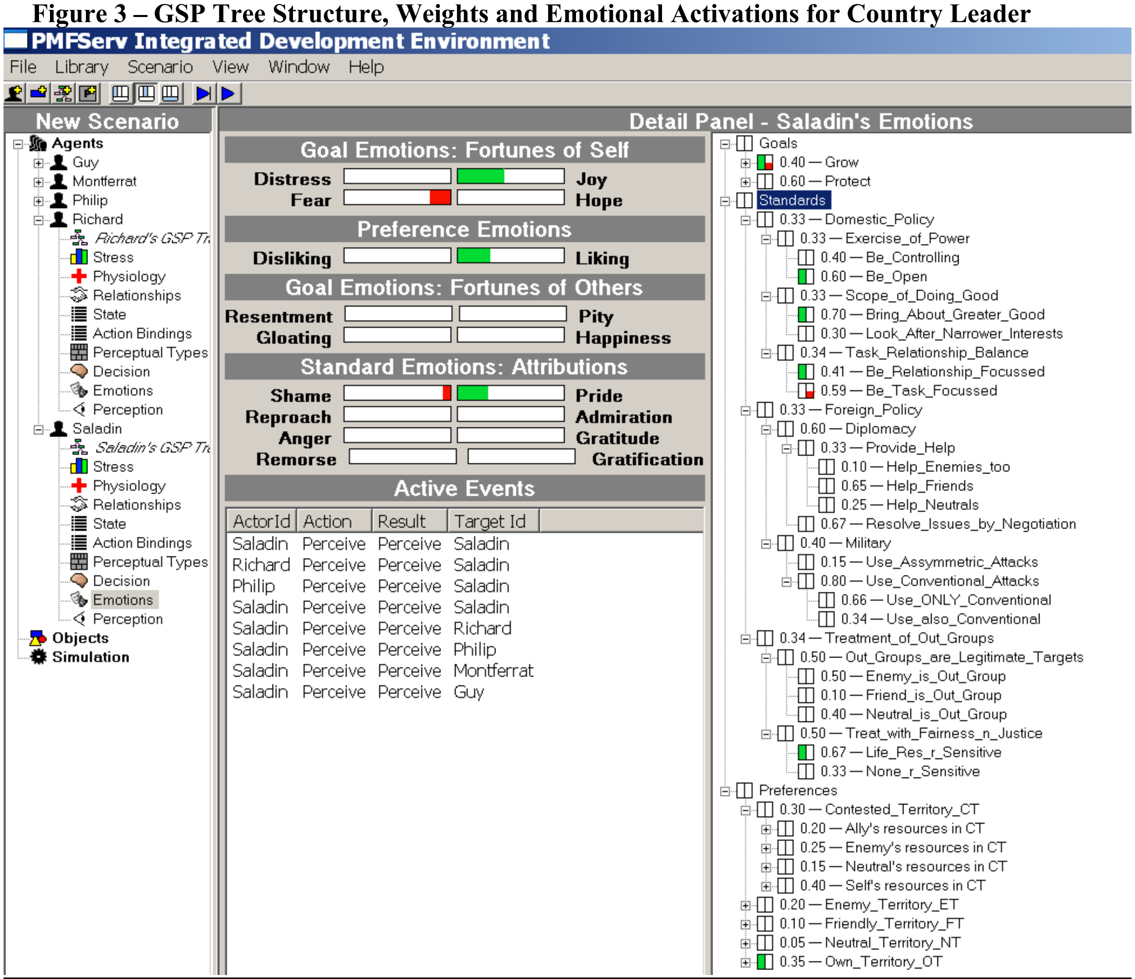
Our LeaderSim implementation includes a full set of screens and sliders for quickly tuning these parameters for each leader in a conflict scenario. Due to space limits we omit presenting these here, but interested readers should consult Silverman et al. (2005 –IA wkshp). Using our Hermann implementation moves us toward Aim 2 (best of breed models) as one can populate a game with real leader profiles provided the profiling were done properly. Thus, for example, one could determine which leaders tend to be deceitful vs. honest. Specifically, the leader with low belief in control (trait 1) but high need for power (trait 2) tends toward deceit, while the leader with high trait 1 and high trait 2 tends toward accountability and high credibility. Likewise, the same could be done for the other traits (and our new trait of protocol vs. substance), as we will attempt to demonstrate. Any implementation of a best of breed, paper-based model runs into the catch-22 outlined in Aim 3, and the need to try and enhance that model by integrating it with others and making it executable by autonomous agents. Hermann gives no guidance on how an agent computes if it is achieving its need for power (trait 2). We turn in the next section to a discussion of some of the mathematics needed to complete her model and attempt to interpret it faithfully, yet provide an implementation.

Subsequent sections examine our interpretation in terms of face validity, Turing tests, correspondence tests, and sensitivity analyses.

2.1) Agent Personality, Emotions, Culture, and Reactions

In LeaderSim, each leader is modeled within a framework known as PMFserv (Silverman 2005) where the leader's cultural values and personality traits represented through a Goals, Standards and Preferences (GSP) tree. These are multi-attribute value structures where each tree node is weighted with Bayesian importance weights. A Preference Tree is one's long term desires for world situations and relations (e.g., no weapons of mass destruction, stop global warming, etc.) that may or may not be achieved in the scope of a scenario. In Lsim agents this translates into a weighted hierarchy of territories and constituencies (e.g., no tokens of leader X in resource Y of territory Z). When faced with complex decision spaces, different individuals will pursue different long-term strategies which, mathematically, would be very difficult to compare objectively. Chess players, athletes, and scientists develop their own styles for solving the types of problems they encounter. We make use of the *preference* structure of an agent to account for much of this. For example, one can say that a particular chess player *likes* or is comfortable with certain configurations of the pieces on the board. This allows for the expression of long-term strategic choices that are simply a question of style or preference as to how the world should be.

Figure 3 – GSP Tree Structure, Weights and Emotional Activations for Country Leader



The Standards Tree defines the methods a leader is willing to take to attain his/her preferences. Following from the previous section of this article, the Standard tree nodes are mostly Hermann traits governing personal and cultural norms, plus the additions of protocol vs. substance, and top level guidelines related to Economic and Military Doctrine. Also, we add two standards from the GLOBE study (House, 2004) on scope of doing and sensitivity to life (humanitarianism). Personal, cultural, and social conventions render inappropriate the purely Machiavellian action choices ("One shouldn't destroy a weak ally simply because they are currently useless"). It is within these sets of guidelines where many of the pitfalls associated with shortsighted AI can be sidestepped. Standards (and preferences) allow for the expression of strategic mindsets. When a mother tells her son that he shouldn't hit people, he may not see the immediate tactical payoff of obeying. However, this bit of maternal wisdom exists and has been passed down as a standard for behavior precisely because it is a nonintuitive strategic choice whose payoff tends to derive from what *doesn't* happen far into the future as a result. Thus, our framework allows our agents to be saved from their shortsighted instincts in much the same way as humans often are.

Finally, the Goal Tree covers short-term needs and motivations that implement progress toward preferences. In the Machiavellian and Hermann-profiled world of leaders, the goal tree reduces to a duality of growing vs. protecting the resources in one's constituency. Expressing goals in terms of power and vulnerability provide a high-fidelity means of evaluating the short-term consequences of actions. To this, Athena also adds 3 options for manage reputation (switch from none, to mirroring, to bounded rational) instead of just mirroring in Lsim.

With GSP Trees thus structured, we believe it is possible to Bayesian weight them so that they will reflect the portfolio and strategy choices that a given leader will tend to find attractive, a topic we return to in Section 4 of this write-up. As a precursor to that demonstration and to further illustrate how GSP trees represent the modified Hermann profiles, consider the right side of Figure 3. There we see the weighted GSP tree of Saladin. Other papers discuss how the weights may be derived so as to increase credibility: e.g., see Bharathy (2006), Silverman (2002a,b, 2006 pt.2). Here it is more pertinent to discuss how the G-tree implements the Hermann power vs. protect trait. Beneath each subnode that has a + sign, there are further subnodes, but under the G-tree (and P-tree) these are just long sets of constituency resources with importance valuated weights and hence they aren't show here. The standards or S-tree holds most of the other Hermann traits and their important combinations, such as traits 1 and 2 that combine to make the four subnodes covering all possibilities of Belief in Control vs. Need for Power. Likewise, there are subnodes for the intersection of In Group Bias vs. Degree of Distrust. Openness, as mentioned earlier, is a direct replacement for two other traits, while task vs. relationship focus is also supported. The modifications to Hermann show up as the protocol vs. substance subnodes and the key resource specific doctrines of importance to that leader. In Saladin's case most weights are fairly balanced, while in Richard's case, the G-tree weights show he leans heavily toward power and growth which is also consistent with his P-tree weights on his own resources. His standards reveal him to be Hi BnC - Hi N4C, Hi IGBias - Hi Dtrust, Low Openness, substance- and task-focused, and favoring asymmetric or non-conventional attacks (he did slaughter thousands of unarmed townsfolk).

Just to the left of the weight value on each node of the GSP trees of Figure 3 are two "reservoirs" that reflect the current activation of success and failure of this node, respectively. These reservoirs are activated and filled by events and states of the game world as observed by the agent. Figure 3 shows the start of a game where Saladin has yet to be attacked and he perceives the world in a fairly satisfied light. In general, we propose that any of a number of *k* diverse activations could arise with intensity, ξ, and that this intensity would be somehow correlated to importance of one's GSP values or node set (GSP) and whether those concerns succeed or fail for the state in question. We express this as

$$\xi_k(b \in B) = \sum_{j \in J_k} \sum_{v \in V} \left[Wij(v \in V) * \Phi(r_j) * \zeta(v) * \psi \right] \quad [1]$$

Where,

$\xi_k \rightarrow \xi_k(b \in B)$ = Intensity of activation, *k*, due to the bth state of the world.

J_k = The set of all agents and objects relevant to *k*. J_1 is the set consisting only of the self, and J_2 is the set consisting of everyone but the self, and J is the union of J_1 and J_2.

$W(v \in V)$ = Weighted importance of value set V to the agent.

V = The set of goals, standards, and preferences held by the agent.

$\phi(r_j)$ = A function that captures the strength of positive and negative relationships one has with agent or object j that are effected or spared in state b.

$\zeta(v)$ = degree of activation for a goal, standard, or preference

ψ = A function that captures temporal factors of the state and how to discount (decay) and merge one's GSP activations from the past (history vector), in the present, and for the future

It is important to note that the weights adhere to principles of probability; e.g., all child node insights add to unity beneath a given parent, activations and weights are multiplied up a branch, and no child has multiple parents (independence). Although we use fixed weights on the GSP trees, the reservoirs serve to render them dynamic and adaptive to the agent's current needs. Thus, when a given success reservoir is filled, that tends to nullify the importance of the weight on that node (or amplify it if the failure reservoir is filled). In this fashion, one can think of a form of spreading activation (and deactivation) across the GSP structure as the scenario proceeds.

