Agent-based Simulation System for Human Terrain Effect Assessment

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ABSTRACT

Development of computer tools to understand how social identity beliefs of interacting social groups evolve in response to various changes can help use better understand root causes of intergroup conflict and design intervention strategies to address such confliects. This paper develops a socio-cognitive model of social identity dynamics and illustrates how agent-bases social simulation can be a valuable tool for theory refinement.

Author Keywords

agent-based social simulation; social identity theory; influence operations; human terrain effect assessment

ACM Classification Keywords

I.6.1 Simulation and modeling
1.2.11 Distributed artificial intelligence
J.4 Social & behavioral sciences.

INTRODUCTION

The Western Military commanders are increasingly being asked to take into account the secondary and tertiary effects of their actions on the "hearts and minds" of their target populations similar to the way that they take the physical/kinetic effects of their actions into account. The problem is that while there are a number of tools that commanders can use to assess physical effects of their kinetic actions, commanders have little or no access to computer tools for assessing the human terrain effects of kinetic and non-kinetic actions, and select actions that are most likely to produce desired human-terrain effects. The reason we have computer simulation tools that allow us to precisely simulate and predict the physical impact of a kinetic action is that centuries of physics allows us to isolate irrelevant physical terrain processes and variables from the relevant ones. We currently do not have an equivalent socio-cognitive model of human terrain that isolates variables and processes most relevant to the development of socio-cultural beliefs that cause and perpetuate inter-group conflict. This article argues that agent-based social simulation can be a useful addition to the traditional social science toolkit of human-subject experimentation (both controlled experiments in the lab and in-the-field participant observation) and development of verbal models to explain an isolated phenomenon (occasionally accompanied by mathematical modeling). Agent-based social simulation (ABSS) can help build and refine integrated testable theories that connect micro-level individual cognitive tendencies with macro-level socio-cultural patterns. We illustrate this approach by developing a socio-cognitive model of group-interactions that integrates elements drawn from social identity theory [8], rational choice theory [1], and entrepreneurship theory [7, 10, 5].

Rational Choice Theory

Rational Choice Theory suggests that when faced with a number of possible actions, people select the action that seems to them to offer maximum utility in the given situation [1]. While rational choice models of human behaviour have had some success in explaining human behaviour in a wide range of domains, they have also been criticized for their inability to account for people's seemingly irrational behaviour in various situations. By acknowledging people's deep seated desire to feel good about themselves, social identity theory allows us to see that seemingly irrational decisions may be rational after all.

Social Identity Theory (SIT)

Social identity theory (SIT) is considered to be one of the most well developed socio-cognitive theories of intergroup conflict [8, 1]. SIT specifies that people's intergroup behavior is primarily driven by their need to maintain a positive self-esteem. People belong to groups because they derive part of their esteem from their affiliation with various social groups present in their information environment. Thus, the higher the social status of a group people feel strongly affiliated with (i.e., their *in-group*), the

better people feel about themselves. If people's in-group status is lower than a comparison *out-group* (i.e., a group they don't feel affiliated with) then they may engage in a restorative social identity management strategy designed to enhance their ingroup's status. The selection of a social identity management strategy depends on people's intergroup perceptions (called people's *sociostructural beliefs*). Tajfel and Turner [8] identified three types of sociostructural beliefs as key.

- **Permeability** of a group is the sense of how easy it is for outsiders to enter the group. A high permeability indicates a low cost of entry into the group while a low permeability indicates a high cost of joining the group. If a group member perceives that it is difficult for outsiders to join the group and take some of group's resources away from her then her expectations of future rewards would be higher than those of a group member who perceives that it's easy for anyone to join the group and dilute the share of rewards members receive from their group.

- **Legitimacy** of a status structure is defined as the people's sense of how legitimate the status hierarchy is. A highly legitimate status structure indicates that the higher or lower status of a group relative to a comparison group is perceived as just and deserving while an illegitimate status structure indicates that people perceive the higher/lower status of a group as unfair and unjust. If a group member perceives her group's higher status relative to a comparison group to be legitimate then she can expect larger future rewards than a group member who perceives the higher status to be illegitimate.

