

Model description: An Agent-Based Model of Status Construction in Task Focused Groups

Our model description is based on the updated version of the ODD protocol (Grimm et al. 2010), in which we combined the sections *Adaptation* and *Learning*. Parts of the description are modified elements of the article in which we develop the model (*reference to be included after publication*).

The model has been implemented in NetLogo 5.0.5 (Wilensky 1999). However, the description provided here is intended to be independent of the specific modeling language that is used. Auxiliary variables and procedures that were needed to implement the model in NetLogo are therefore described only in the NetLogo code. The GUI of the NetLogo implementation also provides instructions for creating the three different versions of the model that we used in the article.

1 Overview

1.1 Purpose

Our agent-based computational model aims at modeling interactional processes that can turn salient social characteristics, such as sex and ethnicity, into status characteristics. A status characteristic is any social distinction that separates individuals into at least two categories that are believed to differ in social worth and general competence.

Mark, Smith-Lovin, & Ridgeway (2009) described a mechanism by which social distinctions can become associated with beliefs about competence differences, even in the absence of actual competence differences between members of the different categories that a distinction creates. Drawing on status construction theory and related research on the emergence of hierarchies in task focused groups, Mark et al. highlighted that task focused groups can spontaneously develop hierarchies of influence and deference in which some individuals appear more competent than others, even when this is objectively not the case. When hierarchical differentiation occurs consistently between members of different social categories, group members can come to believe that the distinction generally coincides with competence differences. Once emerged, such beliefs can diffuse throughout the population, because individuals carry them into new group contexts, treat new interaction partners accordingly, and thereby create hierarchies that teach their beliefs to others. By that, status beliefs can both emerge and spread, even when there are no objective competence differences between members of the different social categories.

In their formal modeling efforts, Mark et al. (2009) focused on dyads as the smallest possible groups in which hierarchical differentiation can occur. The focus on dyads is a useful starting point for examining status construction process, because it allows researchers to abstract from some of the complex interaction dynamics that might develop in larger groups. However, many of the task focused interactions that take place in today's societies occur in groups larger than dyads. The model that we describe here thus aims at modeling task focused interaction in groups larger than the dyad. To this end, we have combined insights into hierarchy formation in groups larger than dyads, as provided by the expectation states framework (e.g., Fisek, Berger, and Norman 1991), with insights into status belief formation, as provided by status construction theory (e.g., Ridgeway and Correll 2006).

The resulting model is an abstract model that aims at exploration and hypothesis generation. It emulates task focused interactions in small discussion groups. This can be considered a prototype of task groups that has frequently been studied in empirical research and simulation studies. The members of such groups have to develop a solution for a complex problem that might not have an objectively correct solution. For such groups, the model enables us to theoretically examine questions such as: Do basic principles of task focused interaction systematically favor the emergence of status beliefs in groups larger than dyads? Does the time-frame over which small groups interact affect the likelihood with which status beliefs emerge? How does group size affect the emergence of status beliefs?

1.2 Entities, state variables, and scales

The model consists of two entities: agents (i) and behavior interchange patterns (b_{ij}) between them. The simulation proceeds in discrete time, measured in iterations. One iteration represents one interaction among group members (see details in the section *Processes overview and scheduling*). Next to the properties of these entities, the model also includes a number of global parameters. Finally, there is a number of global variables that measure aspects of the social structure in the agent groups.

Agents: Individuals who belong to one of two social categories.

Variable	Brief description	Range
N_i	Agent i 's state on a nominal social distinction.	$N_i \in \{A;B\}$
S_i	Agent i 's status belief that indicates which state of N_i it believes to be associated with higher competence.	$S_i \in \{A;O;B\}$
$\#neg_{ij}, \#pos_{ij}$	Pieces of information that agent i perceives to suggest that agent j is less (<i>neg</i>) or more (<i>pos</i>) competent than other group members.	$0 < \#neg_{ij} \leq \infty,$ $0 < \#pos_{ij} \leq \infty$
e_{ij}	Performance expectation that agent i has for agent j .	$-1 < e_{ij} < 1$
e^*_{ji}	Average performance expectation that all group members have for agent i .	$-1 < e^*_{ji} < 1$
E_i	Expectation standing that agent i has in the group.	$0 < E_i < 1$

Behavior interchange patterns: Ties between dyads of agents that indicate which of the members appeared more/less often in the higher competence role in all past interactions.