According to other best-of-breed models (Damasio, 1994; Ortony, Clore, and Collins, 1988; Lazarus, 1991), our emotions are arousals on a set of values (modeled as trees) activated by situational stimuli as well as any internally-recalled stimuli – e.g., see full descriptions of these models in Silverman et al. (2002a,b, 2006a,b).These stimuli and their effects act as releasers of alternative emotional construals and intensity levels, and they assist the agent in recognizing problems, potential decisions, and actions. According to the theory, the activations may variously be thought of as emotions or subjective (moralistic) utility values, the difference being a matter of semantic labeling. Within such a framework, simply by authoring alternative value trees, one should be able to capture the behavior of alternative "types" of people and organizations and predict how differently they might assess the same events, actions, and artifacts in the world around them.

2.3) Agent Decision Making

What is missing in the previous section is how an agent notices the game world, moves of others, and sense of situation. This discussion will illustrate how this happens using one Hermann factor (power and vulnerability) as an example. Hopefully, it is fairly straightforward for the reader to extend that to how the other factors are also deployed. Full details exist in Johns (2006).

Central to a given leader's G-Tree reasoning is its perceptions of who threatens it and/or whom it's vulnerable to. Likewise a given leader may be equally interested to estimate who can it influence to best increase its resource assets and thereby its power in the world. Obviously, GSP tree weights will govern how aggressively a given leader pursues each of these vulnerability vs. power concerns, however, we assume that all leader agents need to be able to compute how vulnerable and/or powerful they are at each turn of a game. Since the game rules define precisely which resources can be used to take hostile actions against which other resources, one can derive a measure of a player's *vulnerability* directly from the state of the game world and the rule set. Intuitively, by factoring vulnerability into the world utility calculation, an agent can avoid world configurations in which another is poised to conduct a devastating attack. Adding border defenses, stocking up on supplies, and pulling money out of the economy can all be viewed as behaviors motivated primarily by vulnerability management.

The vulnerability formula (β) works by generating the percentage of a given player's tokens that can be expected to be lost to a given player in the coming round of attack actions (ai). For each hostile action ($a_i \in A$) that can be initiated by another player (g), the number of tokens available to attack and defend is tallied. From this the probability of victory is determined, and then multiplied by the percentage of tokens vulnerable to this attack versus the total number owned by the vulnerable player in each resource category. This is the expected percentage of tokens to be lost if this attack occurs in the next round. The maximum over all attacks, then, gives this player ℓ's vulnerability score β to player y.

$$\beta xy = \text{Max}\, a \in A \left\langle \Pr(a) * \frac{\sigma(x,a)}{C(x)} \right\rangle \qquad [2]$$

Agents who purely manage vulnerability, while interesting in their behavior, are not entirely realistic. Human players tend to balance vulnerability against its inverse, *power*. Where vulnerability measures the expected number of tokens a player can lose to other players in the coming round, power measures the expected number of tokens a player can take from others. The calculation of the power heuristic is exactly the opposite as for vulnerability. Player A's vulnerability to Player B is the same as Player B's power over Player A.

Taking the leader's perceived difference between power and vulnerability provides a surrogate for the leader's overall sense of utility of the current state of the world, G, when divorced from his value system and other factors:

$Ul(Gx) = \alpha x - \beta x$ [3]

Recall, however, that a given leader agent (1) tracks who is aligned with whom, tallying things like trust, (2) monitors all resource levels and who used what actions upon them, and (3) its own actions to achieve its long term preferences or P-tree, as modulated by its standards. Thus α and β serve primarily as activations on the leaf nodes of some of the GSP tree branches. PMFserv uses a wide assortment of similar activation mechanics for other factors and computes the Expected Utility (EU) of the world and of new action possibilities when projecting next steps. That is, PMFserv serves as the point where diverse GSP personality and cultural value sets, stressors, coping style, memories, and perceptions are all integrated into a decision for action (or inaction) to transition to a new state (or remain in the same state) and to determine the portfolio of strategies-moves-actions that best maximize that agent's GSP Tree values as mfollows.

$$\mathrm{Max\,EU}(a) = \sum_{b \in Ba} Ul(b) * pr(b) \quad [4]$$

Where,
$a \in A$
A = action set available after GSP and stress-constrained perception
$p_r(b)$ = probability of action *a* leading to state *b*

$$u_l(b) = \frac{\sum_{k \in K} \xi_k(b)}{11} \quad [5]$$

Utilities for next actions, a_k, are derived from the activations on the GSP trees in the usual manner as in Silverman, Johns, et al. (2002a, b) and as Silverman et al (2002a, b) and as briefly summarized for power and vulnerability here. That is, utility is the simple summation of all positive and negative activations for an action leading to a state. Since there will be 11 pairs of oppositely valenced activations in PMFserv's emotion model, we normalize the sum as follows so that utility varies between –1 and +1.

2.4) Formulating Speech Acts

A large part of the value of our paper-based multiplayer game comes from the interaction among players. Indeed, while the game mechanics provide a concrete scenario with quantified parts, it is the interpretation of board configurations and resulting relationships among players that are of primary importance. A large part of this interaction concerns the communicative acts and conversations that ensue. Another finding was that we could sort the hundreds of speech acts across several dozen sessions into a rather simple taxonomy consisting of agreements, threats, and statements of motivation. In Athena we have added a human to human chatting window as well as a contract language for sending and receiving speech acts to the agents. Also, espionage budgets can be allocated to try and eavesdrop and learn which agents are conspiring and possibly even the content of some of their messages.

1) *Agreements* are proposed lists of actions for two or more parties. If all parties accept, a contract is formed. Agreements are composed of both promises to perform certain actions as well as promises not to perform certain actions in the future. Agents keep track of who keeps or reneges on agreements.
2) *Threats* are similar to agreements, but rather than striving for mutual benefit, a threatening agent instead gives another player a choice between two distasteful acts. Threats involve two parties: the threatening agent (L_1), and the threatened agent (L_2), and consist of the desired action on the part of the threatened party (a_1), and the action to be carried out by the threatening party if the other fails to comply (a_2).
3) *Statements of Motivation* are lists of actions the utterer thinks are important and if another agent values that utterer, the motivation should provide added activations on the GSP trees when following it. These could be fatwas, calls for Jihad, a Pope's speech to kill infidels, deceptions, and so on. Motivational statements take the form "I want to [grow/destroy/ignore] L_x's C_i", where L_x is a leader or group and C_i is a resource belonging to L_x or "I favor A_j's against L_x" where A_j's are actions in A.

An Lsim or Athena agent can invoke PMFserv to compute the expected utility of agreement, threat and/or motivation statements. For example, for threats, supposing ℓ_2 can perform an action of higher utility to ℓ_1 than could be done otherwise, then it is worthwhile to search for actions that can induce ℓ_2 to perform it. The ℓ_2 then searches for actions that ℓ_1 can perform, minimizing the utility to ℓ_2. This allows it to calculate the utilities of heeding and ignoring the threat for both parties.

$$U_{heed} = EU(a_0(\ell_1), a_1) \quad [6]$$

$$U_{ignore} = EU(a_2, a_0(\ell_2)) \quad [7]$$

where $a_0(\ell_1)$ and $a_0(\ell_2)$ are the chosen actions for ℓ_1 and ℓ_2, respectively. If the utility of heeding the threat is greater than ignoring it for both parties, the threat is worth carrying out.

2.5) Intention Modeling and Mirroring Biases

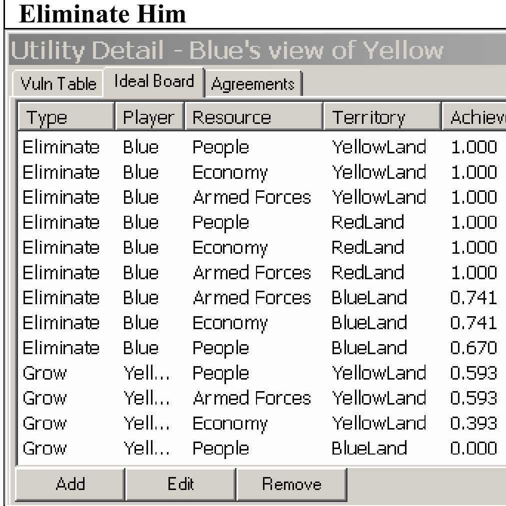
In order to assess speech acts and motivations of others, agents require certain information about the other players of the game. Specifically, an agent needs to be able to evaluate an action from the perspective of another. This is nested intentionality – or – model of mind. For it to work in Lsim, each leader agent seeks to model the goals, standards, and preferences of other leaders to the best of its ability, using starting assumptions (mirroring) updated by observation. It does this so that its subjective expected utility algorithm can determine the likely next moves of the other players it is most threatened by and/or most hoping to influence.

As mentioned earlier, our Aim #2 is to try and implement realistic heuristics. As a starting set of heuristics, Heuer (1999) indicates people commonly use mirroring and confirmation. We accomplish this by modeling the utility functions of other agents as derived from one's own goals, standards, and preferences. Models are initialized through a "mirroring" process, where agents assume that the motivations of other agents are similar to theirs, but inverted. As implemented, this involves copying GSP trees and swapping names where appropriate. For instance, if L_x wants to destroy L_y's armed forces, L_x assumes that L_y wants to destroy L_x's armed forces as well. These assumptions are updated as action unfolds via observation as follows. Suppose leader L_x performs an action A_y:

- For each resource C*i*, determine whether A_y has increased or decreased its vulnerability β
- If C_i is less vulnerable, he must want to protect it
- If C_i is more vulnerable:
    - If L_x owns C_i, he must not value its protection
    - If L_x does not own C_i, he must want to destroy it

Figure 3 – Using the Mirror Heuristic to Model the Intentions Of Others

a) Blue Thinks Yellow Wants to Eliminate Him



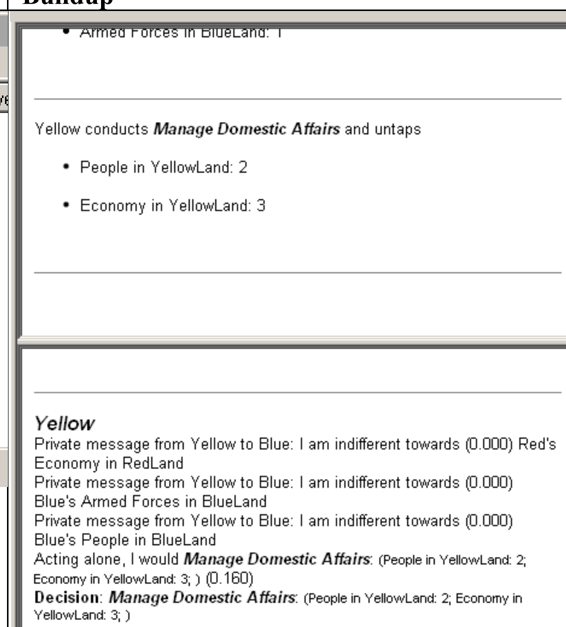
Utility Detail - Blue's view of Yellow

Vuln Table | Ideal Board | Agreements

Type	Player	Resource	Territory	Achieve
Eliminate	Blue	People	YellowLand	1.000
Eliminate	Blue	Economy	YellowLand	1.000
Eliminate	Blue	Armed Forces	YellowLand	1.000
Eliminate	Blue	People	RedLand	1.000
Eliminate	Blue	Economy	RedLand	1.000
Eliminate	Blue	Armed Forces	RedLand	1.000
Eliminate	Blue	Armed Forces	BlueLand	0.741
Eliminate	Blue	Economy	BlueLand	0.741
Eliminate	Blue	People	BlueLand	0.670
Grow	Yell...	People	YellowLand	0.593
Grow	Yell...	Armed Forces	YellowLand	0.593
Grow	Yell...	Economy	YellowLand	0.393
Grow	Yell...	People	BlueLand	0.000

