Modeling the Spread of a "Cultural Meme" Through an Organization

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Abstract. Improvement of organizational performance is a universal, yet tantalizingly elusive, goal. Most efforts in the past decade focus upon process improvement, yet the ultimate results are often disappointing. The impact of the "culture" of an organization on its performance is well known, yet little is understood as to how such a culture spreads through that organization. This effort models culture as a meme and explores the impact of the initial individual cultural state of an organization's members, as well as their role in the organization's hierarchy, on the spread of culture. Additional factors varied in this exploration include the overall economy and the levels of continuing Education and Disenchantment in the members, distinct from interaction with other agents in the organization.

Keywords: agent-based modeling; organizational culture; meme; Tribal Leadership; performance improvement

1 Introduction

Improvement in organizational performance and productivity is a key focus in most organizations, be they corporations, academic departments, governmental units or healthcare entities. Particularly in healthcare, most efforts are focused upon process improvement and measurement of process indicators as proxies for outcome. However, despite massive expenditure of resources, little improvement in healthcare quality can actually be demonstrated [1].

This intense concentration on process has failed, perhaps in part because of the limited understanding that healthcare behaves as a Complex Adaptive System (CAS) [2-3]. Process tools work very well when dealing with complicated problems, but are of limited use when faced with problems that are complex [4-5]. While complicated problems are best solved through the reductionist approach of experts, complex problems exhibit emergent order, co-evolution of the agents and the system, importance of starting point and path-dependency. These problems are best approached by tools that can demonstrate that emergent order and identify possible

patterns and modulating attractors. Agent-based modeling is just such a tool [6]. The measured quality in this investigation is the quality described as "Organizational Culture".

2 Organizational Culture

Logan, King and Fischer-Wright investigated the impact of Organizational Culture on performance and reported their findings in "Tribal Leadership: Leveraging Natural Groups to Build a Thriving Organization" [7]. In their view, the basic unit of human productivity is the "tribe", a group of 20-150 people that forms naturally in virtually any human effort. Members of the tribe share a common understanding of purpose, values, history, identity and future. There may be a biological basis for the limit size of such a human group. In his study of primates, Robin Dunbar suggested 150 ("Dunbar Number") as the limit of an effective social group imposed by the size and organization of the primate neocortex [8].

A number of authors have related group dynamics with the emergent quality of creativity. Harnessing this creativity results in increased productivity. Csikszentmihalyi terms this harnessing "flow" [9]. His protégé, Keith Sawyer, describes it as "group genius" [10]. The exact means by which members of the group communicate, exchange or uncover this quality of creativity is not known with certainty. Zaffron and Logan feel this is rooted in language, particularly future-based generative language [11]. In their view, language patterns are prescriptive, as well as descriptive. Rather than merely reflecting the group dynamics of an organization, a change in language is the primary means of transforming those dynamics. Language is the means of either augmenting or dampening attractors and is therefore a portal for entry into the CAS of the organization.

Regardless of the exact nature of this interaction, it clearly involves relational contact between the members of the tribe. The effectiveness of transmission or communication of the concept of culture in an organization is itself influenced by the level of culture in the individuals involved. In other words, the shared purpose, values, history, identity and future of individuals within an organization shape the nature of ongoing interpersonal interaction within that organization as a whole. Culture functions as a positive-feedback loop, similar to the Increasing-Returns described by W. Brian Arthur [12]. This ability of culture to elicit behavior in an individual that enables its transmission to other individuals is similar to Adam McNamara's discussion of an "i-meme" [13].

In developing their thesis on Organizational Culture, Logan and co-authors utilized four main research tools [7]:

1. Organizational Development Surveys (n=472): Found that cultures operate at consistent levels across cultural factors, such as listening, problem-solving, job support and participation/engagement. Once formed, cultures resist perturbation.