- **Stability** of a status structure is defined as the people's sense of how likely the status hierarchy is to last into the future. A highly stable status structure is expected to last, while an unstable status hierarchy is likely to go through changes. If a group member perceives her group's higher status relative to an outgroup to be highly stable then she can expect larger future rewards than a group member who perceives the higher status to be unstable and in danger of the status difference being eliminated or even reversed.

People engage in collective as well as individual strategies to improve their self-esteem.

- Individual Strategies:
  o Individuation: People can deemphasize their group membership and focus on their individual characteristics as a larger component of their esteem. Depersonalization is the opposite of individuation where people come to see themselves as indistinguishable from the groups they belong to.
  o Mobility: People can distance themselves from an unfavorable group and increase their affiliation for a favorable group.
- Collective Strategies:
  o Raising or lowering of group boundaries: People can make their group more or less permeable by making it harder or easier for outsiders to join their group.
  o Glorify: People can create and propagate myths intended to enhance the legitimacy of their ingroup's status.
  o Boasting: People can create and propagate myths intended to enhance the perceptions of the stability of their ingroup.
  o Delegitimize: People can create and propagate myths intended to cast doubt on the legitimacy of an outgroup.
  o Denigrate: People can create and propagate myths intended to cast a doubt on the continuation of an outgroup's status into the future.
  o Attack: People can engage in violent action against outgroup members intended to deprive them of their resources.

Information Entrepreneurship Theory of Social Change

The notion of some people taking up the role of information entrepreneurs as champion advocates of changes to a group's shared beliefs has been developed by a number of scholars from a wide variety of disciplines to explain phenomena ranging from religion [7] and new religious movements [10], to organizational dynamics.

Sociologists of religion, Bainbridge and Stark [7], argued that religions are founded by *information entrepreneurs* who recognize people's unmet needs for goods that are in short supply and step in to fulfil this demand by supplying *compensators*. A compensator is an unverifiable promise of a future good. According to the Stark-Bainbridge theory, in situations where some goods are in low supply or not available at all, some people may be willing to accept compensators in lieu of actual rewards. For instance, a religious founder may be able to sell the unverifiable promise of life after death to those people that intensely value immortal life. The entrepreneurship models allows the use of economic analysis tools for explaining the higher rates of religious participation in societies with more religious pluralism, such as the United States, as compared to religiously homogenous societies, such as Sweden [6]. Upal [10] emphasized that much of the information that new religious movement founders seek to change is shared by a large number of members of an existing group. Calls to change a group's shared beliefs are bound to be resisted by norm enforcers within a group who attempt to inflict punishment on deviants. In order to succeed in the face of such opposition, information entrepreneurs must be high identifiers and must have a high social status in the group they seek to change. Political scientists also emphasized the key role that norm entrepreneurs play in the establishment of social norms in a social group.

Social psychologists Haslam and Reicher [5] developed a model of leadership based on Turner et al.'s self-categorization theory [9].

> Turner argues that the psychological basis of group membership is the cognitive act of defining oneself as a category member (i.e., the act of social identification). This entails a process of self-stereotyping whereby, having identified with the group, people seek to ascertain the 'criterial attributes' associated with the given category membership and conform to them. This has three important implications for the influence process:
>
> 1- The people who are subject to common influence are those who share identification with a common social category.
> 2- The ideas and proposals that are influential are those that are consonant with the criterial attributes of the social category.
> And, most critical for present purposes,
> 3- The people who are influential are those who are in a position to supply information about the category definition — in particular those who are seen as (proto)*typic*al group members.   [5]

Haslam and Reicher [5] call group leaders who shape the group identity and mobilize group members to take actions in support of group goals as *social identity entrepreneurs*.