Add | Edit | Remove

b) Yellow is Indifferent to Blue, Continues Buildup



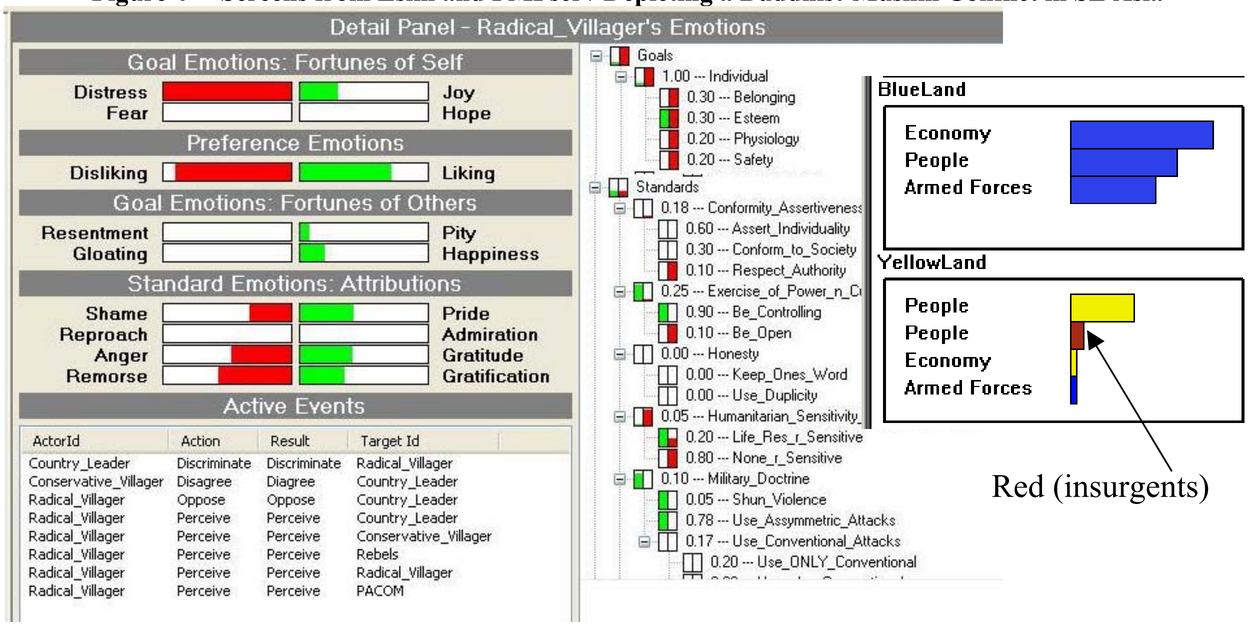
As an example, in the current Lsim scenario of earlier Figure 2, Yellowland (Saladin) has no aspirations towards the elimination of other parties (its P-Tree values are only to grow its own resources), plus he values out-groups, relationships and sensitivity to life as much as other factors. This causes Saladin to play chivalrously, or at least with tolerance. Indeed the bottom right of Figure 3 shows Yellow's motivational speech acts to Blue about how he is indifferent to either Blue or Red. The trace of his action choice in the next move (upper right) shows he ignores them and focuses on managing domestic affairs (build up of his internal tokens and power). However, both BlueLand (Guy) and RedLand (Richard) prefer to eliminate Yellow folks from their own lands and elsewhere. Also we set up the game so that RedLand and BlueLand have roughly congruent value systems (except economically where they wish to 'constrain' each other on their P-trees). By constructing the Other-Leader P-Trees with the mirror method, each of them tend to find the other compatible, yet they both also fear encroachment by the Yellow leader (left side of Figure 3 is Blue's model of Yellow). Since Yellow is richer in all resources, Red and Blue start out feeling quite paranoid, vulnerable, and threatened by Yellow's continued existence. In this case, this is a beneficial thing for Red and Blue since, while Yellow has no specific interest in eliminating either Red or Blue, this would certainly be a side-effect of Yellow's imperialism. In all three runs of Section 4.1, Blue and Red start out with attacks on Yellow. This in turn precipitates Yellow updating its model of Blue and Red, and becoming increasingly concerned with the avoidance of board configurations that leave his resources vulnerable to either. This benefits Yellow by emphasizing the need to protect what one already owns while trying to acquire more. However, these effects can also prove harmful. Suppose Yellow was in fact not imperialistic and instead preferred to see Red prosper. The mirroring process would nonetheless cause Red to initially believe Yellow was out to destroy him. This would cause Red to be extremely careful about his vulnerability to Yellow, when in fact there is little threat. Worse yet, Red may choose to pre-emptively attack Yellow in order to reduce this vulnerability, consequently wasting both his own resources and those of one who would have put them towards advancing his ideals.

3) Modeling Follower Value Systems: The Evolution of Dangerous Ideas

We introduce three refinements in order to also be able to model the values and motivations of followers – (1) additions to the GSP trees, (2) a group-affinity profiling instrument, and (3) group transfer dynamics. In keeping with Aim 2, each of these refinements is an implementation of a well-respected model drawn from the social sciences. In this section, we describe this integration and synthesis in terms of an example individual Villager from a SE Asian country. He grew up as a Muslim in a society with a Buddhist majority (Blueland on right of Figure 4), where the Buddhists occupy the cities, hold the elected posts, and get the best jobs. Most of the Muslim's are villagers in the rural provinces, a region they would like to separate and have autonomy over (shown as Yellowland), The elder villagers tend to be more moderate and compliant, while the younger ones, like the one modeled in Figure 4, were sent to Wahhabi schools elsewhere, went to college for training, and have returned to find there are no sources of employment that will use their college training (Yellow's economy is very low in Figure 4). Further, their religious practices are frowned upon, their community is unable to open Wahhabi schools officially (these are being operated by the returned college grads in their homes), and their initially peaceful protest events have been met with police brutality (Blue ArmedForces present in Yellowland). The bottom left box of Figure 4 shows the country leader has been discriminating against Muslim villagers, the moderates disagree with these policies, while this individual is opting to "oppose". He is just at the juncture of having switched groups from moderate villagers to the local insurgency (Red tokens on right side in YellowLand) which itself is on the verge of connecting with groups such as Jemaah Islamiah and Al Qaeda if the discrimination continues. Let us now see how the three sets of refinements allow the PMFserv model to capture such a radicalization.

In terms of the GSP tree changes, as the right side of Figure 4 reveals, there are additional nodes on the Goal and Standards trees. While Figure 4 does not show the full trees, the previous goals and standards are still there but may be zeroed out if this is strictly a follower, or may be left in at some degree of importance if this is a mid-level leader. For villagers in general, where day-to-day existence is a struggle, Maslow's hierarchy of needs is considered a useful representation of the range of short term goals that a person might have to be concerned about. Each of these nodes are activated by lower level branches on the tree, tanks in the physiology and stress model, or the affinity instrument described below. Clearly all of this individual's basic needs are failing to be met, and the Malovian nodes are all activated with negative stimuli in this example, accounting for the extreme distress level of the goal emotions on the left of Figure 4. In terms of the Standards Tree, the Hermann factors are all still there, but two new nodes on the tree exist that capture several Hofstede (198x) and House (2004)'s GLOBE study cultural factors. Conformity Assertiveness is a way to capture Hofstede's Power-Distance and Individualism factors (respect authority, conform to society) with the GLOBE study's Assertiveness factor. Likewise, the Humanitarian node is a GLOBE factor. The weights on Figure 4 for this villager's standards reflect his idealism, training in religious and college settings, and his alienation. Hence he differs from the moderate villagers in the various Hofstede and GLOBE factors, and also his personal 'military doctrine' does not shun violence. According to Sageman (2004), these are the seeds, but they do not alone explain performing violent and suicidal acts. The activations on his Standards tree tanks must also be such to tip him from just disagreement and protest over to actual physical opposition and violence. We turn now to the second set of refinements that enable radicalization and provide the needed extra activations for these tanks.

Figure 4 – Screens from Lsim and PMFserv Depicting a Buddhist-Muslim Conflict in SE Asia



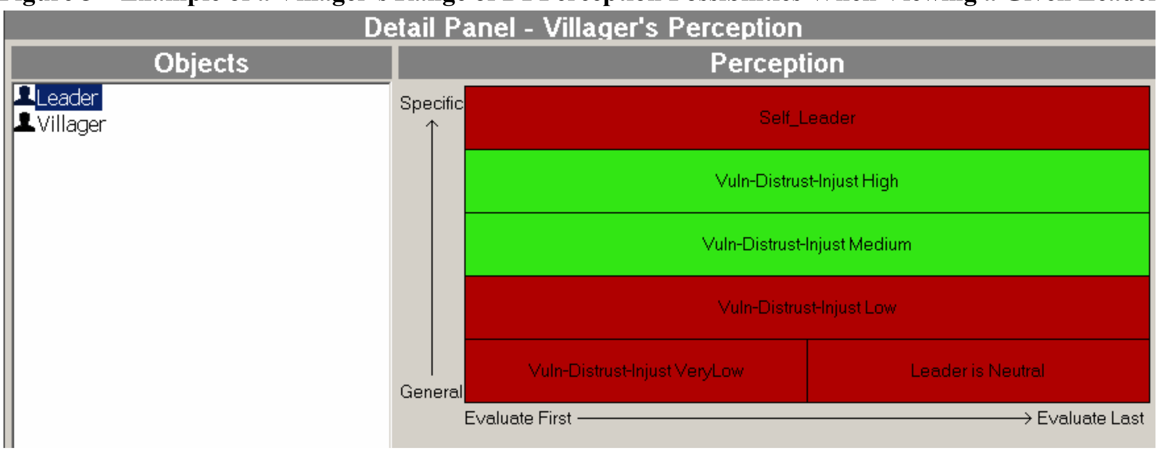
Specifically, for determining an individual's group affinity, one needs an instrument that measures it. The instrument that we have adopted here involves Eidelson and Eidelson (2003) who have developed a five belief ("dangerous ideas") framework for better understanding the psychology of individual-group dynamics particularly relevant to conflict settings. These five beliefs revolve around issues of vulnerability, injustice, distrust, superiority, and helplessness(in short H|VID|S):

•*Vulnerability* (V) Revolves around a sense of living in harm's way amid constant threat and peril.
•*Injustice (I)*. Reflects perception of being victim of mistreatment by specific others or by the world at large.
•*Distrust (D)*. Focuses on the presumed hostility and malicious intent of other individuals or other groups.
•*Superiority (S)*. Revolves around conviction of being better than others—morally superior, chosen, entitled, or destined for greatness.
•*Helplessness (H)*. Refers to perceived inability to influence or control events and outcomes; self-perpetuating because it diminishes motivation.

Eidelson has developed the Individual-Group Belief Inventory (IGBI) to measure these five beliefs at three different levels of analysis: (1) an individual's personal beliefs about his personal world; (2) an individual's personal beliefs about a specific group in which he holds membership; and (3) an individual's personal perceptions about the shared beliefs this group holds about itself. In the simulation work described here, we have focused on the second of these three levels, namely the beliefs that individual group members hold about their group (in future work we may attempt to more fully implement the other levels of analysis as well). These beliefs are considered particularly important influences on a group member's perceptions of his/her group's current circumstances and future prospects. In our current modeling work, we have simplified the dangerous ideas framework into three domains by combining the vulnerability, injustice, and distrust domains into one broader domain (hereafter labeled VID) representing a member's belief that his/her group has legitimate grievances against a threatening adversary.