Variable	Brief description	Range
<i>weight</i>	Integer value that together with the direction of the tie indicates which of the two agents appeared more often/less often more competent. For instance, when agent <i>i</i> is the source and agent <i>j</i> is the sink of a tie with weight 8, agent <i>i</i> has appeared more competent in 8 more of their interactions than <i>j</i> . By contrast, if <i>i</i> is the sink and <i>j</i> is the source, agent <i>j</i> would have appeared more competent in 8 more of their interactions than <i>i</i> . Ties for which the value of <i>weight</i> is 0 (i.e. in which both agent appeared equally often more/less competent) are undirected.	$0 \leq weight \leq \infty$

Model parameters: Run-time settable parameters that govern the model's behavior.

Parameter	Description	Range
<i>I</i>	Number of agents in the group.	$2 \leq I \leq \infty$
I^A, I^B	Number of agents in the group with the states <i>A</i> and <i>B</i> on the nominal social distinction N_i .	$0 < I^A \leq \infty,$ $0 < I^B \leq \infty,$ $I^A + I^B = I$
γ	Governs the effect that differences in agents' expectation standings E_i have on interaction probabilities in the group.	$0 \leq \gamma \leq \infty$
δ	Governs the effect that agents' expectation standings E_i have on the probability that the suggestion of a given agent <i>i</i> will be accepted/rejected by another agent <i>j</i> .	$0 \leq \delta \leq \infty$
<i>c</i>	Threshold that <i>r</i> needs to pass for agents to acquire or maintain status beliefs.	$0 < c \leq 1$
<i>a</i>	Probability with which agents adopt a status belief when <i>r</i> (- <i>r</i>) passes the threshold <i>c</i> (- <i>c</i>).	$0 < a \leq 1$
<i>l</i>	Probability with which agents loose a status belief when <i>r</i> (- <i>r</i>) fails to pass the threshold <i>c</i> (- <i>c</i>).	$0 < l \leq 1$

Global variables: Variables that measure different aspects of the social structure in the agent groups

Variable	Description	Range
$comp$	Comprehensiveness of past interactions in the group that might be indicative of competence differences between members of the categories A and B .	$0 \leq comp \leq 1$
$\#b^{A-}_{ij}, \#b^{A+}_{ij}, \#b^{AO}_{ij}$	Number of behavior interchange patterns/ties b_{ij} in which members of category A took the lower (-), higher (+), or the same (0) competence role in their interactions with members of category B .	$0 \leq \#b^{A-}_{ij} \leq \infty,$ $0 \leq \#b^{A+}_{ij} \leq \infty,$ $0 \leq \#b^{AO}_{ij} \leq \infty$
$cons$	Consistency with which behavior interchange patterns/ ties b_{ij} support different status beliefs.	$-1 \leq cons \leq 1$
r	Measure of how much $comp$ and $cons$ together support different status beliefs.	$0 \leq \delta \leq \infty$
largest_share_of-_believers	Measures the information about the largest share of agents that hold the same state on S_i which is different from O .	$0 \leq$ largest_share_of -_believers ≤ 1
changes_cons	Measures the number of times that $cons$ has changed its sign over the course of the simulation.	$0 \leq$ changes_cons $\leq \infty$

1.3 Processes overview and scheduling

Each model run consists of two phases: The initialization phase and the simulation phase. In the pseudo codes that outline each phase, we mention model parameters and measures. We describe these entities in the sections *Design Concepts* and *Submodels*.

Initialization phase

The initialization phase serves initializing a simulation run.

Pseudo code

Create agents one at a time.

For each agent, determine the performance expectations e_{ij} that it has for all group members, including itself.

Create variables that store the values of $comp$, $cons$, and r .

Create an auxiliary variable `largest_share_of_believers` that stores the information about the largest share of agents that hold the same state on S_i which is different from 0.

Create an auxiliary variable `changes_cons` that stores the information about the number of times that `cons` has changed its sign over the course of the simulation. Set the value of `changes_cons` to 0.