> "For us, leadership activity and leadership effectiveness largely revolves around the leader's ability to create identity definitions and to engage people in the process of turning those definitions into practical realities. Leaders (and followers), we argue, are not mere ciphers, but rather *entrepreneurs* of identity." [5]

An Integrated Socio-Cognitive Account of Group Interactions

We developed a theoretically rigorous sociocognitive account of group interactions by starting with the social identity theory and filling two major gaps in existing theory.

1- How does an agent decide which social identity management strategy to engage in? While SIT framework offers general guidelines on when to take action, detailed criteria for deciding which action to take in any given situation have not been developed. We used rational choice theory to develop such criteria.

2- What are the mechanics of collective social identity management strategies? While SIT specifies a number of collective strategies, it does not specify a detailed mechanism for how such strategies are co-ordinated by large number of independent agents acting selfishly, each of whom may be differently affected by the outcome of such actions. We rely on the guidance offered by the information entrepreneurship theory to fill this gap.

In our model, agents are rational and take those actions that maximize their utility. In accordance with social identity theory (SIT), an agent's utility is defined as its self-esteem. In any given situation, an agent carefully weighs costs and benefits of taking an action and selects the action that offers it the largest benefit–cost differential. An agent chooses inaction if the costs of all actions exceeds their benefits. Costs and benefits of an action are defined in terms of loss or gain of the agent's self-esteem. In accordance with SIT, an agent's self-esteem (SE) is defined to have two components: the individual (ISE) and the social (SSE) component.

In accordance with SIT, an agent can have differing degrees of affiliation $A_1 \ldots A_N$ for the groups $G_1 \ldots G_N$ present in its information environment. Agents derive their social self-esteem (SSE) from the status of each of the group they are affiliated with (moderated by their degree of affiliation for the group). Thus higher the status of group G_i and stronger the affiliation an agent A has for G_i, the higher the component of SSE that the agent receives from G_i. An agent maintains perceptions of the permeability (P_{gi}), stability (S_{gi}), and legitimacy (L_{gi}) of each group G_i in its information environment. This information allows it to compute its perceptions of the status (STS_{gi}) of these groups. These perceptions are also used to compute the costs and benefits of various social identity management strategies and the strategy that offers the highest net benefit is selected.

- Individual Strategies:
  - Individuation*: Deriving more of one's self esteem from the individual component of the self-esteem (ISE) is rational if one fares better in comparison to individuals present in one's social network but none of the groups one's affiliated with have a high status i.e., when ISE is high but SSE is low.
  - Depersonalization : makes sense when SSE is high but ISE is low.
  - Mobility: It is rational to lower one's affiliation to a lower status group and increase affiliation for a higher status group if the resulting gain in SSE is higher than the costs one has to pay for moving away from a group and entering a new group. The costs of entering a

group are inversely related to the permeability of that group.

- Collective Strategies: Collective actions take place in multiple steps. In accordance with the information entrepreneurship theory, these actions are initiated by social identity entrepreneurs (SIDs). Because of their stronger affiliation for the group, SIDs have more at stake in the group' status and therefore are more strongly motivated to call others to engage in collective actions to enhance their group's status. As rational individuals, social identity entrepreneurs only advocate a collective action on behalf of the group when they perceive benefits of advocating such action to be greater than its expected costs. SIDs can expect to receive both personal and social benefits by calling for collective action as well as from the results of the actual social action that may happen as a result of their calls. Once non SID group members receive calls to join a collective action from an SID, they evaluate the costs and benefits of joining their fellow group members. Similar to SIDs, lay members can also expect to receive personal and social benefits by joining collective action.

Agent-based Model of the Integrated Socio-Cognitive Framework

We developed an agent-based model (ABM) based on our integrated socio-cognitive framework discussed above. The ABM is just one of many possible ways of instantiating our general framework. The purpose of this section is to document the design decisions we made to achieve a practical implementation of the framework.

- An agent's total self-esteem (SE) is a weighted sum of the individual (ISE) and social (SSE) components.

$$SE = W_i \times ISE + (1-W_i)\, SSE$$

where W_i is the parameter that describes the weight that an agent places on individual self-esteem.