The PMFserv implementation of this model lies in marking up diverse leaders and groups with all possible levels of "dangerous ideas" (DI) that they could afford to different potential members and perceivers of their group. Depending on the perceiver, two individuals may view the same group as superior or inferior, as suffering grave injustices or as exaggerating minor slights, as helpless or capable of effective action, and so on. The markups expose all the possibilities and include universal rules that apply to all viewers. Thus if a viewer sees a group as helpless and he doesn't want to be helpless, there will be negative activations for remain loyal to this group and following its action choice policies. Conversely less negative (and possibly positive) activations will be afforded for the member who exits away from this group perceived as helpless. The mechanics of how PMFserv handles perception have been covered in Cornwell et al. (2003), Silverman et al. (2005, 2006a) and we won't go into them in full detail here except to mention that once markup is done, perceptual types are driven by the agent's emotional and utility construals of the current state of the world. For example, when Standards and Preferences are perceived to be violated Injustice and the anger emotion are aroused, while Vulnerability comes from the Safety failings on the GSP tree, and emotions about that. Part of a Muslim villager's perception of the Bhuddist country leader is as shown in the PMFserv screen of Figure 5 which reflects a range of VID parameter settings (neutral, very low, all the way to High), and the fact that the villager sees the leader as causing VID High. This perception on the part of the villager is based on observing actions that the leader has taken to discriminate against Muslims (no jobs), to deny their request for Wahhabi schools, to brutally put down protest, etc. Conversely, Buddhists who view this leader see him as neutral, or low VID. The former would be for those in his political party, while the latter would be others who pursue normal political processes to resist his positions. Likewise, the Muslim villagers and Buddhists will form similar judgments about the various Muslim groups/leaders in the scenario.

Figure 5 – Example of a Villager's Range of DI Perception Possibilities When Viewing a Given Leader



Up to this point we have seen how an agent's GSPs and perception of the range of possible DI markups permit him to examine the state of the world and assess the utility and emotional construals that each group/leader affords up to that point. What remains is to examine the third piece, the parameters that govern switching group affinities, and for that we implement a Hirshman (1970) type model on exit, voice, and loyalty. Graphically, one may imagine a vertical axis with VID increasing and the horizontal axis as members of that group. The loyalty for remaining in that group is governed by the slope or elasticity of the downward sloping demand curve. As VID rises, members may express their grievance (GR) as voice, if their grievance tolerance passes a threshold, they may chose to exit the group. Hirshman's research concerned consumers who found exit less costly than voice (complaints). In a political world, exit is more costly, and hence voice to complain and improve situations will be of import.

Mathematically, the reader may recall ϕ (r_{ij}) from earlier Equation [1]. Here we examine the case where j is a group (or leader) and the term refers to the membership, relationship, or strength of affinity of agent i to group j. An agent i can belong to multiple groups at varying strength according to,

$$\Phi(r_{iA}) = \frac{Superiority_A \times GSPcongruence_{iA}}{VID_{Ai}} \qquad [8]$$

where Superiority and VID are from DI instruments if available, else derived by GSP trees of agent I in reacting to leader or group A. Groups are characterized by GSP weights for the average of all members as well as by property lists defined a priori (religion, political system, etc.), and GroupPorosity factors. GSP congruence is estimated using the sum of the means square differences in the GSP nodes. GSPcongruence = 1 – Sqrt[Sum[(wi1 –wi2)^2], which is the correlation of the weights between two GSP trees. If an agent is in Group B, it will not be drawn to a Group C whose GSP archetype is substantially incongruent to its own. If an agent is in a group (or under control of a leader) whose average GSP is greatly different from its own, the agents tend to use Voice to resist the leader or attempt to Exit to another group, depending on porosity. Let us now see how each of these work.

If agent i desires to exit from any group A to join any C, this is governed by the delta in utility of membership in each group plus a cost factor adjusted for transfer rate or demand elasticity. If the delta is positive, or larger than some loyalty factor, exit may occur. Let, this delta be

$$\Delta\Phi_i = [U(\Phi_C) + COST_{TR}/TR_{AC}] - U(\Phi_A) \quad [9]$$

where,

U(ϕ)	=	utility of membership, found by invoking the PMFserv emotion model and GSP trees
$COST_{TR}$	=	cost of migration, land costs, and lost opportunity costs
TR_{ij}	=	Transfer Rate or group porosity, a measure of ease of entry to or exit from group j for agent i. (TR is a negative value that grows larger as porosity grows)

$$TR_{A\rightarrow C} = Salience_{ExitA} \times Salience_{EnterC} \times GSPcongruence_{iC} \quad [10]$$

This is the transfer rate and it varies between (0,-1). Salience is the extent to which a group permits exiting by ingroup members, and entry by outgroup members. It is the porosity permitted by the group. There is a tuple or value pair that gives both salienceForEntry and salienceForExit. The demand elasticity for exiting a group is 1/TR.

Assuming COST is too high or TR is too small and an agent cannot exit, then their options are to remain silent or use Voice to express their grievance over VID levels. Let, GR_{ij} be the expressed grievance level by agent i relative to group j. This is computed as the negative emotions activated when agent i perceives the VID levels of a given group or leader's actions. GR is thus feelings about the world due to actions that violate one's GSPs and that cause negative emotional utility. In the current model, expressed Grievance is fed from the levels of the goods and security tanks and the individual actions of the leader to affect what these contain. Of course, perceived Grievance alone does not make a rebellion, but it might contribute towards the rebellion. The Grievance should be combined with a feeling that the other group or in this case, the leader or the central authority, induces helplessness, vulnerability, injustice, distrust, and/ or attack on superiority. As the leaders did with Figure 1, the followers similarly take each set of opposing groups and place them along a scale as shown below. The decision that the villagers make is expressed as grievance, where the grievance is in the scale of –4 to +4 are given below (also shown are the Grievance State IDs of the simulation of Sect 4.2):

←				Villager Decision				→
Sacrifice, Go on Attacks	Support, Vote for GroupA	Join Authority Group A	Agree	Neutral (undecideds in Group B)	Disagree, Vote against A	Join, Opposition Group C	Oppose, Non-Violent	Fight Rebel, Exit A
-4.0	-3.0	-2.0	-1.0	0.0	+1.0	+2.0	+3.0	+4.0
				GS0	GS1	GS2	GS3	GS4

These actions are on abstract scale, which ranges from total support of the majority that is oppressing you (if you can't lick them, join them), to being undecided and/or helpless in the middle, to the other extreme of supporting and ultimately exiting A and joining the insurgency. At the extremes on either end, the agent will submit to militaristic commands of the leader of that group, while at the next level two lower levels they will be only willing to go to protests, and verbally and economically support the activities of that group's leaders. Thus, every state all the way through GS4 represent Voice. We only permit Exit from A and joining of C after occupying GS4 for a significant interval.

In terms of our Villager from earlier Figure 4, he has just transitioned from the undecided or neutral Muslim villagers category to the OPPOSE level (GS3). He saw Country Leader as creating high VID. The insurgency group, however, has high GSPcongruence for him and low salienceForEntry given his religious training. This transfer of primary group membership would afford him relief from his sense of helplessness, and we see his military nodes on his GSP tree getting activations as a result. Since he is not yet at the level of performing missions, both his shun violence and asymmetric attacks are simultaneously activated.

4) Socio-Cultural Game Results to Date: Turing, Correspondence, and Sensitivity Testing

The previous section delineated the human behavior model of leaders and followers in terms of value trees and activation mechanics in PMFserv. Here we turn to an examination of how these archetypes work in a game. The results about to be presented serve several purposes. First they are part of a test as to whether we can implement personality profiling frameworks such as Hermann and DI with any success (Aims 1 & 2), and whether our extensions are effective (Aim 3). Also, these results provide insight into what is needed as next steps. Next, these results offer validity assessment insights of our cross-cultural Sims including Turing and historical correspondence tests. Finally, once validity is established, it is interesting to use the models and gameworlds to explore what-ifs and sensitivity of outcomes to alternative competing action policies, leader styles, and other group parametrics (Aim 4).

4.1) LeaderSim: Fighting Due to Misconceptions, Exploring Alternatives

In this section we configure the game in Lsim to involve 3 autonomous leader agents - Yellow (Saladin), Red (Richard Lionheart) and Blue (Guy of Lusignan), each with 3 resources as shown in Figure 2. There are no human role players, and followers are just tokens under the control of the leaders. The GSP trees of the leaders are as already described.

In this section, the longitudinal plots are strip charts summing the strength of all 3 resources over time (turns are a surrogate for time) for each leader. Being stochastic systems, repeating the runs of the game with identical starting conditions such as above can produce different results due to chance and randomness of action outcomes. The outcomes (I & II) in Figures 6 are example runs illustrating two possible futures from the same starting conditions.

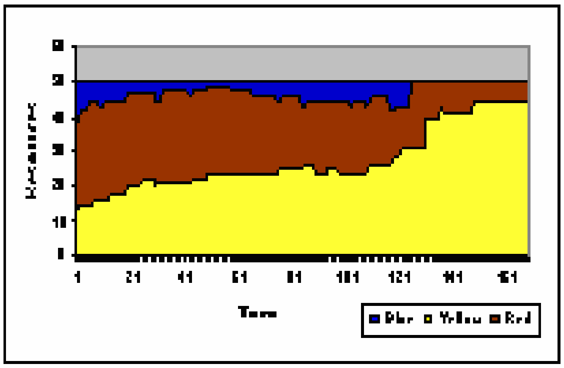


Figure 6A: Resources vs. Turns for Outcome I

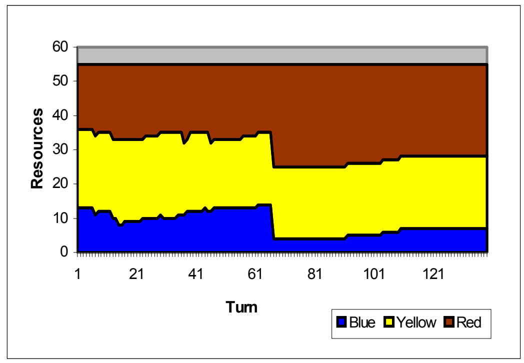


Figure 6B: Resources vs. Turns for Outcome II

4.1.1) Correspondence Tests -- The actual course of the Third Crusade involved most battles going in Saladin's favor, and in the end Richard only secured the rights of Christians to live in and visit Jerusalem. Guy lost his right to the throne of the Latin Kingdom of Jerusalem when his wife died, and was banished to Cyprus. Figure 6a seems remarkably in accord with that history. It begins with Yellow (Saladin) being attacked by Red and Blue, but unfolds in Yellow's favor. In the end, Blue (Guy) is eliminated from the game board and Red (Richard) only survives by removing his military and economy and specializing in a non-threatening resource (People).

However, we are not running a warfare model, but rely instead on dice rolls for the outcome of each individual battle. If we do not bias the battle outcomes to fall largely in Yellow's favor (or add substantially more Yellow military), we can wind up with very different outcomes. Figure 6B shows Red growing more powerful, and all three co-existing by the end, where a somewhat stable equilibrium takes hold. In fact, this seems like the outcome of the First Crusade where the Crusaders did dominate until Saladin amassed a large army, defeated Guy, and retook Jerusalem in the Second Crusade.