2. Burke's Cluster Analysis of transcribed interviews (n=1061): Showed word grouping and a standard way of talking that cut across technical and educational levels in the organization.
3. Sociograms of organizations (n=241): @90% correlation of social structures within an organization with language.
4. Training on the stages and then anonymous and confidential self-rating of departmental, divisional and organizational culture (n=22,418): An understanding of the prevalence of various stages of culture and proof that culture can be transformed at leverage points.

To Logan and co-authors, the advancement of culture is linear [7]. It is impossible to "skip" levels. However, the increase in both individual and organizational productivity shows a non-linear proportional correlation to an increase in the "Stage" of culture. They describe five such stages, with the following taglines:

Stage 1-Gang Culture, alienated disconnection, "Life sucks".
Stage 2-Passive Aggressive, "My life sucks".
Stage 3-The Lone Warrior, "I'm great! And by the way, you're not".
Stage 4-Group Centered Productivity, "We're great! And by the way, they're not".
Stage 5-Transcendent, "Life is great".

Most corporations in the United States, and virtually all physicians, lawyers, professors and other professionals spend their entire lives living under the Stage 3 ceiling. Readers of this paper will no doubt recognize the tagline of Stage 3 as prominent in their own experience, perhaps at faculty meetings! Therefore this model will focus on a resilient Stage 3 organization that is resistant to perturbation and investigate possible avenues for cultural advancement to Stage 4.

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3 The Model

The model is constructed using NetLogo [14]. An organization consisting of 31 agents (2 Executives, 4 Managers and 25 Workers) randomly distributed over a 32 x 32 unit time/space grid is established. Each patch on the grid is 10 pixels in size and represents a time-space proximity in which an "interaction" between 2 agents can take place. This interaction is purposely left vague. It could be a conversation, a written report or another means of communication.

The observer establishes the initial starting points of the Stage of Culture of the agents. The "Baseline" for the model consists of 1 Executive, 2 Managers and 3 Workers at Stage 3 and 1 Executive, 2 Managers and 22 Workers at Stage 2. The program stochastically assigns the Levels (Low, Medium and High) within each Stage as well as a numerical value for the individual agent's Culture. The overall Culture of the organization is defined as the mean Culture for the agents. The program also stochastically assigns a numerical value to the initial states of Education and

Disenchantment in each of the agents. The number of agents as well as their initial Stages of Culture (2, 3 or 4) were chosen by trial and error to produce an organization that was stable at high Stage 2/low Stage 3 (ending Organizational Culture of 40 ± 2). As the model progresses, these values of Education and Disenchantment will be altered based upon stochastic formulae and are meant to represent external forces (other than those based upon interaction of the agents within the organization) that add or subtract to the individual's Culture.

Additional global variables include a modifier for the general state of the Economy. Formulas describe the exchange of Culture between agents with different Stages of Culture (peer, peer plus or minus one, peer plus or minus two). Relational Modifiers (RM1 and RM2) further modulate the exchange based upon the Role of each agent in the organization's hierarchy (Executive, Manager or Worker). The result of an interaction between a Worker and a Manager, or between a Manager and an Executive will be primarily based upon the differences in the Stage of Culture between the agents, but will be modified, either positively or negatively, by a factor of 0.15. Similarly, the interaction between an Executive and a Worker will be modified by a factor of 0.30. A "Tuner" global variable is used to capture other modifiers that are surely present and significant, but which have gone unrecognized in the construction of the model.

Each unit of time or "tick" represents one week. With the passage of each tick, the agents move through the time-space grid and sense if other agents are in proximity for an interaction. If so, they interact according to their corresponding Stage and Level of Culture, as well as their respective Roles in the organization. Culture can be gained, lost or remain unchanged. If the interaction is between agents at the same cultural Stage (peer) but each agent is at the low end of that Stage (both Low Level), the culture of each is diminished. If both are at the high end of that Stage (both High Level), the culture of each is increased. If both are at the middle range of the Stage (both Middle Level), nothing changes. In an interaction between an agent at a Low Level and one at a Middle Level, the culture of the agent at the Middle Level is slightly diminished, but that of the agent at the Low Level remains unchanged. In an interaction between an agent at Low Level or Middle Level and one at High Level, the culture of the agent at Low Level or Middle Level is slightly increased, and that of the one at High Level remains unchanged:

Table 1. Cultural change based on Cultural Level in a Peer Cultural Stage interaction. L = Low, M = Medium, H = High.