- An agent's SSE is weighted sum of the status of various groups and the agent's affiliation for those groups.

$$SSE = A_{g1} \times SST_{g1} + \ldots + A_{gn} \times SST_{gn}$$

where A_{gi} is the agent's affiliation for group G_i and SST_{gi} is the agent's perception of the status of group G_i

- An agent's perception of the status of a group (SST_{gi}) is directly proportional to the agent's perception of the group's stability (S_{gi}) and legitimacy (L_{gi}) and inversely proportional to agent's perceptions of the group's permeability (P_{gi}).

$$SST_{gi} = S_{gi} \times L_{gi} / P_{gi}$$

- An individual's estimate of the cost of moving away from a group G_1 and moving closer to a group G_2 are inversely proportional to the perceived permeability of the group

G_2.

$$Cost_{g1 \to g2} = \frac{1}{P_{g2}}$$

The estimated benefits are proportional to the status difference between the two identities.

$$Benefit_{g1 \to g2} = SST_{g1} - SST_{g2}$$

The effect of mobility is an increase in affiliation for G_1 and a decrement in affiliation for G_2.

$$\begin{cases} A_{g1} = A_{g1} - \left(1 - \dfrac{Cost}{Benefit}\right) \times Spd_M \\ A_{g2} = A_{g2} + \left(1 - \dfrac{Cost}{Benefit}\right) \times Spd_M \end{cases}$$

where Spd_M is the *speed of mobility* parameter.

- The benefit of increasing individuation weight (W) by the *speed of individuation* parameter (Spd_I) is $= W \times Spd_I \times ISE$
The cost of individuation is $= (W - Spd_I) \times SSE$
The impact of individuation is an increment in the individuation weight $W = W + Spd_I$

- The benefit of decreasing individuation weight (W) by the *speed of depersonalization* parameter (Spd_d) is $= W \times Spd_d \times SSE$
The cost of depersonalization is $= (W - Spd_d) \times ISE$
The impact of depersonalization is a decrement in the individuation weight $W = W - Spd_d$

- Agents can expect to receive/incur benefits/costs in both personal and social self-esteem by becoming SIDs and calling others to collective actions.
  - Benefits:
    o Personal benefits: an increase in the SID's social status within a group (ST) obtained as new members joins the group one leads. This increment is currently modeled by a *new follower homage* parameter (*Hom*).
    o Social benefits: A gain in the group status through the change in the group beliefs/behaviors that the message is seeking to cause in the group members. In case of a message calling for an increment in ingroup's sociostructural perceptions this would be modeled by the relevant *speed of legitimacy/stability/permeability adjustment* parameter. In case of attack on the outgroup members the *war-booty* parameter is used to decrease perceptions of attacked group's resources and increase ingroup's resources by. Furthermore,

the attacking party gets to divide the war-booty among themselves with each member getting the booty in proportion to its social status within the attacking group.

- Costs:
  - o Personal costs: Costs of message creation, design and dissemination (modeled by a parameter) and a potential loss of personal status within the group if either enough people do not join or if the effort does not succeed (also modeled by a parameter).
  - o Social Costs: Loss of group resources if enough group members join but the action does not succeed. The decrease in the perception of group resources is modeled by the *reparations* parameter.

The likelihood of success and failure of a collective action (and hence the expected value of the costs/benefits of various collective actions) is affected by the number of people who join the group and is used to weigh the potential success/failure of the action by those considering joining the action by surveying their social network to see who's joining a social action.

ANALYSIS OF THE AGENT-BASED MODEL
The objective of the system evaluation is two-fold: first to see whether the system behaves as expected given our integrated sociocognitive framework, and secondly to better understand the conditions under which groups adopt various social identity management strategies. Based on the theoretical framework we had following expectations.

1- The mobility strategy should be preferred by agents when outgroup boundaries are permeable and the status of both groups is stable and legitimate.

2- Individuation should be preferred when individuals have high resources and all groups have low legitimacy and stability.

3- Collective strategies should be preferred when outgroup is not permeable and ingroup members do not have enough resources to migrate to other groups.