4.1.2) Turing Test – This test is whether a knowledgeable reader would view the agent's decisions as similar to what the real human would tend to do, and feel, under those circumstances. In a separate paper, we expose the Richard leader to a stimuli – that of the weakly-defended, wealthy city of Acre. He proceeds to siege the town, demand ransom for sparing it, and finally slaughters all inhabitants when ransom payments are too slow: Silverman & Bharathy (2005). In the current paper, rather than repeat those results, Figures 7A-D illustrate (using Outcome of Fig. 6A) the type of parameters that are tracked and available for inspection. They respectively include (but are not limited to) Utility, Error of Impression of the Opponents' Preference Tree, Power (or its inverse, Vulnerability), and Preference Achievement. Each of these figures includes an explanation of the 3 leaders. Upon showing these to reviewers, the response is generally favorable. At any juncture, one also can drill into the heads of any of the leaders and inspect the GSP trees and succeed/fail buckets (as in earlier Figure 3)

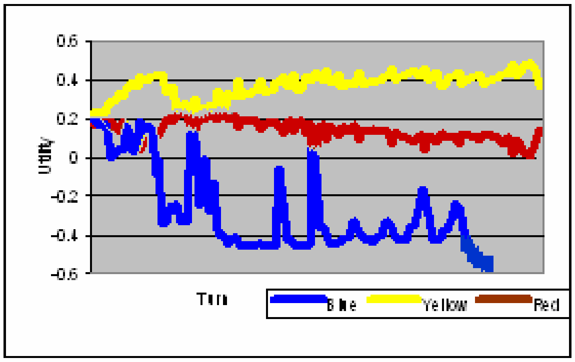


Figure 7A: Utility vs. Time
Yellow's utility is highest since he is able to grow. Blue is driven to the brink of extinction early on, and suffers a big dip in utility as a result. Red's utility of the game shrinks only marginally. This may be since his GSP is task-focused (war itself) and insensitive to life, plus he is able to withdraw with a symbolic win (People remain).

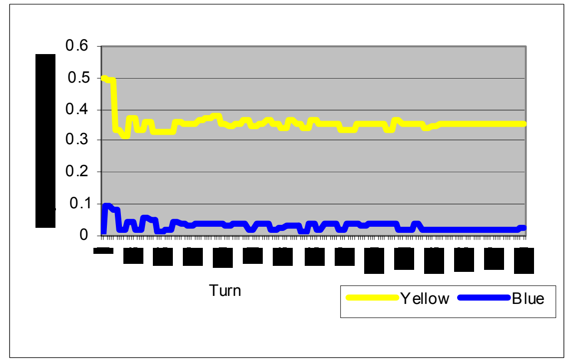


Figure 7B: Impression Error vs. Time
By mirroring, Red is consistently able to assess the compatible GSPs of Blue, but suffers from significant error when it comes to assessing the goals and preferences of Yellow.

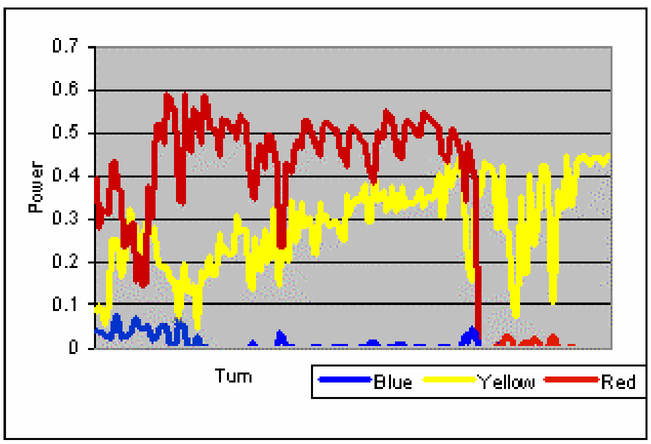


Figure 7C: Power vs. Time
The above figure shows the rise of power for Yellow and the fall of Blue and Red. These parameters activate "distress vs. joy" on the leaders' Goal Tree, as well as the emotions about the fortunes of others (e.g., gloating, resentment, etc.).

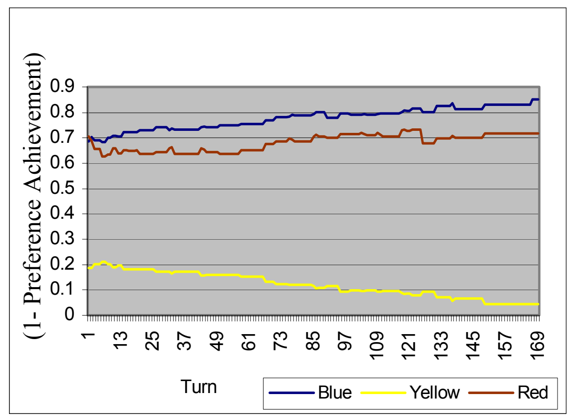


Figure 7D: Preference Failure vs. Time
Failure (1-preferences) measures how unsatisfied each of the leaders is over time. Yellow-L's low and declining preference is understandable in a world of growth. This measure correlates with the "like and dislike" emotions.

Turing Test and Cooperate-Defect Behaviors –Hobbes (1947[1651]) posed the influencing issue with which we opened this article as the central dilemma of political science -- how to persuade individuals to act in the interest of the collective. Too often, this has come to be framed as the Prisoner's Dilemma game where the implication is that rational, non-trusting individuals will act in their own self-interests (defect) rather than for the collective good (cooperate), even though the latter would improve their utility as well: e.g., see Axelrod (1993). While game theoretic PD formulations are commonly researched and taught, there is recent evidence that this is not necessarily how real people act. In fact, there is now strong laboratory evidence documenting humans' frequent willingness to cooperate even in one-shot PDs where the incentive to defect is substantial and unambiguous: e.g., see Field (2001), among others. Conversely, individuals in tribes (e.g. in the Crusade factions, or in today's MidEast) are renowned for harboring grudges against each other for years, yet these fade when they are faced by a common enemy.

Such behaviors seem to be spontaneously emerging in the game results of Figures 6-8. For example, due to their perceived preference compatibility, Red and Blue discount their vulnerability to one another when making decisions, and amplify the importance of avoiding vulnerability to Yellow due to the fact that some of their preferences conflict directly with what they perceive to be Yellow's preferences. This creates an implicit pact between Blue and Red, with no acts of communication uttered, in which they will sometimes, in their pursuit of Yellow's destruction, create opportunities for one other to cause harm, and trust that these will not be exploited. For instance, suppose all three leaders have equal strength in military resources and it is Blue's turn to act. Blue may consider a full-scale attack against Yellow, which would ordinarily be hampered by the fact that allocating all of his military resources to such an attack would allow Red to destroy these exhausted forces at will on his next turn. However, since Blue believes their goals to be compatible, and destroying the resources of those who will use them to advance one's own preferences is unwise, Blue can discount, if not entirely dismiss, this concern. Of course, Blue's model of Red's preferences is imperfect, and consequently this unspoken agreement may be broken when Blue does not expect it. Indeed, when Yellow is countered, we see Red and Blue facing off militarily.

4.1.3) Sensitivity Analyses – If one accepts that the results of correspondence and Turing tests are within the satisfactory range, then the logical implication is that a CultureSim toolset should be viable for helping to generate and study alternative competing hypotheses (ACH) about the world, how to reduce conflicts, socio-cultural parameter elasticities, and so on. One would like to use it to design experiments, for example, to see if there are multiple different policies or action sets that can lead to the same outcome. We have not yet (been funded to) set up a Monte Carlo Simulation dashboard for running the game world repeatedly for designing ACH experiments that explore the range of personality parameters and action policies. We will not do that here, and such results could go on for many more pages, but we wish to take a few paragraphs to clarify how that might best be pursued.

An obvious analytical question of interest to Yellow would be: What are the ways to reduce conflict without sacrificing cultural (religious) freedoms or altering continual, peaceful growth? There are many avenues that one could design experiments to explore. As but one example, Figure 6A shows that a possibility is to dominate militarily, and indeed that is the historical outcome. However, we have restarted the scenario about a dozen times, and we find that Yellow is conquered by its opponents slightly more than half the time (with yellow managing to survive and sometimes flourish in other outcomes such as in Figure 6A). Clearly, the current relative size of Yellow's military (Figure 2) is insufficient to prevail against the randomness of battle outcomes in all cases. An easy experiment would be to continually enlarge Yellow's starting tokens until the point is found where the predominance of runs lead Yellow to a military victory. The exact percent of time that Yellow should win for this to be acceptable could be a risk tradeoff curve that would be up to the analyst to generate.

One might be tempted to think that a reasonable follow-up question is how valid is the random dice roll for determining battle outcomes, and can one get better answers with a set of dice tuned to each side's abilities (or better yet, with a warfare model)? For example, Richard and his knights were fierce and effective fighters. There are accounts of them winning battles when outnumbered 100 to 1. Guy in turn was an embarrassingly dysfunctional military leader, causing the death of 1,000s of soldiers and his own capture and imprisonment due to ineptitude. Saladin prevailed only when amassing armies of many tens of 1,000s or more. We believe such factors to be second order effects for a socio-cultural toolbox. Dealing with precision, would be important once one decided that relative force size is the vital solution to the continued peace of the region. However, there may be other ways to reach the desired outcome, and these should be checked into first. That is, after all, the point of ACH (or effects-based operations, as the military prefers to call it). Accuracy and effectiveness are more important than precision.

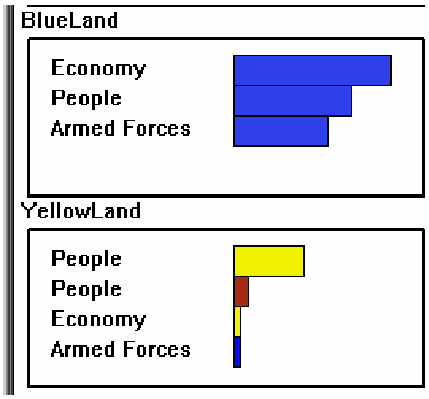
With that as advice, we further examined the runs we have conducted to date. They reveal that a recurrent tipping point away from conflict and towards stability occurs when leaders in a region appear to differentially specialize. This means possession of a different genre of resources minimizes attrition of that resource and hence reduces direct conflict. Interestingly, this strategy may overwhelm an opponent leader's own preference tree for distribution of resources. Figure 6A had an example of this when Richard secured continued rights for his People in exchange for ceasing all hostilities and removing his military (turning it back into People). Many other runs illustrate this outcome as well, though space precludes including them here. In summary, the evidence examined thus far suggests that when power issues are reduced for emotive agents, new stable equilibria can emerge that reflects a balance that examination of Preference Trees alone might not predict. Military might is not the only solution. Experimentation that looks for counter-intuitive results can be a useful endeavor in simulations involving emotion-, personality-, and cultural value-driven agents.