Create an auxiliary variable `number_iterations` that stores the number of iterations that have already been conducted. Set the value of `number_iterations` to 0.

Simulation phase

The simulation phase models interactions between agents. The simulation proceeds in discrete time steps, referred to as iterations. One iteration corresponds to one interaction in the group. In each iteration, the following computations take place:

Pseudo code

```
While number_iterations ≤ max_number_iterations:
{
    For each agent, update its performance standing  $E_i$  in the
    group.

    For each agent, create a temporary variable  $E_i^\gamma$  that stores
    the value of  $E_i$ , weighted with  $\gamma$  as an exponent.

    Randomly select one agent for being interactant_1, with a
    probability proportional to  $E_i^\gamma$  over all agents.

    Randomly select one agent for being interactant_2 from the
    set of agents that excludes interactant_1, with a
    probability proportional to  $E_i^\gamma$  over all agents in this
    set.

    For both interactant_1 and interactant_2, create a temporary
    variable  $E_i^\delta$  that stores the value of  $E_i$ , weighted with
     $\delta$  as an exponent.

    Randomly select interactant_1 or interactant_2 for appearing
    in the higher competence role in their interaction,
    with a probability proportional to  $E_i^\delta$  over both agents;
    assign the respective other agent the lower competence
    role.

    Update the behavior interchange pattern/tie  $b_{ij}$  between
    interactant_1 and interactant_2, based on the outcome
    of their interaction.

    Calculate comp, cons, and r.
```

```

    For each agent, update its status belief  $S_i$ .

    For each agent, update the performance expectations  $e_{ij}$  it
        has for all group members, including itself.

    If cons has changed its sign compared to the last iteration,
        increase the value of changes_cons by 1.

    Calculate largest_share_of_believers.

    Report comp, cons, changes_cons, r,
        largest_share_of_believers.

    Increase number_iterations by 1
}

```

2 Design concepts

2.1 Basic Principles

The behavioral principles in the model are based on research in the expectation states framework, which includes status construction theory.

Expectation States Framework

The expectation states framework is a set of theories that examine the emergence of hierarchical differentiation in newly established groups with a collective task focus. Hierarchical differentiation is defined as inequalities in task participation and influence among group members. Those group members who are relatively more active on the task and whose opinions have more weight in decision making processes hold higher positions in the group's hierarchy. One central question that this framework addresses is how task focused groups might develop hierarchical differentiation if there are no obvious differences among group that might 'justify' a hierarchy (e.g., differences in competence or knowledge relevant to the task at hand). A possible explanation that the framework offers is based on the following mechanism.

The expectation states framework builds on the notion that when previously unacquainted individuals meet in a group setting with a collective task focus, "they act as if one of the subtasks of the group is to decide who has high and who has low ability at the task—thus to take advantage of high ability members and not be misled by low ability members" (Driskell 1982:232). Assumptions about relative abilities are represented by so-called *performance expectations* (Berger et al. 1977) that group members hold for each other.

Performance expectations affect the way group members coordinate their work on the task (Balkwell 1991; Berger, Rosenholtz, and Zelditch 1980; Driskell 1982). First, those who are expected to perform relatively better than others are more likely to receive *performance opportunities*. This means that they are more often asked for their opinion, more often receive the opportunity to make suggestions, and are given more time to elaborate their views. Second, the contributions of those who are expected to perform relatively better receive more positive *performance evaluations*. This means that even when their suggestions are qualitatively similar

to the suggestions of group members for whom performance expectations are relatively lower, their suggestions are still more likely to be accepted and appreciated.

When individuals lack objective information about each other's competence, they look for cues that might provide such information. The two cues that are relevant in the context of this article are *status characteristics* and *behavior interchange patterns* (Fisek et al. 1991; Webster, and Rashotte 2010). Status characteristics are connected to beliefs about competence differences between members of different social categories. For instance, when gender is a status characteristic that favors men over women, individuals tend to believe that men are generally more competent than women. Performance expectations therefore tend to be higher for male than for female group members. Behavior interchange patterns are interactions among group members that might indicate competence differences between them. For instance, when group member A_1 appreciates and accepts the suggestions of group member A_2 , whereas A_2 criticizes and rejects A_1 's suggestions, a behavior interchange pattern becomes established in which A_2 appears more competent than A_1 . As a consequence, group members are more likely to pay attention to A_2 's suggestions, even compared to other group members A_3 , A_4 , and A_5 , who were not themselves involved in the interaction. Conversely, group members are likely to pay less attention to A_1 's suggestions, even compared to other group members.