- a. Attacks on outgroup members should be preferred when outgroup members have moderate amount of resources (because if outgroup members don't have any resources there's no point attacking them but if they have too much resources, they may be too strong to steal from) but ingroup members have more resources than outgroup members (so that the attack is more likely to be successful).

- b. Boundaries should be raised when a group has high permeability, resources, legitimacy and stability (and therefore high status) and group

members do not want to lose these rewards to outsiders.

- c. Boundaries should be lowered when a group has lower resources than an outgroup because admitting higher resourced outgroup members can help increase the ingroup resources (and therefore improve its status).

- d. A group should denigrate an outgroup when group members perceive the outgroup status to be stable (and therefore lowering those perceptions would allow their group's status to improve relative to the outgroup).

- e. A group should delegitimize an outgroup when the outgroup status is perceived by the group members to be legitimate (and therefore changing those perceptions would allow ingroup status would improve relative to the outgroup).

- f. A group should glorify itself when its members perceive its status to be illegitimate (and therefore increasing legitimacy can help improve status).

To carry out this analysis, we ran the agent-based simulation software described above twelve thousand times using random distributions of individual resources, agent perceptions of permeability, legitimacy, stability, and the individual esteem weight. The range for an agent's initial resources was set from zero to one thousand. The random distributions were spaced at intervals of one hundred. All the remaining variables are based on a zero to one range so intervals were spaced at every one tenth. The affiliation range is negative one to positive one and is expected under most conditions to be positive for the member identity and negative for the non-member identity. A uniform distribution with the respective full range was used for all the simulations in the experiment. A total of 100 agents divided into two groups was used for each simulation run. Each of the 12,000 simulations consisted of 500 rounds.

Results & Discussion
Bivariate Pearson correlation values were calculated between input variables and the social identity management strategies adopted by agents in the populations instantiated with those input variables. The following results were found in comparison to the theoretical expectations. All correlations were found to be significant at $p < .05$ level.

1- Mobility was not found to be strongly correlated with Outgroup Permeability (r=-0.074), Outgroup Stability (0.097) or Outgroup Legitimacy (0.096). It was, however, weakly correlated with Resources (0.190) and Outgroup Status (0.210). One reason a relationship with permeability was not found could be the confounding effects of Outgroup Status, as groups that are highly permeable would presumably have a low status, and therefore agents would receive little benefit from

	Mobility	Individuation	De-personalization	Raise Boundaries	Lower Boundaries	Glorify	Attack	De-legitimize	Denigrate
Ingroup Resources	.187**	-.223**	-	.318**	.181**	.216**	.163**	-.063**	.189**
Outgroup Resources	-.033**	-.190**	.061**	-.287**	-.308**	-.327**	-.417**	-.073**	-.332**
Individual Weight	-.001**	-.437**	-.529**	-.123**	-.081**	.025**	.168**	-	-
Ingroup Permeability	.081**	.412**	-.048**	-.048**	-	-.050**	.057**	-	-
Ingroup Legitimacy	-.020**	-.132**	-	.072**	.019*	-.101**	-	-	-.027**
Outgroup Permeability	.096**	-.024*	-.031*	-	-	-	-	-	-
Ingroup Status	-	.151**	.377**	-.136**	.189**	-.032*	-.043**	-	.072**
Outgroup Status	.265**	-.054**	-.062**	-	-	-	-	-	-

Table 1: standardized β co-efficients for regression sociostructural variables and social identity management strategies.
** significant at the p < 0.01 level (2-tailed); * significant at the p <.05 level (2-tailed)

moving to this group. The Status variable was controlled for, and the Pearson values recalculated to see if this was the case. The direction of the correlation between Mobility and Outgroup Permeability did change to become positive, but was still of negligible strength (0.080). Surprisingly, controlling for Status also increased the strength of the correlation between Mobility and Ingroup Permeability (0.130).