Cultural Level Difference Agent1-Agent2	**Change Agent1**	**Change Agent2**
L-L	--	--
L-M	0	-
M-L	-	0
M-M	0	0
L-H	+	0
H-L	0	+
M-H	+	0
H-M	0	+
H-H	++	++

The same pattern holds for interactions between agents at different cultural Stages (peer plus or minus one, peer plus or minus two) but the magnitude of change is proportional to the difference in culture between the agents.

After the interaction, the agents reassess their Stage and Level of Culture (the Role remains constant). In addition, possible additions to the agents' Education and/or Disenchantment levels are made stochastically. When these levels reach a threshold, the Culture of the agent involved is modified either up or down, and the Education and/or Disenchantment level of the agent is reset to zero. This serves as an analog to mutation in this "Cultural Meme".

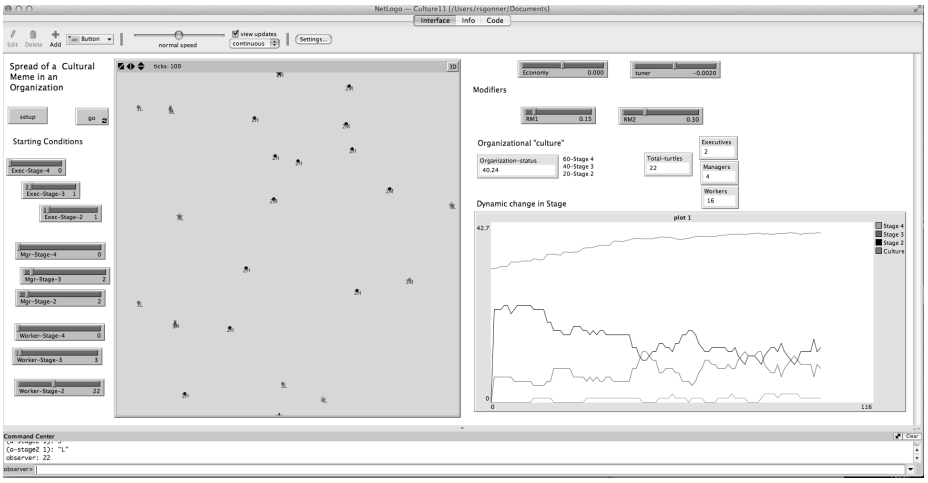
With each tick of time, the mean Culture of the Organization is displayed and plotted. The number of Stage 2, Stage 3 and Stage 4 agents is plotted and the count of Executives, Managers and Workers displayed. If the Cultural value of an agent rises above 80, a new Worker at Stage 3 is created and randomly placed in the time-space grid and joins the movement and interaction of the field of agents. If the value of Culture of an agent drops below 20, the agent "dies" or leaves the organization. The model continues for 99 ticks or until only one agent is left.

The main output indicators are the total number of agents in the organization and the overall value of the Culture of the organization, which is determined by the mean value of the culture of the agents, irrespective of their role. If the overall Culture of the organization rises to 60 or above, it is considered a positive transformation to Stage 4. The model is run 20 times for each alteration in the Stage of Culture from baseline and the probability of advancement to Stage 4 calculated for that initial condition. Because of the stochastic nature of many of the variables, the result is based upon the starting point, but evidences path-dependency as well.

4 Simulation Results

The model was run 500 times (25 iterations of 20 runs) with baseline initial settings to insure that it was stable (Fig 1).