Both status characteristics and behavior interchange patterns tend to create stable hierarchical differentiation between group members, even in the absence of objective competence differences. When there are status differences between social categories from the outset, the relatively higher performance expectations that group members have for members of a status advantaged category will lead the members of this category to dominate group interaction (Berger et al. 1977). In the absence of salient status characteristics, group members who manage to make suggestions that are accepted by other group members in an early phase of group interaction increase the performance expectations that other group members have for them. This leads to a "self-fulfilling prophecy" (Meeker 1994:107) in which they become more likely to receive subsequent performance opportunities and their subsequent suggestions are more likely to be evaluated positively. This implies that small, randomly created status differences tend to grow and become stable over time.

Status Construction Theory

Status construction theory complements the above cited research by describing how the observation of hierarchical differentiation in task focused group interaction might imbue social distinctions with status value.

According to status construction theory, individuals tend to infer competence differences from behavior interchange patterns. When such patterns are juxtaposed with differences in a salient social distinction (e.g., men generally accept the suggestions of women, whereas women generally reject the suggestions of men), there is a chance that group members "misattribute" (Webster and Hysom 1998:357) seeming competence differences to differences in the distinction. That is, they acquire status beliefs that turn the distinction into a status characteristic.

The likelihood with which such belief acquisition takes place depends on how *comprehensively* and *consistently* the social distinction is associated with apparent competence differences (Ridgeway 2000:96–97). Comprehensive means that individuals have observed a number of

behavior interchange patterns between different members of different social categories (Ridgeway 2000). Consistent means that in these patterns members of one category generally appeared in the higher competence role, whereas members of the respective other category almost invariably appeared in the lower competence role (Ridgeway and Correll 2006; Ridgeway 2000). When both conditions are fulfilled, individuals tend to have little doubt in the observed association and are thus likely to acquire a corresponding status belief.

Even when individuals doubt an observed association between categorical differences and relative competence, they have reason to act as if they would personally believe it. Consistent displays of influence and deference between members of different categories imply some degree of consensus among others as to who should assume leadership roles and who should have the chance to contribute to important collective tasks (Ridgeway and Correll 2006). Acting against such consensus bears the risk of social “backlash” (Ridgeway et al. 2009:47) that can incur significant costs for the individual. This creates a subjective incentive to comply with the perceived consensus.

By this process, coincidentally created hierarchical differentiation among the members of a small group might induce status beliefs among group members.

The focus and use of the model

Mark et al. (2009) have shown that the above principles together might lead to the spontaneous emergence and diffusion of status beliefs in larger populations. For showing this, they focused on dyads as the smallest possible group in which hierarchical differentiation between members of different social groups can emerge. In such groups, individuals learn about an association between apparent competence differences and a social distinction by first-hand experience. Furthermore, any hierarchy that emerges is necessarily fully aligned with different states of the social distinction. In larger groups, by contrast, more complex hierarchies can emerge, and group members can gather experience with hierarchical differentiation through observing the interactions of others. Our model enables us to study how this increased complexity affects the emergence of status beliefs in such groups.

All aspects of the model are aligned with theoretical and empirical research in the expectation states framework/status construction theory. In particular, the equations used for modeling the formation of status beliefs, the distribution of interactions across groups members, and dyadic interactions are modelled after equations that have been developed to model empirically observed interaction patterns (see section *Submodels*).

2.2 Emergence

Two outcomes of the model have emergent properties. First, the hierarchical structure that develops among agents is emergent in the sense that the status differences that tend to develop cannot be predicted based on knowledge of agent properties. This emergence derives from the fact that the interactional processes that the model implements have the tendency to reinforce random deviations from status equal interaction among group members. Second, hierarchical structures can lead to the emergence of status beliefs among agents, when they are coincidentally aligned with differences in a social distinction.