4.2) Impact of Leader Policies on the Evolution of Dangerous Ideas

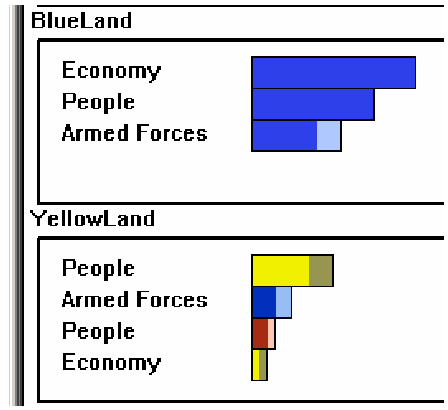
The scenario in the previous section showed that two groups with congruent GSP values came to believe (mistakenly) that they were threatened by a larger group whose values they misunderstood. There the main concern for YellowLand was to find out how it could live peaceably with its 'opponents'. In this Section, by contrast, we return to the scenario of Sect.3.2 where a larger group of one religion and its leader (Blue) actually do discriminate against the two smaller groups (the moderate Villagers, Yellow, and the rebels, Red) of a different religion, both in terms of values as well as overt policies. The main policy concern here will be to find out: how should Blue leader address this problem so as to attain his own goals yet also be more tolerant and prevent a full blown insurgency from being spawned? Why is violence rising? What are the consequences for domestic politics? What would be the best targets and times to intervene? Unlike the ancient history of the Crusades, this case will draw training and test data from events during the past three years in SE Asia. Only publicly available data sources have been used, but the sponsor requested this land remain unnamed, and hence we will refer to them solely as Blue, Yellow, and Red (see Figure 8A).

Figure 8 – Start and End States During the Correspondence Test: LeaderSim Summary View

A – Blue Land at Start of Test with Minimal Forces in Yellow Land, Minimal Insurgency



B – By End of Test, Blue Leader has Moved Forces to Yellow Land, Insurgency Grows



Lsim Legend: Blue = Leader and Cops/Armed Forces, Yellow = Moderates and Radicals, Red = Rebels

Figure 8 (cont'd) - Civil Violence View of Population Membership Before and After Correspondence Test

C – Starting State (Avg of Weeks 1 & 2) Muslim Population at Start Is Neutral with Few Grievances Registering		D – End State (Avg of Weeks 103, 104) Muslim Population Reflects Radicalization and Spread of NonViolent and Violent Protest	
GrievanceState0 - Neutral	30%	6%	GrievanceState0 - Neutral
GrievanceState1 - Disagree	55%	1%	GrievanceState1 - Disagree
GrievanceState2 - Join Opposition	15%	37%	GrievanceState2 - Join Opposition
GrievanceState3 – Nonviolent Protest	0%	39%	GrievanceState3 - Nonviolent Protest
GrievanceState4 - Fight-Rebel	0%	17%	GrievanceState4 - Fight-Rebel
TOTAL	100%	100%	TOTAL

4.2.1) Correspondence Test

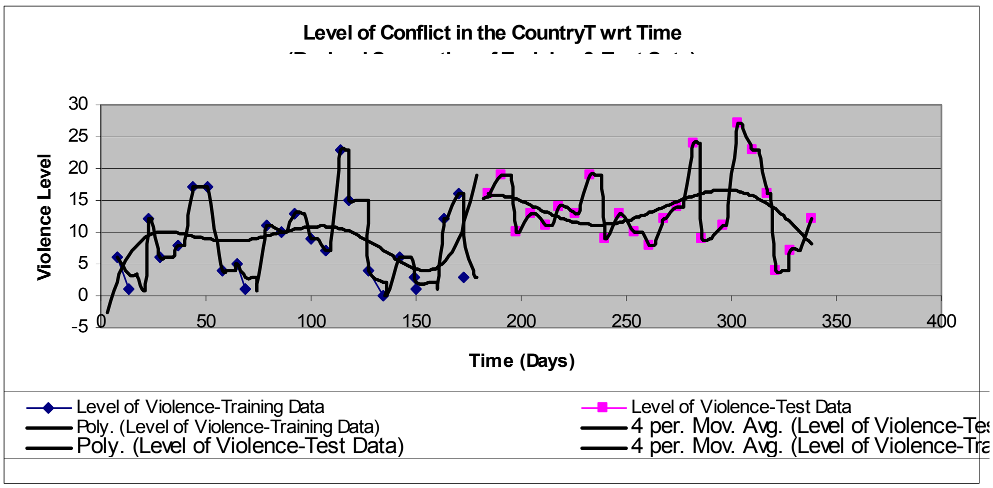
There were three types of data/ empirical information employed in this model:

- Numerical data as well as empirical materials on BlueLand, particularly the violent incidents occurring in the rural Yellowland provinces under the control of Blue,
- Empirical information about the decisions made, along with the contexts of these decisions, by the specific personnel being modeled (the Leader of the Blue), and
- Culture specific information for the Blue and Yellow from such studies as GLOBE (House et.al., 2005), as well as religious doctrines affecting the people of concern.

During the 1990s, the country was relatively stable, however, in the last few years, the rural provinces (YellowLand) have seen a rise of Muslim anger against the central Blue government, and the internal security situation in these provinces has rapidly decayed. Certain factions in YellowLand are seeking independence from BlueLand. During 2004, a small group of people, indicated as Red in Figure 8A has committed an increasing number of violent acts against Buddhists (Blue people). The level and sophistication of the attacks has been increasing to the point where people are questioning whether there may be outsiders assisting this group. The reaction of the Blue Leader to these violent incidents has been generally viewed as heavy-handed, and even inappropriate. The Blue Leader has branded the separatists as bandits, and has sent the worst behaving police from the north (BlueLand) to handle all protesters in the YellowLand. There are many accounts of police brutality and civilian deaths. In December 2004, the Tsunami hit and ravaged portions of YellowLand. The massive arrival of relief workers lead to an interruption of hostilities, but these resumed in mid-2005, and Blue Leader declared martial law over YellowLand in the summer of 2005.

The violent incidents in the country were classified based on the size and intensity of the incident. The incidents were then aggregated and plotted against time to obtain a longitudinal plot of incidents (Figure 9). The data was then longitudinally separated into 'independent sets' with training set consisting of Jan-June 2004 while test set beginning in July 2004 and running till Dec 2004. We curtail the test data to end before the tsunami.

Figure 9 –Violence Events on Grievance Scale



<u>Setting Up The Testbed and Tuning It With The Training Dataset</u>: Training data and evidence were used to calibrate three types of agents in PMFserv:

- <u>Blue Leader</u> (structure of his GSP trees are in Fig 3) - data indicates harsh, cruel, task, corrupt, wealthy, successful. Sends worst behaving cops down to YellowLand, never discourages brutality.
- <u>Moderate villagers</u> -Lack of cultural freedom, schools, etc. Want own land and autonomy.
- <u>Radical villagers</u> - Wahhabi and college-trained, unemployed, running religious schools in family homes. Earlier Figure 5A shows such a male and his GSP trees.

In order to adequately test these PMFserv agents' ability to interact at the population level, Lockheed Martin/ATL connected a version of our Red/Yellow/Blue scenario to a cellular automata that is known as the Civil Violence model (Epstein et al., 2001), though they replaced Leader Legitimacy with PMFserv agents' view of membership. We have since improved and altered that setup as described here. The Civil Violence model involves two categories of actors, namely villagers (or simply agents) and cops. 'Agents' are members of the general population of YellowLand and may be actively rebellious or not, depending on their grievances. 'Cops' are the forces of the BlueLand authority, who seek out and arrest actively rebellious agents. The main purpose of introducing the Civil Violence model is to provide a social network for the cognitively detailed PMFserv villagers to interact with. The social network consists of one layer of the normal arena or neighborhoods as well as a second layer of secret meeting places, simply represented as a school. Civil Violence agents can exist in more than one layer (namely in the normal as well as school layers), however, the PMFserv agents that show up in the school layer are only the young Wahhabi- and college-trained males.

The training data set also was used to fit the between-the-models parameters, especially between the PMFServ and CV model bridge and to tune up the Civil Violence villagers. Specifically, three types of cellular automata villagers were added:

- Neutral Villagers (these are modeled as simple agent automata in the CV model) -- 1,360 of them exist. The simple villagers are uniformly distributed in terms of risk aversion, but derive their grievance from witnessing cop activities in their neighborhood, from polling neighbors for opinions, and from hearing about hardships and news from PMFserv agents they may be in contact within their own neighborhood or school.

- Moderate Villagers – there are 80 of these in Civil Violence who are controlled by 80 PMFserv agents. They influence neutrals via small world theory in different neighborhoods of the Civil Violence cellular automata.
- Radical Villagers – there are 80 of these in Civil Violence who are controlled by 80 PMFserv agents. They influence neutrals via small world theory in different neighborhoods of the civil violence cellular automata and in the school layer.

The bridge between PMFserv and Civil Violence includes Blue Leader and 160 villagers, and works as follows. Blue Leader examines the state of the world and makes action decisions to assist or suppress Red or Yellow (e.g., pay for Buddhist schools, add more cops, reduce cop brutality, etc.). The 160 PMFserv agents then assess their view of the world, react to how cops handle protester events, how their GSPs are being satisfied or not by leader actions, and to their emotional construals. The grievance level and group membership decisions by 160 archetypical villagers in PMFServ are passed via an XML bridge to 160 agents they control in the cellular automata based population model. These agents influence the neutrals of the population who spread news and form their own view of the situation. The number of Civil Violence villagers in each of the five states of the Grievance Scale (neutral through Fight Back) are added up and this information is passed back to PMFserv to help determine its starting level of grievance for the next cycle of reactions to Blue Leader actions. For the purposes of this writeup, the Red Group has no active agents, but is marked up as rebels that afford activations as mentioned in Section 3.

Running the Simulation -- The correspondence test is whether the overall parameterization for the GSP tree-guided PMFserv agents in the bridge with the Civil Violence population will faithfully mimic the test data set. That is, by tuning the GSP trees of 1 leader and 160 villagers, and by connecting all that to the Civil Violence mode of spreading news and grievances, do we wind up with a simulation that seems to correspond to what happened in the real world test dataset? Specifically, we are interested in testing the null hypothesis that there is no statistically significant correlation between real decisions and the simulated decisions. That is to say that real incidents and simulated base case are mutually independent.

The simulation starts on the left side of Figures 8A for Lsim and 8C for Civil Violence. When the simulation is run, one observes Blue Leader trying some assistance measures initially (usually offering to set up Buddhist school and institutions) but maintaining a high police presence, and turning increasingly suppressive as the run proceeds -- Suppressing by Increasing Militarization and by Increasing Violence Unleashed. The end state is reflected in Figures 8B and D for each view, respectively. We can also examine what happened as the run proceeded. Figure 10A shows the average PMFserv villager perceptions of the Blue Leader actions in terms of the Dangerous Ideas model's terms – Vulnerability, Injustice, Distrust. Initially, Moderate Villagers respond positively to needed assistances given by the Blue Leader (negative VID and grievance is positive support). However, once they are suppressed violently and lose faith in the government, they tend to disagree with even positive government decisions. Radical Villagers start out disagreeing with Blue Leader and shift to 'fight back', an action that might continue for a long time before they realize the helplessness of the situation and abandon membership in the moderate side, and join the opposition.