Fig. 1. Ending status of typical model run at baseline settings.



The model consistently produced ending values of @ 22 total agents with a mean Organizational Culture of @ 40, just inside the value for a Stage 3:

Table 2. Typical baseline run of model

Initial Condition	Baseline	
	Turtles	Culture
	20	40.65
	20	41
	18	39.74
	21	39.08
	24	38.75
	22	41.36
	23	38.71
	25	39.35
	24	40.41
	22	42.12
	26	40.68
	19	40.08
	22	39.43
	20	41.44
	21	39.82
	23	39.5
	22	41.47
	20	38.74
	23	39.39
	23	40.63
Mean	21.9	40.12
STDEV	2.05	1.02
Probability of Reaching Stage 4		0.00

Additional runs were made altering the initial Stage of Culture for various agents. The mean values and standard deviations were calculated for the total number of agents as well as the total Organizational Culture. A significant amount of variability in each of the 20 runs was noticed, indicative of the stochastic elements at play in the model and the importance of path-dependency as well as starting point. Therefore a better outcome for success of the model's starting condition was the probability of that initial condition reaching Stage 4 in those 20 runs:

Table 3. Run of model with the baseline configuration modified to indicate 3 Managers at Stage 4 in the initial configuration:

Initial Condition	3 Mgr	
	Turtles	Culture
	25	44.35
	103	107.95
	21	41.91
	30	48.01
	24	44.19
	20	44.44
	21	42.57
	25	41.69
	86	91.72
	69	79.05
	100	101.69
	22	42.07
	81	91.6
	23	44.69
	76	84.41
	79	87.38
	61	75.77
	68	75.13
	21	43.28
	161	150.91
Mean	55.8	69.14
STDEV	38.93	30.35
Probability of Reaching Stage 4		0.45

If at the initial setup the Stage of an Agent was increased from baseline, the agent with the lowest Stage in that Role cohort was moved up a Stage. For example, the baseline condition had two Managers at Stage 3 and two at Stage 2. If one Manager was moved up to Stage 4, the resulting initial condition had one Manager at Stage 4, two at Stage 3 and one at Stage 2. If two Managers were moved up to Stage 4, the other two were at Stage 3. The probability of the model ending at Stage 4 overall Organizational Culture was calculated as in the above example and the results tabulated:

Table 4. Results of the model run with the initial condition including agents at Stage 4. Table gives the number of agents and their Role. E = Executive, M = Manager and W = Worker.

Initial Condition	2E4M8W	8W	7W	4M	6W	2E4M4W	3M	5W	4W	2M	3W	1E1M1W	2W	2E	1E	1W	1M
Probability of Reaching Stage 4	0.80	0.60	0.60	0.50	0.50	0.45	0.45	0.40	0.40	0.30	0.25	0.20	0.20	0.15	0.15	0.10	0.05

To investigate the effect of the Economy on the function of the model, the baseline configuration was run and the value of the Economy variable decreased by one unit (0.001 on the Economy slider) until the model failed because all but one agent "died", preventing any further interaction:

Table 5. Run to extinction of the model by decreasing the level of the overall Economy

Initial Condition	Base Econ-2		Base Econ-3		Base Econ-4		Base Econ-5		Base Econ-6	
	Turtles	Culture	Turtles	Culture	Turtles	Culture	Turtles	Culture	Turtles	Culture
Mean	21.65	33.63	18.85	31.63	15.00	31.39	10.70	32.62	7.40	36.16
STDEV	1.93	0.80	2.54	0.72	2.38	0.99	2.00	1.77	1.10	1.92
Initial Condition	Base Econ-7		Base Econ-8		Base Econ-9		Base Econ-10		Base Econ-11	
	Turtles	Culture	Turtles	Culture	Turtles	Culture	Turtles	Culture	Turtles	Culture
Mean	6.05	38.17	6.05	36.79	5.95	33.35	5.15	28.22	2.95	24.43
STDEV	0.22	0.66	0.22	0.96	0.22	1.68	0.93	1.81	0.83	1.62

Extinction occurred when the Economy was reduced by 12 units, as all but one of the agents died in that run. Interestingly enough, even though the number of agents

decreased with each successive drop in Economy, the overall Culture of the organization was retained until right before the organization failed. It in effect fell off a cliff.