2.3 Adaptation and Learning

Adaptive behavior is implemented by the fact that the probabilities that a given agent will be selected for interaction and for taking the high/low competence role in an interaction with somebody else change based on observed behavior interchange patterns and status beliefs. This shift in probabilities implements the notion that group members adapt their behavior when seemingly task relevant information becomes available. That is, agents ‘learn’ from observation and first-hand experience which group members are seemingly more competent and adapt their own behavior accordingly as to maximize the likelihood that the task will be completed successfully.

2.4 Objectives

Agents adapt their behavior as to maximize the likelihood that the task will be completed successfully. Yet, the task that the model assumes is complex and success cannot be measured objectively and agents receive no feedback about success.

2.5 Prediction

Agents adapt their behavior under the assumption that this will maximize chances of group success.

2.6 Sensing

Agents have perfect information about the states on the social distinction among group members and have perfect information about the direction and weights of behavior interchange patterns in the group. They also know about their own status beliefs.

2.7 Interaction

Agents engage in interactions in which one of them directs a suggestion for solving the group task towards another group member. The target of the suggestion decides whether it evaluates this suggestion positively or negatively.

2.8 Stochasticity

Three parts of the model involve stochasticity: the selection of interactants, the determination of the outcome of interactions, the acquisition and loss of status beliefs among agents (see details in the section *Submodels*).

2.9 Collectives

Collectives exist in the sense that agents belong to one of two pre-defined categories that the social distinction creates. Membership in these collectives is fully visible for all agents.

2.10 Observation

There are several measures that keep track of the development of hierarchical differentiation in the simulated groups (for details on calculation see the section *Submodels*). The measure *cons* measures how consistently existing behavior interchange patterns put members of one social category in the high competence role, compared to members of the other category. The measure

comp measures how comprehensive the provided status information is, defined by the share of possible interactions among members of different social categories that have already been realized. The measure *r* combines the information provided by *cons* and *comp* and provides an overall assessment of how consistently and comprehensively the observed behavior interchange patterns in the group support a given status beliefs. We also measure how often *cons* changes its sign over the course of a simulation run (*changes_cons*) and we measure the largest share of group members with a state on S_i that is different from $S_i = O$ (*largest_share_of_believers*). All measures are calculated and reported at the end of each iteration.

2.11 Initialization

We used groups of size two, four, six, eight, and ten. All groups are equally divided into agents I belonging to each of the two categories (i.e. $I = I^A + I^B$). Initially, no agent holds a status belief (i.e. all $S_i = O$), and initially there are not behavior interchange patterns among them. The values of the exogenous parameters δ and γ are set to 2.5 and 1 respectively (see details in the section *Submodels*).

2.12 Input data

The model does not make use of input data.

3. Sub-models

3.1 update_performance_expectations

According to the expectation states framework, individuals tend to balance contradicting information from multiple behavior interchange patterns and status beliefs. In this balancing process, the weight of status beliefs is similar to the weight of a single behavior interchange pattern (Webster and Rashotte 2010). Furthermore, given a set of observations that suggest that a particular group member is (not) very competent, additional information that further supports this perception has a decreasing marginal effect on performance expectations. This has been referred to as the *attenuation effect* (Berger et al. 1977). Based on this, we calculate the performance expectation e_{ij} that agent i has for j at moment t as

$$e_{ij,t} = .8^{\#neg_{ij,t}} - .8^{\#pos_{ij,t}} \quad (1)$$

In Eq. (1), $\#neg_{ij}$ and $\#pos_{ij}$ are pieces of information that, from i 's point of view, imply that j has low or high competence respectively. Using $\#neg_{ij}$ and $\#pos_{ij}$ in the exponent with a base smaller than one implements the attenuation effect; the value of e_{ij} is restricted to the range $-1 < e_{ij} < 1$. The form of Eq. (1) and the values that we use are based on earlier efforts to model interactions in empirical data (e.g., Berger et al. 1977; Fisek et al. 1991).