Figure 10B shows the output of the Civil Violence model being sent back to the PMFserv villagers. Specifically, it shows what percent of the population has been shifted from Neutral Grievance to higher states (recall the scale of earlier Section 3): GS0 (neutral) through GS4 (fight back). From the first graph, it can be seen that at the start, most villagers are neutral and occupy GS0 while a small percent start in GS1. Many of them rapidly shift to GS1 (disagree), then abandon that and shift to GS2 and higher states. The occupancy in lower grievance states fall with time, while that in higher grievance states climb. From about week 50 onwards, there is a fairly stable, though regularly punctuated equilibrium in which the highest occupied states are GS3 and GS4. This is an indication of progressive escalation of violence in the society.

In order to compare this simulated grievance to that of the real world, we need some reliable measures of the population's grievance during actual events. Unfortunately, there are no survey or attitude results available. In the real world (test) dataset, the incident data was available, however, with a record of fatalities and injuries. There are a number of schemes for weighting those (e.g., depression and morale loss, lost income, utility metrics, others), however, here we take the simple approach of just computing a weighted incident severity. We computed incident severity scores using weighted average of fatalities and injuries, where injuries are simply counted, but the weight on fatalities is 100. $IncidentSeverity = w_f \times fatalities + w_i \times injuries$. The result serves to indicate how severe these incidents were. While severity is only an indirect measure of how the population might have felt, it is a measure that can be tested for correlation to the rise and fall of grievance expression due to leader actions in our simulated world.

To conduct the comparison, we apply the non-parametric Kendall's Tau measure of correlation. This statistic estimates the excess of concordant over discordant pairs of data, adjusted for tied pairs. With a two sided test, considering the possibility of concordance or discordance (akin to positive or negative correlation), we can conclude that there is a statistically significant lack of independence between base case simulation and observed grievances rankings at a confidence interval of 88%. Since there is a probabilistic outcome determining if a simulated leader's action choice will result in injury and fatality incidents (and how the news of these events are propagated through the cellular automata is probabilistic as well), we repeated the simulation runs thirty times and the confidence interval mentioned above is the mean across those 30 correlations. In sum, the null hypothesis is rejected and real (test interval) incident data and simulation results are related

Figure 10A – PMFserv Villagers View the Blue Leader's Actions And Communicate That to Their Civil Violence Counterparts

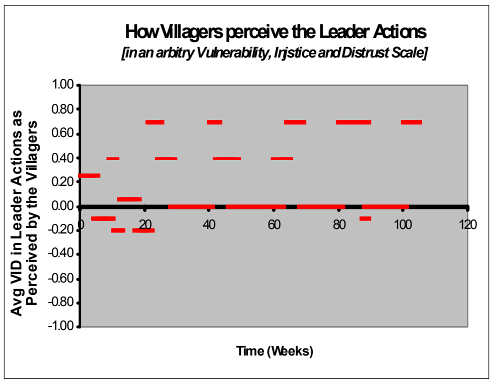
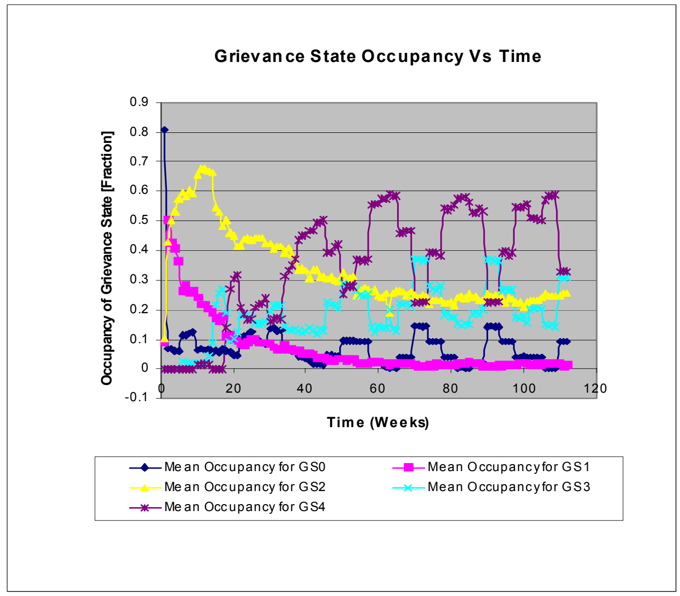


Figure 10B – Percent of Civil Violence Villagers Shifting from Neutral To Higher States of Grievance



4.2.2) Turing Test

The Turing test looks beyond population statistics, and examines what transpires inside the heads of the various types of agents in the simulated world. The Turing Test of Sect 4.1.2 showed the PMFserv emulation of Crusades leaders to be reasonably credible. In this case study, we have more detailed data and apply a more rigorous test. Specifically, in the test dataset, the real world leader made 52 decisions affecting the population and that we sorted into positive, neutral, and negative actions. In the simulated world, Blue leader made 56 action decisions in this same interval. At this level of classification (positive, neutral, negative), we were able to calculate a mutual information or mutual entropy (M) statistic between the real and simulated base cases. M ranges from 0 to 1.0, with the latter indicating no correlation between two event sets X and Y.

M (X: Y) = H(X) – H(X|Y) where X and Y are the simulation and historic sources, respectively, and H (.) is the entropy function, defined by: $H(X) = - \Sigma\, p(x)_i \log p(x)$. Applying this metric, the mutual entropy values were found to be less than 0.05, indicating correlation between real and simulated data. With an M metric, one cannot make statements about the confidence interval of the correlation, however, like the Crusades leaders, the Blue Leader in the current scenario seems equally faithful to his real world counterpart. This gives us reason to suspect the Hermann- and GLOBE-based GSP tree structure works equally well across time periods, locations, and cultures.

Not all aspects of the agent mindset work as well as this, however. As an example, one would expect agents to waiver somewhat in their resolve, yet our mechanism for that waivering seems like it may be too heavy-handed. The reader will recall that at the end of each cycle, the XML bridge feeds average Civil Violence neighborhood grievance back to the PMFserv agents in that neighborhood as a dampening of their reactions. This feedback is in the form of a replacement of the PMFserv agent's memory of past grievance level. Resetting of past grievance leads to flip-flopping behavior of PMFserv agents. This causes moderate villagers to flip between supporting opposition (GS2) and joining government (GS-2) depending on what Blue Leader does, particularly during the early stages. Hence they seem overly fickle. Since radicals are more grieved, their flip-flops are between neutral (GS0) and fight back (GS4), and this seems less troublesome semantically, though a confirmed Jihadist probably has fewer of these issues. We are not sure if this amount of flip-flopping is warranted, and this could only be resolved by further behavioral studies of such individuals (studies of which are currently underway by Atran (2006)). If research shows them to be less fickle in their inner beliefs, this is a relatively easy process to dampen in future versions.

4.2.3) Sensitivity Analysis

Once again, it is interesting to explore "what-ifs" and whether alternative decisions by Blue Leader will yield different outcomes amongst the YellowLand population. The reader will recall, however, that our model's output is conflict parameters (action decisions, grievances, group membership), whereas the model's inputs are characteristics of the leader and the followers. To change the outputs implies shifting the weights on the GSP trees of various archetypes of the population. Here we shift those weights for the Blue Leader, since we are interested to see if his personal decision style and choices are key to driving the villagers toward insurgency.

- By altering Blue Leader's InGroup Bias we should be able to alter his decisions to provide more or less needed assistance (economic goods, non-Wahabbi schools), and then we can observe if that alters the outcome. Specifically, we perturb InGroup Bias on his Standards Tree by 15% in either direction. Figure 11A shows the result.
- By altering Blue Leader's Sensitivity to Life (Humanitarianism) we should be able to alter his decisions to provide more or less violent cops, and then we can observe if that alters the outcome. Specifically, we perturb SensitvityToLife on his Standards Tree by 15% in either direction. Figure 11B shows the result.
- By altering Blue Leader's Openness we should be able to alter the immediacy of his response to opposition and protest. Thus he would send fewer cops down to YellowLand if he were more open, and more cops if he were less open, and then we can observe if that alters the outcome. Specifically, we perturb Openness on his Standards Tree by 15% in either direction. Figure 11C shows the result.

In examining these three sets of what-ifs in Figures 11A-C, as expected, a larger fraction of population occupies higher grievance states of 4 and 3, when the leader exhibits lesser degree of sensitivity-to-life and/or more InGroup Bias. Conversely, the population remains at lower grievance states when Blue Leader is more sensitive-to-life and less InGroup Biased. However, the trend is not the same with respect to the openness trait of the leader. It appears that more open leadership does not necessarily result in lower grievances in the community, but in less sustained (shorter) expressions of grievance.

These types of results help us begin to calibrate the population's demand curve mentioned earlier for exit, loyalty, and voice. Specifically, in Section 3 we presented several equations that help to determine the members' decisions about expressing their grievance (voice) and/or exiting the legitimate authority and joining the separatist movement. In Figure 11D, we see the graphical expression of several of those equations. We plot loss of civil rights and growing vulnerability, injustice, and distrust (VID) up the vertical, with group members along the horizontal. The demand curve is negatively sloped indicating people tend to increase their strength of membership in group A (BlueLand in this instance) as VID drops. Thus Eq. [10] is the Transfer Rate, which helps to define the elasticity or slope of the demand curve. As the policies of the Blue Leader are altered for less InGroup Bias and more Sensitivity to Life (Figures 11A and 11B, respectively), this is equivalent to shifting from point 2 on the demand curve toward point 1. On the other hand, more InGroup Bias and less Sensitivity to Life shift the YellowLand to point 3. From Eq. 9 we had the means to compute the desire to exit, and this is plotted along the horizontal axis. To the right of point 1, $\Delta\Phi$ is below zero, and few members favor the separatism. This is how YellowLand in fact was in the 1990s. In the interval between 1 and 3, the YellowLand people are indifferent since separatism cost is so high. There, they use their Voice and we observe the protests that occurred in the simulation runs of this paper, and that in fact occurred in the real world test dataset. Finally, to the left of point 3, Blue Leader's treatment becomes so intolerable, that he loses the hearts of the Yellow People and even the moderate followers are now on the side of the Red separatists or insurgents. In fact, in late summer of 2005, the Leader of this land had to declare Martial Law complete with curfews and movement checkpoints. The sign of our simulation results thus correspond well to the real world, and give us an ability to suggest outcome possibilities that are realistic for the Leader's policy choices.