2- Individuation is weakly negatively correlated with Resources (-0.170). This could be because the resources were averaged over the entire group, as opposed to looking at the resources of individual agents. There was a weakly negative correlation with stability (-0.1) and a correlation of (-.094) with legitimacy. Individuation was also weakly negatively correlated with Outgroup Resources (-0.218), Status (-0.254), and Outgroup Status (-0.118), and there was a moderate negative correlation with Individual Weight (-0.437).

3- No correlation was found between Collective Strategies and Permeability, but there was a weakly positive correlation with resources (0.138).

   a. There was found to be a moderate negative correlation between Outgroup Resources and Attack (-0.416).

   b. There was no correlation between Raising Boundaries and permeability, legitimacy, or stability, but there was a weak correlation with resources (0.261). There was also a weak negative correlation with Outgroup Resources (-0.284), Individual Weight (-0.121) and Outgroup Status (-0.111).

   c. There was found to be a negative correlation between Lowering Boundaries and the difference between Outgroup Resources and Ingroup Resources (-0.395). Lowering Boundaries was also negatively correlated with Outgroup Resources (-0.306), Permeability (-0.116) and positively correlated with Outgroup Status (0.119).

   d. There was not a strong correlation between Denigrate and Outgroup Stability (-0.095). It was, however, weakly positively correlated with Resources (0.215) and Status (0.131), and weakly negatively correlated with Outgroup Resources (-0.332) and Outgroup Status (-0.145).

   e. There was no correlation between Delegitimize and Outgroup Legitimacy.

   f. Glorify was weakly negatively correlated with legitimacy (-0.109), as well as Outgroup Resources (-0.324) and Outgroup Status (-0.130). It was positively correlated with Ingroup Resources (0.251).

The Pearson Correlations values were found to be weaker than expected. A possible explanation for this is a violation of the assumption of linearity. The scatterplots of the data appear to support this explanation, as the relationships between the variables do not seem to be straightforwardly linear.

As a summary of the preceding correlational analyses, a step-wise linear regression was conducted for each social

identity management strategy. The final models were chosen as they accounted for the greatest percent of the variance. The standardized β co-efficients from the final models of the most significant variables are shown in Table 1.

Table 2 summarizes these relationships by listing the top 3 most relevant variables from Table 1. It shows that out-group resources were negatively correlated with all of the collective identity management strategies. This means that agents are more likely to denigrate, glorify, attack and change entry conditions targeting groups that are believed to have few resources. We expected out-groups that have low to moderate resources to be attacked more often because (1) out-groups with very low or nil resources have no booty to offer potential attackers, and (2) out-groups that have higher resources than in-groups are not likely to be defeated in the event of an attack.

As **Error! Reference source not found.** shows, as expected the frequency of attacks on out-group members

decrease as the out-group resources decrease and the attacks peak in the mid-range. However, the attacks do not decrease as quickly with the drop in average group resources as we had expected it to. We did not expect out-group resources to have any bearing on the collective strategies other than *attack* and *raise boundaries*. The results shown in **Error! Reference source not found.**, however, indicate a similar relationship between out-group resources and all collective strategies. All of the collective strategies initially increase in frequency as the out-group resources increase, peaking in the mid-resource range and then decrease sharply as the out-group resources increase further. Virtually no collective action is taken against out-groups that have very high resources.

Mobility	Individuation	De-personalization	Raise Boundaries	Lower Boundaries	Glorify	Attack	De-legitimize	Denigrate
Outgroup Status	1/Individuation Weight	1/Individuation Weight	Ingroup Resrouces	1/Outgroup Resources	1/Outgroup Resources	1/Outgroup Resources	1/Outgroup Resources	1/Outgroup Resources
Ingroup Resources	Ingroup Permeability	Ingroup Status	1/Outgroup Resources	Ingroup Status	Ingroup Resources	Individual Weight	-	Ingroup Resources
Outgroup Pemeability	1/Ingroup Status	1/Outgroup Status	1/Ingroup Status	Ingroup Resources	1/Ingroup legitimacy	Ingroup Status	-	Outgroup Stability