In the article (*reference to be included after publication*), we describe three different versions of the model that differ in the pieces of information that is considered when performance expectations are updated. In the *basic interaction model*, each behavior interchange pattern in which j holds the higher competence role increases the value of $\#pos_{ij}$ by one and each pattern in which it holds the lower competence role increases the value of $\#neg_{ij}$ by one (note that the weight of the tie that underlies the pattern does not matter). In the *extended interaction model*, $\#pos_{ij}$ additionally increases by one if j belongs to a social category that i believes to be generally

more competent and $\#neg_{ij}$ additionally decreases by one if j belongs to a social category that i believes to be generally less competent. In the *random interaction model*, $\#neg_{ij}$ and $\#pos_{ij}$ are always equal to zero, so that all agents always have the same performance expectations for all group members.

Note that we assume that all agents perceive the behavior interchange patterns that develop in the group in the same way. In the *basic interaction model* the performance expectations that different group members have for a particular agent are thus the same. In the *extended interaction model*, these expectations can vary when there is variation in group members' status beliefs.

3.2 select_interactants

According to the expectation states framework, the probability that a given agent makes a suggestion to a particular other agent depends on their relative expectation standings in the group. Those agents for whom group members have on average higher expectations than for the rest of the group are more likely to be involved in an interaction, either as the sender or receiver of a suggestion.

In our model, e_{ji}^* represents the average performance expectation that all group members, including i , have for i . We transform this value (non-linearly) to the range of 0 to 1 by

$$E_{i,t} = \frac{\exp(e_{ji,t}^*)}{1 + \exp(e_{ji,t}^*)}, \quad (2)$$

where E_i represents the expectation standing of agent i in the group. Based on this, in the *basic interaction model* and the *extended interaction model*, the sender of a suggestion is randomly selected from the set of all group members with a probability proportional to E_i^γ . Subsequently, the receiver of this suggestion is randomly selected from the set of remaining group members, also with a probability proportional to E_i^γ . In both cases, γ ($\gamma \geq 0$) is an exogenous weighting factor that enables us to control the extent to which interactions concentrate among the higher ranking group members. When $\gamma = 0$, performance expectations do not affect the interaction probabilities among agents and all group members are equally likely to be the sender or receiver of a suggestion. The larger γ becomes, the more likely it becomes that agents with higher expectation standings in the group become selected as senders or receivers of suggestions. In the *random interaction model*, expectation standings have no effect on interaction probabilities and all agents are always equally likely to be selected as the sender or receiver of a suggestion. This approach to modelling the distribution of dyadic interactions in discussion groups is a simplified version of the approach presented by Skvoretz and Farraro (1996).

3.3 interaction

According to the expectation states framework, the probability that a given receiver of a suggestion will accept or reject it depends on the sender's and receiver's relative expectation standings in the group.

After the sender i and receiver j of a suggestion have been selected, in the *basic interaction model* and the *extended interaction model* the probability that j accept i 's suggestion is equal to

$E_i^\delta / (E_i^\delta + E_j^\delta)$. The probability that j will reject i 's suggestion is equal to $1 - E_i^\delta / (E_i^\delta + E_j^\delta)$. In both cases, δ ($\delta \geq 0$) is an exogenous weighting factor that enables us to control the extent to which performance expectations affect interactions. When $\delta = 0$, differences in the performance expectations that group members have for i and j do not affect their interaction, so that j is equally likely to accept or to reject i 's suggestion. The larger δ becomes, the more a difference between E_i^δ and E_j^δ to the advantage (disadvantage) of i increases the probability that j will accept (reject) i 's suggestion. Note that we use here the expectation standings (E_i) of i and j , rather than the performance expectations (e_{ij}) that i and j personally have for each other. This implements the notion that group members tend to take the performance expectations of other group members into account when interacting with each other. In the *random interaction model*, expectation standings have no effect on the outcomes of interactions, so that suggestions are always equally likely to be accepted or rejected. This approach to modelling dyadic interaction is a simplified version of approaches used to estimate acceptance and rejection rates in dyadic interactions as, for example, presented by Balkwell (1991).