Figure 11A – Alternative Outcomes (Grievance Level) When Altering Blue Leader InGroup Bias

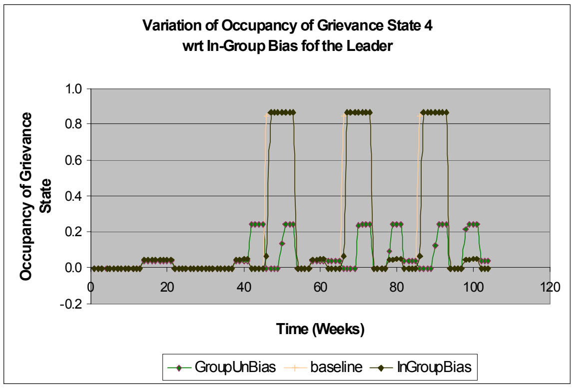


Figure 11B – Alternative Outcomes (Grievance Level) When Altering Blue Leader's SensitivityToLife

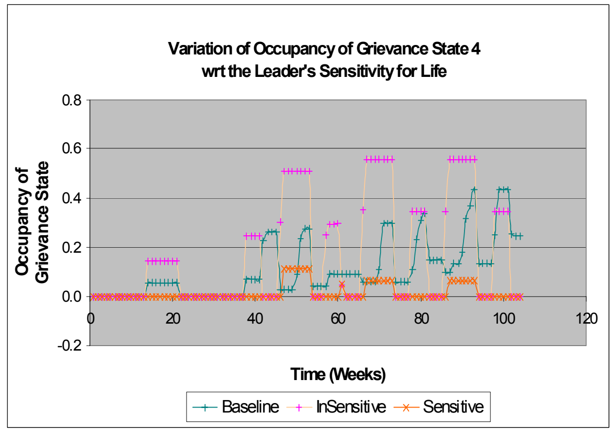
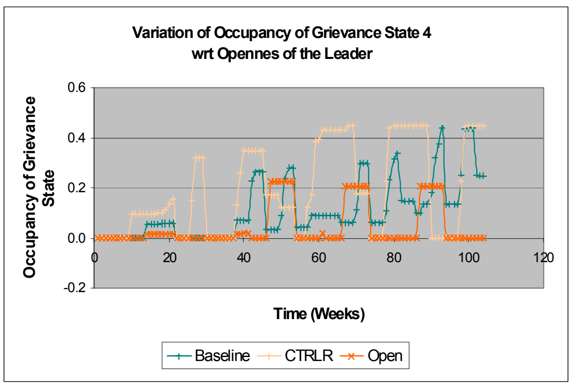


Figure 11C – Alternative Outcomes (Grievance Level) When Altering Blue Leader's Openness



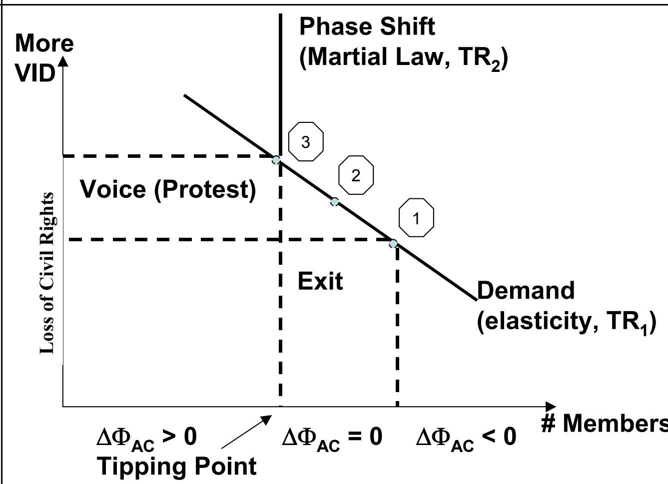


Figure 11D – The Low, Medium, and Upper Limits in Figs 11A-C Combine Into Points 1, 2, and 3 Culminating in a Tipping From Voice to Exit and Martial Law.

5) Lessons Learned and Next Steps

In concluding, it is useful to revisit the four aims of the introduction, and to see what has been learned in each of them and to point out some items seen as priorities for further development.

5.1) Socio – Cultural Game Generator (Aim 1)

Aim 1 was to create a role-playing game generator where one could rapidly set up and play out numerous conflict scenarios from around the world. Conflicts arise when groups vie over the control and allocation of resources (land, economy, markets, militias, media outlets, followers, etc.). Socio-cultural aspects concern any perceived injustices that have arisen historically with respect to these allocations, where perception is a matter of the value systems, norms/standards, and emotional utility of the perceivers. LeaderSim (and its larger implementation, Athena's Prism) implements such a conflict scenario generator and this article showed two examples of its usage: Christians versus Muslims in the Crusades, and Buddhists versus Muslims in modern day SE Asia. The game generator was shown to reduce conflicts to the bare essentials that allow one to explore the intertwined issues affecting welfare (economy, in-group standards, health services), security (freedoms/liberties, military), and political support for leaders (popularity of positions).

In zero sum games, what one spends on actions affecting one area of welfare, security, or populace effects what one has to allocate to other areas. Borrowing from diplomatic video games the idea here is to make the game immersive and engaging, and to date hundreds of players have participated in multi-hour sessions that they were unwilling to terminate. All this game-play also gave us a rich source of data to help guide the construction of agents who can serve as synthetic opponents, allies, followers, and the like. Also, we have learned that our game state representations are intuitive and that domain experts can readily use them to express conflict scenarios that are hard to verbalize. As with anything done in software, there are always next levels of sophistication and detail that one can add, and we identified many new features we would like to add such as, to mention a few examples, (2) scale up of all features shown here for the larger game generator we call Athena's Prism; (2) resources and assets (e.g., economy and black markets) that are supported by institutions that grow more self-sustaining and resilient, the larger they are; and (3) logging services and explanation functions that help users to generate reports on model outcomes, agent decision choices, and effects. These are some of the laundry list of next steps for the game generator.

5.2) Using "First Principles" and Synthesizing Social Science (Aim 2)

Modeling leaders and followers is a complex enterprise and one would like to use only first principles of social science, yet the field has not matured sufficiently. Still, that is no excuse for modelers to "make up" their own rules and algorithm for how groups behave, nor is it justification to just create entertaining agents. The alterative we explored here is to try and adopt best-of-breed and well-respected social science models for leadership, group dynamics, and the hearts and minds of the populace (AIM2). These models are implemented atop a unified architecture of cognition, call PMFserv that manages six modules of an agent's mind: memory, perception, physiology/stress/coping level, value system, and emotional construal, relationships and models of other, and (stress and emotion-constrained) decision making processes. PMFServ exposes many parameters in each of these modules and permits analysts/developers to visually "program" best-of-breed social science models that govern how the modules work, and in turn, how that agent tends to behave. This framework supported the ready implementation of leader models from Hermann (style), Hofstede and Globe (cultural factors), and Heuer (biases) atop pre-existing models in the PMFServ modules. These synthetic leaders passed the Turning and Correspondence tests in both conflict scenarios—The Crusaders and SE Asia – where each leader attempted to maximize his respective economic welfare, security, and populace resources in accord with his GSP trees of goals, standards, and preferences in the game scenarios. It was no surprise that leaders' biased models of other leaders often proved to be self-fulfilling prophecies. It was a surprise; however, that once leaders satiated their main preferences they chose "cooperation solutions" if the opponent leader chose to specialize in non-threatening resource allocation choices.

Likewise, the PMFServ modules allowed group followers to be readily modeled via their personal motivations (Maslow-style), group member factors (injustices, vulnerabilities, etc.), and loyalty decisions (follow happily, helplessly, vocally, separate, etc.). Again the followers' behavior passed Turing and Correspondence tests of Muslim moderates and radicals as the outgroup leader's policies shifted: a real world case study was used. Our population model involved a cellular automata with 1,360 agents influenced in their neighborhoods and schools by 160 PMFserv agents. Inside the PMFserv agents, one can readily observe and track their GSP tree implementation of Maslow, Hofstede, and GLOBE factors, and preference functions. One can follow how they update the Eidelson model factors of group and leader achievement. One gains confidence that these agents are realistic, particularly when one can calibrate them with validated instruments such as Hermann's profiling method or Eidelson's IGBI instrument, just as is done for real world human participants: e.g., see Moaz & Eidelson (2006).

5.3) Improving the Science (Aim 3)

Our contention is that the state of social science today can be advanced by computational rigor such as we have sought to impose. That is, when well-respected models are implemented computationally in socio-cultural games, they are more fully tested, their limitations exposed, and the needs for improvement and refinement are delineated. As one example of this, in order to use the Hermann leader profile instrument we first had to derive a mathematics to quantify each factor relative to game actions and state (e.g. power vs. protect, task vs. relations, in-group bias, etc.). In PMFserv terms this means mapping the Hermann factor sets to a leader's GSP trees and activation mechanics so that it becomes a subjective (emotional) expected utility implementation. In trying to build leaders that function in the game, however, the Hermann factors proved to be not quite sufficient, and we had to quantify and add some factors of Hofstede and from the UN's GLOBE study. The aim of our research is realism not mathematical elegance, however, and this means we also added Heuer-suggested biases and heuristics such as mirroring and confirmation, among others. The end result worked well enough on Turning and Correspondence tests for us to be able to make the following claim about leader modeling: a synthesis of respected models is important if the science and practice are to advance. Also, a virtual laboratory is essential to foster the syntheses needed in social sciences.

This paper presented a second example, that of group member modeling, where we explored unification of a motivation model (Maslow) with a group profiling instrument (Eidelson's Dangerous Ideas or DI model) and the Hirshman model of loyalty, voice, and exit. Mathematically these were once again cast into our subjective (emotional) expected utility formalisms and implemented within PMVserv's six modules and the other best-of-breed models already existing inside PMFserv and the game. The 4th co-author of this paper is in fact the developer of one of these three group modeling approaches and we report his comments on whether the experience of participating in socio-cultural game improved the science and/or practices:

"Implementing my dangerous ideas framework (Eidelson & Eidelson, 2003) in the PMFserv framework produced a series of challenges and opportunities, and required that I substantially advance my own thinking in order to effectively address the many operationalization issues that arose. In particular, the process of making underlying assumptions transparent and making key relationships among variables quantifiable in response to questions from my modeling collaborators led me to critically evaluate and refine both abstract and specific components of the framework. In short, this enterprise has definitely helped to move my own theoretical analysis forward." *- Roy Eidelson, 2006*

This seems to support our claim that science can be advanced by studying its strengths and weaknesses in socio-cultural games. In fact, we contend this is a vital pathway to improving the science of this field in general.

5.4) Analyzing Alternatives (Aim 4)

The entire point of insisting on well-respected models inside and on validation efforts for the synthetic agents is so one can have trust that experiments on these agents will yield insights about the alternative policies that influence them. As mentioned above, a major objective of this research is to utilize experiments on synthetic agents to identify those policy instruments that will most influence the real-world agents they represent. A number of efforts to explore the impacts of alternative policies have already been alluded to above. Examples of this approach were reported in the current effort. An example of exploring alternative policies to effect the same outcome was seen in The Crusades where free access to Jerusalem for Christians was gained by removing the military. An example of an attempt to explore policy robustness in the Crusades example was the finding that Yellow's force size needs to be increased as a function of Yellow leader's risk tolerance. That is the only way for Yellow to more consistently assure victory. Finally, the slope of the demand curve of Figure 11D shows the elasticity of out-group follower loyalty, protests, and insurgency being derived as leader style is altered.

These serve to illustrate how analysts might use our policy tool to support their tradecraft, to explore policy alternatives and robustness, and to identify parameter elasticities. Hence an important line of investigation in our future work will be to develop a range of more systematic and less effort-intensive statistical techniques that can be used by practitioners as preliminary steps in the construction and evaluation of policy alternatives. Of key importance here are general screening tests of parameter sensitivity, such as the random-walk procedure developed by Morris (1991) and extended by Campolongo et al. (1999) and others. Once key parameters are identified by such methods, one can undertake more detailed sensitivity analyses [such as the regression techniques of Kleijnen (1992, 1998) and others, as well as the Monte-Carlo filtering technique of Saltelli et al.(2004)] to determine the nature of their impacts on agent behavior. By linking such parameters to specific policy instruments, practitioners may then be able to identify those policy alternatives that are potentially most effective in guiding agent behavior toward desired outcomes. Hence part of our future research efforts will be devoted to developing software packages to make it easier for users to design, run, and analyze the results of such statistical procedures for policy construction and evaluation.

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