5 Conclusions

The model appears to accurately mirror the known pattern of a high Stage 2 / low Stage 3 organization. It is stable over a broad number of runs and reaches a fairly consistent equilibrium. Periodically, Stage 4 agents will spontaneously bubble up from the interaction of the organization and external influences of Education and Disenchantment (mutation), but in most cases, those agents will also revert back to Stage 3 during the course of the run. Patterns of rise and fall in the number of Stage 3 and Stage 2 agents are seen during maturity of the run. Equilibrium is reached at baseline levels. The model also is very resistant to deterioration in the Economy, losing agents but retaining its level of culture until late in the course of its demise.

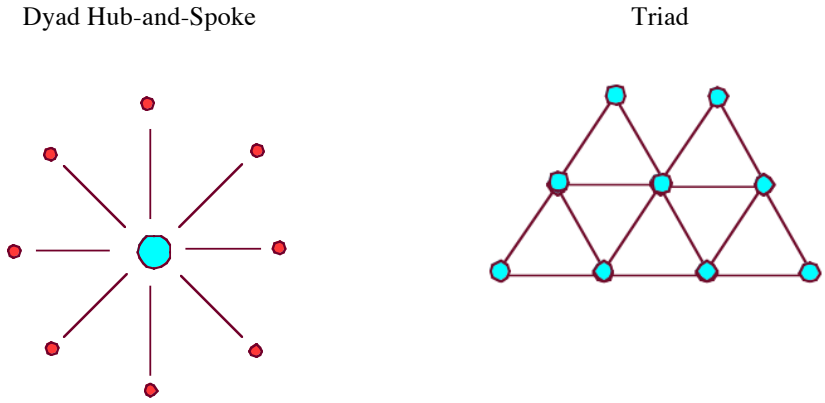
Surprising was the relatively small effect that increasing the initial Stage of Culture of the Executives had on Organizational Culture. The model was developed thinking that the Executives could have more of an impact because of their stature in the organization and the Role Modulating variables were adjusted to reflect that. A similar Role Modulating variable was constructed for interactions involving Managers, but this was set at half the value of that for Executives. Although one Executive starting at Stage 4 did increase the probability of the organization ending at an overall Stage 4 to 0.15 versus 0.05 for one Manager and 0.10 for one Worker, when both Executives started at Stage 4 that probability remained unchanged. However increasing the starting number of Managers and Workers to two increased the probability to 0.30 and 0.20 respectively. That slight edge to the Managers continued throughout the runs of the model.

The model exhibits the influence of the importance of starting point as well as path-dependency. Choosing the probability of advancement to Stage 4 culture, rather than measuring the mean value of Organizational Culture at each starting point configuration reflects that path-dependency. The model is consistent with what is known about Organizational Culture (resistance to perturbation, formed by aggregate of individual culture and communicated by personal interaction), Complex Adaptive Systems (resistance to perturbation, co-evolution of the system and the agents, outcome exhibiting importance of starting point as well as path-dependency) and mimetic transfer (a set of behavior that replicates through assimilation, retention, expression and transmission [13]).

Additional avenues of investigation will attempt to introduce learning into the model, perhaps by segregating the time-space environment into areas that are more and less conducive to Culture transfer and allowing the agents to sense this difference and alter their behavior to take advantage of it. There remain a number of probably unrecognized but important variables to add to the model. At this point they are represented in the global variable Tuner, but perhaps a more specific determination will be possible in the future.