3.4 calculate_comp

We capture the comprehensiveness of the observed structures with the measure *comp* ($0 \leq comp \leq 1$). This measure is calculated as the number of dyads of agents who differ in the social distinction and who have interacted already (i.e. the number of ties b_{ij} between group members who differ in N_i , regardless of the weight of these ties), divided by the total number of dyads of agents who differ in the social distinction (regardless of whether they have already interacted or not). With this approach, the interactions between two group members who differ in N_i provides only a fraction of the information that is potentially available for evaluating competence differences between members of the different categories in larger groups. Accordingly, if only two group members who differ in N_i have interacted so far, the value of *comp* will be low in larger groups. However, its value increases as the number of such interactions increases. It reaches its maximum when all members of the two categories in the group have interacted at least once with each other.

3.5 calculate_cons

We capture the consistency of the observed interaction structures with the measure *cons* ($-1 \leq cons \leq 1$). This measure is based on the interactions that have occurred between agents who differ in the social distinction. It assesses whether agents who belong to category A appeared more often in the higher or lower competence role in their interactions with agents who belong to category B . More technically, we model *cons* as

$$cons_t = \frac{\#b_{ij,t}^{A-} - \#b_{ij,t}^{A+}}{\#b_{ij,t}^{A-} + \#b_{ij,t}^{A+} + \#b_{ij,t}^{A0}}, \quad (3)$$

where $\#b_{ij}^{A-}$ and $\#b_{ij}^{A+}$ are the number of behavior interchange patterns/ties in which agents who belong to the category $N_i = A$ appear in the lower (-) or higher (+) competence role in their interactions with members of the category $N_i = B$ (as indicated by the directions of the ties between them); $\#b_{ij}^{A0}$ represents behavior interchange patterns which are balanced, so that both agents appear similarly competent. The closer *cons* comes to -1, the more often members of the

category $N_i = A$ appear in the higher competence role; the closer it comes to 1, the more often members of category $N_i = B$ appear in the higher competence role.

3.6 calculate_r

Together *comp* and *cons* determine how strongly the structure of behavior interchange patterns in the group supports a status belief. We express this support with the measure r ($-1 \leq r \leq 1$), which relates to *comp* and *cons* in the following way:

$$r_t = \frac{r_{t-1} + (comp_t * cons_t)}{1 + comp_t} \quad (4)$$

Eq. (4) implies that r approaches its minimal or maximal value only when the structure of behavior interchange patterns is maximally consistent (*cons* = -1 or *cons* = 1) and maximally comprehensive (*comp* = 1). When $r = -1$, the observed structure maximally supports the belief that members of category $N_i = A$ are more competent than members of category $N_i = B$. When $r = 1$, the observed structure maximally supports the belief that members of category $N_i = B$ are more competent than members of category $N_i = A$. Note that Eq. (4) creates some time lag in the effect that observed behavior interchange patterns have on r . This implements the notion that when a particular status belief has been supported for some time, new information that contradicts it might initially be conceived as a merely coincidental deviation from well-established hierarchical structures (cf. Ridgeway 2000).

3.7 update_status_beliefs

Agents acquire (and maintain) a status belief when the observed structure of behavior interchanges patterns sufficiently supports it. We assume that agents perceive a given belief as sufficiently supported when the value of r crosses the threshold c (with $0 < c \leq 1$), either in the negative or positive direction. For instance, when at time t the value of r is smaller than or equal to $-c$, then the belief $S_i = A$ is sufficiently supported and agents who currently hold no status belief acquire this belief with probability a (with $0 < a \leq 1$). Yet, when at time t the value of r is larger than $-c$, then the belief $S_i = A$ is not sufficiently supported and agents who currently hold this belief loose it with probability l ($0 < l \leq 1$). Similarly, when r is larger than or equal to c , then agents who currently hold no status belief adopt the belief $S_i = B$ with probability a ; when r is smaller than c , agents who currently hold this belief loose it with probability l . This implies that agents who hold a status belief that is not sufficiently supported anymore always need to make the transition through $S_i = O$ before they can acquire a new belief. This approach to modeling changes in status beliefs is similar to the approach used by Mark et al. (2009).

3.8 largest_share_of_agents_with_status_belief

The maximal share of belief holders is calculated as the largest number of agents with the same state on S_i that is different from O , divided by the total number of agents.

4 References

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