Table 2: The top 3 sociostructural variables significantly correlated with each of the identity management strategies, ranked by the magnitude of the observed correlation. No significant correlation was found between delegitimize and any of the measured independent variables
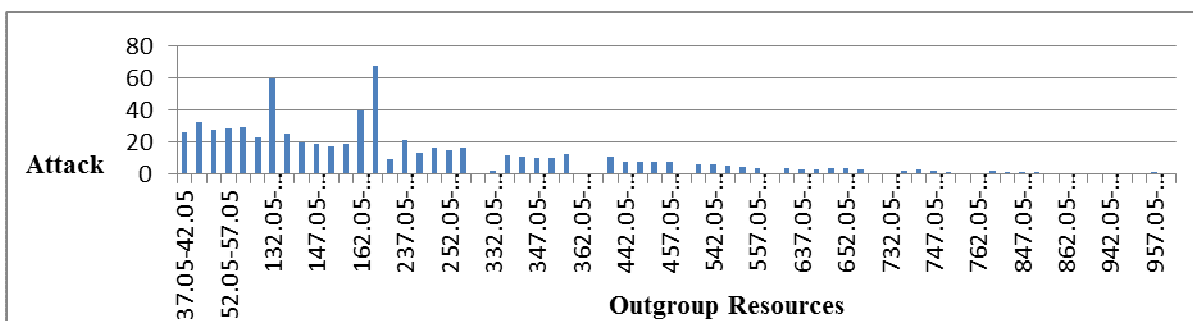
Figure 1: A graph showing the relationship between frequency of attack and average out-group resource

Furthermore, all collective strategies (except delegitimize, which was rarely adopted and thus insufficient data was available) are also positively correlated with in-group resources. As in-group resources increase, agents become more likely to engage in collective strategies against the out-group members. This makes some sense because all collective actions require expenditure of considerable

resources by social identity entrepreneurs (SIDs) for creation and dissemination of a message. Since group resources are a major component of group status, groups with higher resources are more likely to have a higher status. Groups with higher status are also more likely to have agents with low individuation weights more of whose self-esteem depends on the social component. These very

depersonalized agents with high resources become SIDs and call others to collective actions. In case of attack (but not other collective actions), ordinary agents are more likely to respond to a call if they believe that their group has higher resources than the target outgroup because they believe that they are more likely to defeat a poorly resourced enemy. This explains the strong negative correlations between attack and outgroup resources. As discussed earlier, we also expected to find a negative correlation between outgroup resources and raise boundaries. However, we did not expect to find such relationships between all collective actions and outgroup resources. The reasons for that relationship are a bit more complicated and need more discussion of the costs and benefits of collective actions.

The benefits that an agent derives from taking various collective actions depend on the amount of social-esteem it would gain from lowering the status of the out-group or increasing the status of the in-group. Lowering the status of the out-group would be beneficial to an agent that has a negative affiliation for that out-group. However, if the agent has a positive relationship with an out-group, lowering its status would lead to a decrease in overall social esteem, thus preventing an agent from considering it. Since out-groups with vast resources and higher status are more likely to elicit positive affiliation from outsiders, this may explain the observed negative correlations between out-groups status and frequency of all collective actions.

We did not anticipate either of these two emergent patterns (namely, the positive correlation between average group resources and collective actions, and the negative correlation between outgroup resources and collective actions) for all collective actions. Such emergent patterns are often argued to justify spending the time and effort on developing agent-based social simulation models because they allow us to learn about those consequences of the theory that are difficult to see without the aid of such tools.

CONCLUSIONS
The main contributions of this paper are (a) the development of an integrated theoretical model of social identity dynamics, (b) the development of an agent-based social simulation system based on this theoretical model, and (c) empirical evaluation and analysis of the results of running the agent-based model. The emergent relationships between frequency of various social identity management strategies and various socio-structural variables demonstrate the promise of using agent-based social simulation as a tool for socio-cognitive theory refinement. Iterative theory refinement and computational modeling can help us towards the goal of the development of a predictive sociocognitive model of social identity dynamics in human societies that can be used to develop human terrain visualization and simulation systems of use to military and civilian decision makers.

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