Logan and co-workers found an important marker of the difference between a Stage 3 and Stage 4 culture was a sociometric shift from dyads to triads (Fig 2) [7]. A dyadic relationship in an organization is a hub-and-spoke model. At the center a Stage 3 individual surrounds him or herself with subordinates at Stage 2 ("I'm great and you're not"). In a Stage 4 culture, the relationship shifts to triads between equals. The triads in turn interlock with other triads to propagate. A further model will incorporate the formation of these networks.

Fig. 2. Dyad and triad relationships.



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Modeling the Spread of a "Cultural Meme" Through an Organization
ODD Protocol

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1. Purpose

One of the key determinants of organizational effectiveness and productivity is the overall "culture" of the organization. The culture determines how the members of the organization interact with each other, their shared values and the energy with which they approach their activities. Sharing of this culture is complex. Starting point is critical to outcome, and there is path-dependency. The ability to share this vision is in fact a part of the culture of the organization. In this regards, it operates as a positive-feedback system, similar to the concept of Increasing-Returns formulated by W. Brian Arthur. In addition, it elicits behavior that results in its transmission and therefore behaves as a meme. This model was developed in an effort to test how a culture spreads through an organization and identify possible attractors to aid in that spread.

2. Entities, state variables and scales

Agents. The model is composed of individuals in a mythical company or academic department. They have three possible Roles: Executive, Manager and Worker. The state of their "culture" as to Stage 2, Stage 3 or Stage 4 further characterizes agents in each of those roles, and each Stage is further subdivided to a Level that can be Low, Medium or High. A value of culture from 20 to 39 corresponds to Stage2, from 40 to 59 to Stage 3 and 60 or above to Stage 4. While agents can move up or down in their Level and Stage of culture, their Role throughout the model is static.

Spatial units. The agents move throughout a 32 x 32 unit grid that wraps both vertically and horizontally. Each patch is 10 pixels in size. In this iteration, the grid represents combined spatial and temporal proximity and represents opportunity for interaction between the agents. One time step represents one week in the life of this organization and the model ends after 99 weeks or if the number of agents drops to one, where no further interaction is possible.

Environment. In this iteration of the model, the environment varies depending upon the status of the Economy, which is controlled by a global variable and a slider. Additional global variables, also controlled by sliders, are RM-1 and RM-2 (to modulate exchanges of information between agents of differing Roles) and a "Tuner" to regulate the sum of other unrecognized yet important variables that impact the exchange of information.

Collectives. The interaction of the agents is controlled by both random movement throughout the environment and the Stage and Level of their own culture and their Role in the organization.

3. Process overview and scheduling

In random order, each agent moves forward 2 steps and senses if another agent is on their patch. If so an "Exchange" of Culture takes place. The exchange may be positive, negative or neutral depending upon both the Stage and Level of the agents as well as their Role. After the Exchange, agents asynchronously recalibrate their Stage and Level depending upon any change in Culture. In addition, the state of the Economy can influence their culture, positively or negatively. The Economy in this version of the model remains constant throughout the 99 weeks duration. Culture is also influenced either positively by a stochastic level of Education or negatively by a similar stochastic level of Disenchantment. If an agent's Culture drops below 20, they leave the organization. If an agent's Culture rises to 80 or above, a new agent is added to the organization in the Role of a Worker at a Low Level of Stage 3. This new agent is placed in a random spot in the environment. A number of states are continuously updated: The number of agents at Stage 2, Stage 3 and Stage 4 are plotted along with the overall mean Culture of the organization. This Culture {"Organization-status") is calculated by dividing the sum of the Culture of all of the agents by the total number, irrespective of their Role. In addition, the number of agents in each Role is displayed in separate output windows, as is the numerical value of the Organization-status.

The processes utilized in the model are: *Setup*, *Go*, *Display* and *Report* of *Organization-status*, agents by *Role* and *Plot* of *Organization-status* and number of agents by *Stage* of *Culture*. Within the *Go* process are sub processes of *Move*, *Exchange*, and *Reset of Culture*. Within *Reset of Culture* is a determination and reset of Cultural *Stage* and *Level* as well as determination of *Education* and *Disenchantment*, use of those values to modulate culture and reset of variables.

4. Design Concepts

Basic Principles. The premise of this model is that *Culture* is a learned concept that develops through interaction between the members of an organization. The effectiveness of that sharing is determined by both the underlying *Culture* of each individual as well as by a multiplier that is dependent upon their *Role* in the organization. *Culture* can be advanced by interaction with an individual with a higher *Stage*, *Level* and *Role*. Similarly, it can be lost through interaction with an individual of a lower state in each of those variables. The magnitude of that gain or loss is dependent upon the relative difference in each of those state variables. Interactions between agents can also result in no change if they are enough similar as to not represent a "pressure to exchange". As it was recognized that there were a number of other unknown variables that would enter into the cultural exchange

between agents, a "*Tuning*" global variable was introduced to further modulate the interaction of the other state variables.

Emergence. The key output of this model is the probability of the organization reaching an overall *Culture* consistent with *Stage* 4 by the end of the 99 weeks. This probability function is determined by the initial starting point of the number of agents and their *Stage, Level* and *Role*, and the influence of *Economy.* After each change in the initial conditions of the state variables, the model was run 20 times and the probability of reaching *Stage* 4 calculated. In addition, elevation of individual *Culture* beyond a certain threshold increases the number of agents in the model. A secondary output is the total number of agents, as the model terminates on the negative side when all agents but one leave the organization, as interaction is no longer possible.

Adaptation. The agents do not change the way in which they move or seek out partners for possible exchange. This is a random process in this model.

Objectives. In this model, the increase of both the *Culture* of the individual Agent and the overall *Organization-status* of the organization is not an adaptive trait. As the exchange o *Culture* between agents can have both a negative and positive impact upon individual and group Culture, it was felt best to leave this to random activity.

Learning. Likewise, no learning is present in this iteration.

Prediction. The power of this model is the ability to predict the probability of spreading a "Cultural Meme" through an organization based upon the number of agents "infected" with that meme and their role in the organization.

Sensing. Each agent can sense the proximity of another with whom to have a possible cultural exchange or "conversation". If another agent is in proximity, that agent's *Stage* and *Level* of *Culture* is sensed, along with their *Role*. Each of those is compared to the values of the same variables in the sensing agent and an exchange carried out based upon that comparison.

Interaction. The interaction between agents in this model is direct, based upon the factors already described.

Stochasticity. The initial placement of the agents in the model is random. The number of agents, their *Role* and initial cultural *Stage* is set by the observer, but within that cultural *Stage* the *Level* is set according to a random-float variable. The initial level of *Education* and *Disenchantment* is likewise determined by a random-float variable. The frequency of update of *Education* and *Disenchantment* is similarly set by a random-float variable, and represents mutation in this "Cultural Meme".

Collectives. While the movement of agents and possibility or frequency of exchange between agents is not influenced by any collective, the interaction between agents is determined by their relative membership in the collectives of *Stage*, *Level* and *Role*.

Observation. After each change in the initial conditions of the model, the model is run 20 times and the final count of agents and *Organization-status* determined for each run. The probability of the total *Organization-status* being *Stage* 4 (60 or above) is then determined for each set in starting conditions.

5. Initialization

Each model run begins with creation of 31 agents: 2 Executive, 4 Managers and 25 Workers. The Baseline-the model that consistently ends with an *Organization-status* of Low *Stage* 3 (*Organization-status* 40-41) consists of 1 Executive, 2 Managers and 3 Workers at Stage 3, and 1 Executive, 2 Managers and 22 Workers at Stage 2. For each of these *Stages*, random values are chosen to place the agent in the Low, Medium or High *Levels* of that *Stage*. In addition, random initial values for an agent's *Education* and *Disenchantment* levels are chosen. The *Economy* global variable is set to "0" and the *Tuner* global variable set to "-0.002". The *Role Modulator-1* global variable (that modulates interactions between agents of 1 step difference, i.e. Worker/Manager or Manager/Executive), is set to "0.015" and the *Role Modulator-2* global variable (modulates interactions Worker/Executive) is set to "0.030".

For additional runs of the model, the *Stage* of each agent, though not their *Role*, is varied. The model stochastically sets the level of *Culture* within each stage. In addition, for determination of the "death" of the organization, the Baseline is kept constant and the *Economy* varied from 0.000 to 0.012 in increments of 0.001.

6. Input Data

No input data is utilized in this model.

7. Sub models

Setup: creates agents according to the number, *Role* and *Stage* determined by the observer. The model stochastically assigns the value of *Culture* and *Level* corresponding to the *Stage* selected. The model also stochastically assigns a starting level of *Education* and *Disenchantment*. The placement of the agents within the environment and their heading is determined stochastically by the model.

Go includes *Move*, *Exchange*, *Set Levels*, *Display* and *Plot* and the advancement of the model one time unit.

Move picks a random heading and moves the agent forward 2 units.

Exchange is complicated. It consists of 5 possible subunits, depending on if the partner in the exchange is at an equal *Stage*, is lower by 1 *Stage*, lower by 2 *Stages*, higher by 1 *Stage* or higher by 2 *Stages*. Within each of those *Exchange* scenarios, there is further modulation based upon the *Level* of *Culture* within the agent's Stage and whether the partner is of the same *Role*, higher, or lower.

Reset of Culture involves modulation of each agent's *Culture* that results from the *Exchange* by the global variables of *Economy* and *Tuner* (set as part of the initial conditions) as well as stochastically determined increases in *Education* and/or *Disenchantment*. Once the level of *Education* or *Disenchantment* reaches a threshold, a modifier to the agent's *Culture* is applied and the *Education* and/or *Disenchantment* variable is reset to 0.

Display of *Organization-status*, *Count* of Executives, Managers and Workers are updated continuously in output windows. In addition, *Organization-status* and count of *Stage* 2, *Stage* 3 and *Stage* 4 agents are plotted continuously.

The model stops when either 99-time units have transpired or all but 1 agent leaves the organization because their *Culture* has dropped below 20.

8. Simulation Experiments and Model Analysis

The model was developed and a baseline state found that would consistently, through 500 runs, result in an ending *Organization-status* at a low *Stage* 3. The initial conditions were the following: 1 Executive, 2 Managers and 3 Workers at *Stage* 3 and 1 Executive, 2 Managers and 22 Workers at *Stage* 2. After 99 ticks, this produced an ending state of 21.9 ± 2.05 agents and an *Organization-status* of 40.12 ±1.02. In no instance was an ending *Organization-status* consistent with a *Stage* 4 organization produced, though the model would produce varying numbers of individual agents that periodically reached and lost *Stage* 4 .

The number of agents at *Stage* 4, as well as their respective *Roles* in the organization, was then varied across a spectrum and 20 runs of the model made at that initial condition. The number of agents remaining, as well as the ending *Organization-status* sent to an Excel spreadsheet. The mean and standard deviation of the runs were calculated and the probability of that initial condition resulting in a *Stage* 4 organization determined. A somewhat surprising result was the comparatively small impact an increase in the initial *Culture* of the Executives had, even though the model was constructed with the assumption that their influence would be greater than agents in the other *Roles*.

The model was also run to extinction by decreasing the global variable for *Economy*. Even as the number of agents decreased, the overall *Organization-status* remained relatively high until the very end. The decrease was not linear, but abrupt.

The model appears to mirror to a large extent the natural state of an organization, particularly an organization of professionals such as a healthcare or academic institution. Subsequent modifications are planned to investigate the role learning and adaptation, as opposed to just *Education* and *Disenchantment* may play in the advancement of *Culture.*